CHAPTER 1

INTRODUCTION

1.1 Background

South African indigenous Naked neck chickens are thought to originate from Malaysia and are now found mainly in the rural areas of South Africa (ARC, 2006). They are characterized as a dual purpose breed (Joubert, 1996). Naked neck chickens contribute a lot to the incomes and nutrition of the rural communities of South Africa. However, Naked neck hens produce few eggs which are small and tend to have low hatchability (Tadelle *et al*., 2000). Poor nutrition may be one of the reasons for low productivity in these chickens. According to Teketel (1986), the productivity of indigenous chickens expressed in terms of egg production, egg size, growth and survivability of chicks under the rural production systems is very low. This low productivity may be attributed to incidences of chicken diseases, poor nutrition and poor management factors (Alemu, 1995). Protein supplementation has been found to improve egg production and hatchability in other chicken breeds (Bunchasak *et al*., 2005). Such information on Naked neck chickens is lacking. Therefore, it is important to ascertain the effect of dietary protein level on egg production, hatchability and chick productivity of indigenous Naked neck chickens.

1.2 Problem statement

Low egg production is common among indigenous Naked neck chickens. Such eggs have a low hatchability. Furthermore, chicks from such eggs have high mortality rates. Poor nutrition may be one of the causes. For example, low levels of dietary protein may result in lower number of eggs produced, lower hatchability and higher chick mortality (Mwalusanya *et al.,* 2002). However, dietary protein levels for optimum productivity in laying Naked neck hens are not known. Similarly, values for egg quality, hatchability and productivity of the chicks from Naked neck hens on different dietary protein levels are not known.

1.3 Motivation

On completion of this study protein requirements for optimal egg production and hatchability in Naked neck hens will be known. Similarly, hen protein requirements for low chick mortality will be known. All this will help in increasing productivity of Naked neck chickens. At the end of the day, it is hoped that rural farmers will benefit nutritionally and economically.

1.4 Objectives

The objectives of this study were as follows:

i. To determine the effects of dietary protein level in indigenous Naked neck hens on egg production, characteristics and hatchability.

ii. To determine the effects of dietary protein level in indigenous Naked neck hens on subsequent chick growth, mortality and carcass characteristics.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Protein is essential for the production of eggs, hatchability and the productivity of chicks. However, optimum protein levels for the production of eggs, hatchability and productivity of Naked neck chickens are not known.

2.2 Biochemical functions of protein

In cells, proteins are an important part of the plasma membrane of the cell, but their most essential role is as enzymes. These are molecules that act as biological catalysts and are necessary for biochemical reactions to proceed. They are also found as keratin in the skin, feathers and hair, in muscles, as well as in antibodies (Clauer, 1995). Proteins play an essential role in the cellular maintenance, growth, and functioning of the living organism. They are vital for cellular and body functions, including cellular regeneration and repair, tissue maintenance and hormone regulation, fluid balance and provision of energy. They are also responsible for the transportation of substances such as oxygen, vitamins and minerals to target cells throughout the body. They help to maintain balance between acids and bases within body fluids (Wikibook, 2008). Chickens need protein to build more muscles in the body. Hens need protein to produce eggs (Clauer, 1995).

2.3 Effect of dietary protein level on egg production and composition

Protein content of food may be a limiting factor for egg formation in birds, but the role of dietary protein and energy level in egg production and egg quality are not clear (Nager *et al.,* 1997). Protein and energy are the major nutrients of the laying hens. As much as 85 % of the total costs of the diet come from protein and energy ingredients. Liu *et al.* (2004; 2005) and Wu *et al*. (2005) reported that increasing protein level significantly affected egg production, egg weight, egg mass, feed consumption, feed conversion ratio, egg specific gravity and body weight of the hen. Bowmaker and Gousi (1989) also found that egg production was increased in their trial because of increased protein in the diet. However, Cave (1984) and Brake *et al*. (1985) attributed the increase in egg production in their trial to an increased protein deposition in the body. Whitehead *et al*. (1985) showed the negative effect of excess protein where the higher protein level reduced reproductive performance, and produced fewer chicks per 100 fertile eggs. Famino (1996) studied three levels of protein (16, 18 and 20 % CP) and three levels of energy (2250, 2450 and 2650 kcal/kg) in layer diets on Black Harco birds, and found that protein level had no significant effect on hen-day egg production and egg weight, and neither protein nor energy level showed any difference in body weight gain. However, Hussein *et al.* (1996) stated that raising crude protein in layer diets from 16 to 19 % did not increase egg production, but 19 % CP significantly improved egg weight. Buchasak *et al*. (2005) in their study reported that dietary protein levels did not significantly affect t egg production, but higher protein contents (16 and 18 % CP) tended to have better percentage of egg production than the 14 % CP. They concluded that the protein requirement for high producing laying hens varies from 16 to 18 % CP of the diet, to meet the needs of egg production, maintenance and growth of body tissues, and feather growth. However, this depends on the energy content of the feed (Buchasak *et al.,* 2005). In the study by Parsons *et al*. (1993), White leghorn hens were fed varying protein levels (16, 18 and 20 %) in the diet, the protein level did not have any influence on egg production, and there was a substantial effect on egg weight by increasing the dietary protein level from 16 to 18 %. Zou and Wu (2005) have reported that hens fed a diet containing 17 % CP had a higher egg production than hens fed a diet containing 15 % CP. Similarly, Liu *et al.* (2005) and Wu *et al.* (2005) reported that increasing protein level in a diet from 15 to 16 % CP improved egg protein content.

It is known that egg weight increases as dietary protein increases, however, the protein intake needed to achieve optimum egg weight is variable. Gunawardana *et al.* (2009) reported that eggs from hens fed the high-protein diet (16.1 % CP) were significantly heavier than those of hens fed the low-protein diet (15.5 % CP). Leeson (1989), Parsons *et al*. (1993), Keshavarz (1995) and Sohail *et al*. (2003) also reported that eggs from hens fed a higher protein level (19.8 % CP) were heavier than those from the hens fed a lower-protein diet (17.4 % CP). Joseph *et al.* (2000) reported that feeding 16 or 18 % CP to broiler breeder hens resulted in the production of larger eggs when compared with eggs from birds fed a diet of 15 % CP. Higher levels of protein have also shown to increase early egg weight in commercial laying hens (Summers, 1993; Summers and Leeson, 1994). Gunawardana *et al.* (2008) and Srivastav *et al.* (1993) indicated that increasing dietary protein from 13.8 to 17.1 % increased egg weight by 2.38 g. Egg weight was decreased from 55.21 to 52.20 g as dietary protein level decreased from 19 to 13 % CP Zootechnica International, 2008. O'Byrne (2002) reported that small eggs may be due to low protein. However, Leeson (1989) reported that egg size dramatically increased as dietary protein intake increased from 13.1 to 20.7 g per bird per day and egg weight was still increasing linearly at 20.7 g level of protein intake. Many producers are feeding dietary protein levels far in excess of a level of 16 g per day in an attempt to maximize early egg weight (NRC, 1984). Novak *et al*. (2006) reported in their study that hens consuming 13.8 g of protein per day had significantly reduced egg weight compared with hens consuming 14.6 or 16.3 g of protein per day. A high level of dietary protein also maximizes the amount of carcass protein available for egg formation as well as egg size. Hussein (2000) indicated that 19 % CP in layer diets significantly increased egg weight of White leghorn pullets compared to 16 % CP in the diet. Kulikov and Sarda (1987) compared 16.6, 17.6, 18.4 and19.5 % CP in layer diets and concluded that higher CP levels increased laying intensity and egg weight. Egg mass of hens fed the 16 and 18 % CP diets were significantly higher than the 14 % CP group due to heavier egg weight (Buchasak *et al.,* 2005). In the study by Parsons *et al*. (1993), egg size and egg weight of hens fed 20 % CP were higher than those from hens fed 16 or 18 % CP. Egg weight and egg size of hens fed 18 % CP were higher than those from hens fed 16 % CP. Zou and Wu (2005) have reported that protein level in the diet had no significant effect on egg weight. This was in consistent with those of Liu *et al*. (2005) and Wu *et al*. (2005), who reported an increased egg weight with increase protein in the diet of hens.

However, Cho *et al*. (2004) reported no increase in egg weight in commercial layers offered diets having protein levels of 15 to 19 % CP.

Bunchasak *et al.* (2005) reported no significant effect of dietary protein level on the proportion of egg components such as yolk and albumen. Wu *et al*. (2007) also reported that there was no significant effect of protein on yolk and shell contents. As protein level increased from 160.7 to 173.9 g/kg, percent albumen linearly increased and yolk to albumen ratio linearly decreased. Protein level in the diet had no effect on the egg solids, yolk solids, albumen solids and egg yolk colour. Wet and dry albumen percentages, albumen solids, and albumen and yolk protein percentages were significantly decreased with feeding low-protein diets. Hens consuming a low-protein diet produced eggs with the lowest specific gravity. Overall, hens consuming high and medium protein diet produced eggs with significantly higher specific gravity than those consuming the lowest protein diet. Karunajeewa (1972) conducted an experiment to evaluate the effect of protein (15 and 17 %) CP and energy level (2650 and 2850 MJ/kg diet) on laying performance of three hen strains, and concluded that neither protein nor energy level in the diet influenced the haugh unit, while the lower protein level improved yolk colour score than the higher level. However, Akbar *et al.* (1983) found that higher protein levels in the diet increased yolk nitrogen content in eggs from commercial laying hens. Wu *et al.* (2007) showed that there was no significant effect of protein on egg percent yolk and shell percentages. As protein increased from 160.7 to 173.9 g/kg feed, percent albumen linearly increased. Egg size usually increases as dietary protein increases; however, the protein intake needed to achieve optimum egg size is unclear. Lopez and Leeson (1994) indicated that for broiler breeder chickens protein intake as low as 13 g/day (9 % CP) with an intake of 1300 mg/day of lysine and 550 mg/day of methionine was adequate for maximum egg production.

2.4 Effect of dietary protein level on egg hatchability

Vo *et al*. (1994) showed higher hatchability in brown egg layers fed higher protein diets. However, Leeson and Lopez (1994) observed that low hatchability is associated with high protein levels in the diets of hens, especially when energy intake is low. Fattori *et al*. (1991) reported that severe reduction of protein and energy intake during the growing period of broiler breeder hens did not affect subsequent fertility or hatchability. Whitehead *et al*. (1985) reported reduced egg numbers and hatchability when broiler breeders were fed on a limited quantity of a diet containing 160 g CP/kg compared to those containing 165 g CP/kg or 130 g CP/kg. ARC (1975**)** recommended 165 g/kg level of CP for broiler breeders and confirmed that several reports that advised levels of protein for broiler breeders were not only excessive (Harms and Wilson, 1980**;** Pearson and Herron, 1982**)** but could also lead to decreased hatchability and growth of broiler chicks (Pearson and Herron, 1982**;** Whitehead *et al.,* 1985**).** In the study by Lopez and Leeson (1994) eggs from birds fed low crude protein were consistently smaller and resulted in a reduction in chick hatch-weight.

2.5 Effect of dietary protein level of the hen on chick productivity of indigenous chickens

The developing embryo is completely dependent for its growth and development on nutrients deposited in the egg, consequently the physiological status of the chick at hatching is greatly influenced by the nutrition of the breeder hen which will influence chick size, vigour and the immune status of the chick (Kemp and Kenny, 2007*).* Kidd (2006) showed that the progeny immunity, body weight and metabolism can be affected by the hen's diet.

Kenny and Kemp (2007) reported that hens fed diets low in protein produced chicks with higher mortality and poor growth compared to those from hens on diets high in protein. However Kingori *et al.* (2010) concluded that the dietary crude protein requirement for laying indigenous hens is about 120 g CP/kg and maternal dietary protein level has no effect on post-hatch offspring feed intake, feed efficiency and growth rate. Calini and Sirri (2007) observed that protein and energy in dam nutrition can alter the carcass fat and protein deposition of offspring at slaughtering.

2.7 Conclusion

There is some evidence in the literature that protein level in the diets of commercial hens can have effect on the number of eggs produced, egg weight, egg hatchability and subsequent productivity of the chicks. However, such information is lacking in indigenous chickens. It is, therefore, important to determine the effect of protein level in the diets of Naked neck hens on egg production, hatchability and chick productivity.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study site

This study was conducted at the University of Limpopo Experimental Farm. The ambient temperature at the farm ranges between 5 and 30 °C during winter and between 15 and 40 °C during summer. The mean annual rainfall is 468.4 mm.

3.2 Preparation of the house

The experimental house and the incubator were thoroughly cleaned with water and disinfected with Jeyes fluid (NTK, Polokwane) and left vacant for two weeks so as to break the life cycles of the diseases that may not have been killed by the disinfectant. All the equipment such as the drinkers, feeders and wire separators were cleaned thoroughly and disinfected.

3.3 Experimental procedure, dietary treatments and design

The first part of the study determined the effect of protein level in diet of Naked neck hens on egg production, hatchability and characteristics. This experiment was conducted from February to March, 2009. A total of 25 Naked neck hens, aged 30 weeks were confined in the cages and fed diets different in protein contents. A completely randomized design, comprising of five diets different in protein levels (12.94, 13.94, 14.38, 15.75 and 18.13 % CP), replicated five times with one hen in each replicate, was used. The hens were weighed at the beginning and at the end of the experiment. Semen was collected from one cock to fertilize all the hens. Artificial insemination procedure was used as described by Das *et al.* (2004). Eggs were collected during the last 10 days of the experiment and were incubated for 21 days. Hatchability was determined and the chicks were weighed immediately after hatching. The treatments were as follows:

$P_{12.94}$: Naked neck hens fed a diet having 12.94 % CP

$P_{13.94}$: Naked neck hens fed a diet having 13.94 % CP

$P_{14.38}$: Naked neck hens fed a diet having 14.38 % CP

$P_{15.75}$: Naked neck hens fed a diet having 15.75 % CP

$P_{18.13}$:	Naked neck hens fed a diet having 18.13 % CP

The diets were formulated and produced by a commercial milling company ($Z_{et\ B}$ feeds, Lousi Trichardt, South Africa). The milling company refused to give us the proportions of the different feeds used in the diets. Nutrient composition of the diets for Naked neck hens are presented in Table 3.01. The diets contained similar energy and lysine levels but different protein levels, ranging from 129.4 to 183.0 g/kg DM.

Table 3.01 Nutrient composition of the diets for Naked neck hens (units are in g/kg DM except energy as MJ ME/kg DM feed and dry matter as g/kg feed).

Diet	Nutrients						
	DM	Energy	Phosphorus	Calcium	Fat	Lysine	Protein
$P_{12.94}$	931	14.6	4.5	23	25	11.6	129.4
$P_{13.94}$	931	14.7	4.5	22	25	11.6	139.4
$P_{14.38}$	930	14.6	4.4	21	25	11.6	143.8
$P_{15.75}$	931	14.6	4.3	22	25	11.6	157.5
$P_{18.13}$	930	14.7	4.4	22	25	11.6	183.0

The second part of the study determined the effect of protein level in the diet of Naked neck hens on performance of their chicks from day old up to seven weeks of age. A total of 95 unsexed day old chicks from the first part of the study were assigned to 20 floor pens according to the number of chicks hatched per replicate. The chicks had an initial live weight of 35 ± 2 g per bird. All the chicks were fed the same commercial grower diet and fresh water *ad libitum* up to seven weeks of age. The grower mash diet contained 880 g DM/kg, 16. 9 MJ energy/kg DM , 200 g protein/kg DM, 11.5 g lysine/kg DM and 25 g fat/kg DM. A complete randomized design was used (SAS, 2004).

The third part of the experiment examined the effect of protein level in the diet of Naked neck hens on performance of their male and female chicks between eight and thirteen weeks of age. Chicks used for this experiment were first raised up to seven weeks of age from the second part of the experiment. A 2 (males and females) × 5 (protein levels of the hens) factorial experiment arranged in a complete randomized design replicated four times. The initial live weight of the chickens ranged between 525 to 648 g per bird. All the birds were fed the same grower mash and fresh water *ad libitum*. The contents of the grower diet contained 880 g DM/kg, 16. 9 MJ energy/kg DM , 200 g protein/kg DM, 11.5 g lysine/kg DM and 25 g fat/kg DM.

3.4 Data collection

All eggs were weighed during the collection period. An average weight was determined for each replication. Two eggs from each replicate were used to determine egg contents. Yolk and albumen contents were determined and analyzed for nitrogen and calcium. Egg hatchability was determined after 21 days of egg incubation. Percentage hatchability was determined by dividing the number of eggs hatched by the total number of eggs incubated and then multiplied by 100.

The initial live weights of the chicks were taken within 24 hours after hatching and then the chicks were weighed every week thereafter until 13 weeks of age. These weights were used to determine the growth rate. Feed intakes of the hens and the chicks were measured weekly by subtracting the weight of the leftover from that of the feed offered per week and the difference was divided by the number of birds in a pen. Then a daily feed intake per bird was calculated. Deaths were recorded daily. Mortality rate of chickens per pen was calculated as the total number of deaths divided by the total number of chickens per pen then multiplied by 100.

At week seven, one chicken per replicate was randomly selected and placed in the metabolic cage for the determination of feed digestibility. The cage is designed with separate drinking and feeding troughs. Chickens were allowed to adapt in the cages for a period of three days. Excreta was collected from each replicate for three days, dried, weighed and then kept for chemical analysis. Feed and water were provided *ad libitum.* Feed offered and feed refusals during the collection period were weighed. Apparent digestibility of nutrients was calculated according to McDonald *et al*. (1992). Digestibility was determined when the chicks were seven and thirteen weeks of age.

At thirteen weeks of age all the chickens were weighed on an electric scale to obtain the live weights and then slaughtered. Immediately after slaughtering, the carcass weight of each chicken was measured. Breast meat yield, breast meat nitrogen content and the fat pad weights were measured. Breast from each carcass was taken and dried in an oven and stored until analyzed for nitrogen.

3.5 Chemical analysis

Dry matter content of faeces, feed refusals, eggs and meat samples were determined by drying the samples for 48 hours at a temperature of 105 °C. The bomb calorimeter was used to measure gross energy values of feeds, eggs, meat and faeces, and the semi-micro Kjeldahl method was used to analyze nitrogen contents of feeds, meat and faeces (AOAC, 2002). Apparent metabolisable energy was equal to energy in the feed consumed minus energy excreted in the faeces (AOAC, 2002). Calcium, lysine, fat and phosphorus were analyzed using the method described by Schroeder (1994).

3.6 Statistical analysis

Effects of protein level in the diets of Naked neck hens on feed intake and digestibility, egg production, egg weight, number of eggs, egg hatchability, chick-hatch-weight, feed conversion ratio, growth rate, mortality and carcass characteristics of their chicks were analyzed using the General Linear Model (GLM) of Statistical Analysis System (SAS ,2004). The Duncan's Multiple Range Test for multiple comparisons was used to test the significant differences between treatment means (P<0.05) (SAS, 2004). The responses in optimal feed intake, egg production, egg weight, number of eggs, egg hatchability, chick hatch-weight, feed conversion ratio, growth rate, carcass characteristics and mortality of indigenous Naked neck chickens were modeled using the following quadratic equation:

$$Y = a + b_1x + b_2x^2$$

Where Y = feed intake, egg production, number of eggs, egg weight, hatchability and chick hatch-weight, growth rate, feed conversion ratio and mortality; a = interception; b_1 and b_2 = coefficients of the quadratic equation; x = dietary protein level and $-b_1/2b_2$ = x value for optimum response. The quadratic model was fitted to experimental data by means of the NLIN procedure of SAS (SAS, 2004). The quadratic model was used because it gave the best fit. Linear regression analysis was also used to predict the relationship between protein level in the diet of hens and carcass weight of male chickens at 13 weeks of age.

CHAPTER 4

RESULTS

The results of the effects of protein level of the diets of Naked neck hens on live weight, feed intake, number of eggs produced, egg weight and egg hatchability are presented in Table 4.01. Hens had similar (P>0.05) live weights. Hens fed a diet with 15.75 % CP had a higher (P<0.05) intake than those fed diets having 14.38 and 18.13 % CP. However, hens fed diets that have 12.94, 13.94 and 15.75 % CP had similar (P>0.05) intakes. Similarly, hens fed diets that have 12.94, 13.94 and 14.38 % CP had the same (P>0.05) intakes.

Hens fed a diet with 15.75 % CP produced more (P<0.05) eggs than hens fed a diet having 18.13 % CP. Hens fed diets with 12.94, 13.94, 14.38 and 15.75 % CP produced similar (P>0.05) number of eggs. Similarly, hens fed diets that have 12.94, 13.94, 14.38 and 18.13 % CP produced the same (P>0.05) number of eggs. Hens fed a diet with 15.75 % CP produced heavier (P<0.05) eggs than those produced by hens fed diets with 12.94, 13.94, 14.38 and 18.13 % CP. Heavier (P<0.05) eggs were produced by hens fed a diet that have 12.94 % CP than those produced by hens fed diets with 13.94, 14.38 and 18.13 % CP. Similarly, hens fed a diet that have 13.94 % CP produced heavier (P<0.05) eggs than those produced by hens fed diets having 14.38 and 18.13 % CP. Hens fed diets having 13.94 and 14.38 % CP produced eggs with similar (P>0.05) weights. Eggs produced by hens fed diets having 14.38 and 18.13 % CP had similar (P>0.05) weights.

Hens fed a diet having 15.75 % CP produced egg yolks having higher (P<0.05) nitrogen contents than those produced by hens fed diets having 12.94, 13.94, 14.38 and 18.13 % CP. Nitrogen contents of egg yolks were higher (P<0.05) in eggs produced by hens fed a diet having 18.13 % CP than those produced by hens fed diets having 12.94, 13.94 and 14.38 % CP. Hens fed a diet having 14.38 % CP produced egg yolks having higher (P<0.05) nitrogen contents than those produced by hens fed diets having 12.94 and 13.94 % CP. Hens fed a diet having 13.94 % CP produced egg whites having higher (P<0.05) nitrogen content than those from eggs produced by hens fed diets having 12.94, 14.38, 15.75 and

18.13 % CP. Hens fed a diet having 18.13 % CP produced egg whites having higher ($P<0.05$) nitrogen contents than those produced by hens fed diets having 12.94, 14.38 and 15.75 % CP. Hens fed a diet having 12.94 % CP produced egg whites having higher ($P<0.05$) nitrogen contents than those from eggs produced by hens fed diets having 14.38 and 15.75 % CP.

Hens fed a diet having 18.13 % CP produced eggs with higher ($P<0.05$) hatchability than eggs produced by hens fed diets having 12.94, 13.94, 14.38 and 15.75 % CP. Similarly, hens fed a diet having 14.38 % CP produced eggs with higher ($P<0.05$) hatchability values than those of eggs produced by hens fed diets having 12.94, 13.94, 14.38 and 18.13 % CP. Hens fed a diet having 15.75 % CP produced eggs with higher ($P<0.05$) hatchability values than those of eggs produced by hens fed diets having 12.94, 13.94 and 18.13 % CP. Eggs produced by hens fed a diet having 18.13 % CP had higher ($P<0.05$) hatchability values than did eggs produced by hens fed diets having 12.94 and 13.94 % CP. Similarly, eggs from hens fed a diet having 13.95 % CP had higher ($P<0.05$) hatchability values than those produced by hens fed a diet having 12.94 % CP.

Chicks hatched from eggs produced by hens fed diets having 14.38 % CP and 15.75 % CP had higher ($P<0.05$) hatch-weights than those hatched from eggs produced by hens fed diets having 12.94, 13.94 and 18.13 % CP. Similarly, chicks hatched from eggs produced by hens fed diets having 13.94 and 18.13 % CP had higher ($P<0.05$) hatch-weights than those hatched from eggs produced by hens fed a diet having 12.94 % CP. Chicks hatched from eggs produced by hens fed diets having 14.38 and 15.75 % CP had similar ($P>0.05$) hatch-weights. Similar ($P>0.05$) hatch-weights were observed among chicks hatched from eggs produced by hens fed diets having 13.94 and 18.13 % CP.

Feed intake, number of eggs, egg weight, egg white nitrogen, egg yolk nitrogen, egg hatchability and chick hatch-weight were optimized at different dietary protein levels for Naked neck hens of 14.7 (r^2 = 0.623), 14.9 (r^2 = 0.568), 13.9 (r^2

= 0.094), 18.2 (r^2 = 0.563), 15.1 (r^2 = 0.424), 15.9 (r^2 = 0.451) and 15.9 % CP (r^2 = 0.898), respectively (Figures 4.01 to 4.07 and Table 4.02).

Table 4.01 Effect of protein level of the diets of Naked neck hens on live weight (kg/hen), feed intake (g/hen/day), number of eggs over 10 days (eggs/hen/10 days), egg weight (g/egg), egg yolk nitrogen content (%), egg white nitrogen content (%), egg hatchability (%) and chick hatch-weight (g/chick)

Variable	Treatment					SE
	$P_{12.94\%}$	$P_{13.94\%}$	$P_{14.38\%}$	$P_{15.75\%}$	$P_{18.13\%}$	
Live weight	1.6	1.7	1.7	1.6	1.7	0.10
Feed intake	88^{ab}	86^{ab}	79^{b}	99^{a}	62^{c}	5.913
No of eggs	8.20^{ab}	7.80^{ab}	7.00^{ab}	9.80^{a}	5.00^{b}	1.226
Egg weight	59.5^{b}	55.7^{c}	55.5^{cd}	60.5^{a}	55.3^{d}	0.092
Egg white N	4.87^{c}	4.94^{a}	4.84^{b}	4.75^{e}	4.93^{b}	0.006
Egg yolk N	12.35^{d}	12.22^{e}	12.36^{c}	12.67^{a}	12.57^{b}	0.004
Hatchability	32^{e}	43^{d}	68^{a}	49^{b}	47^{c}	0.024
Chick hatch- wt	25.4^{c}	30.4^{b}	35.4^{a}	35^{a}	30.6^{b}	0.456

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

SE : Standard error

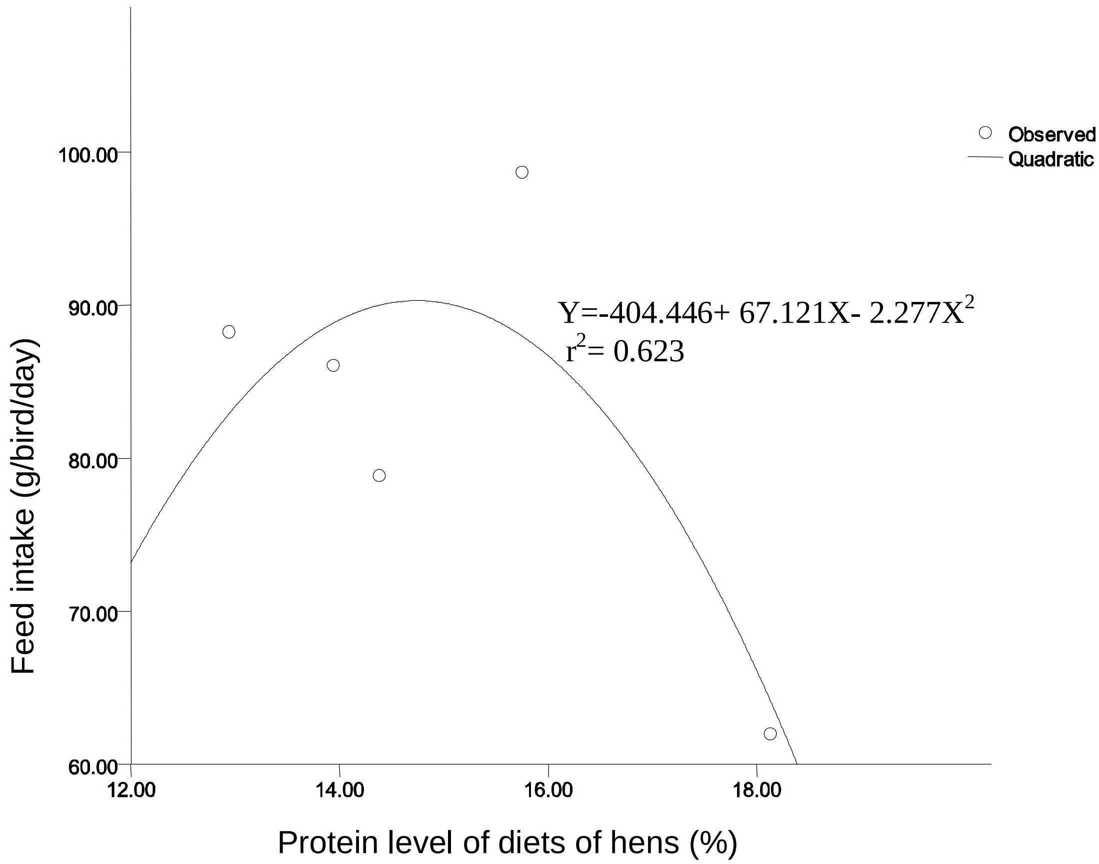

Figure 4.01 Effect of protein level of the diets of Naked neck hens on feed intake

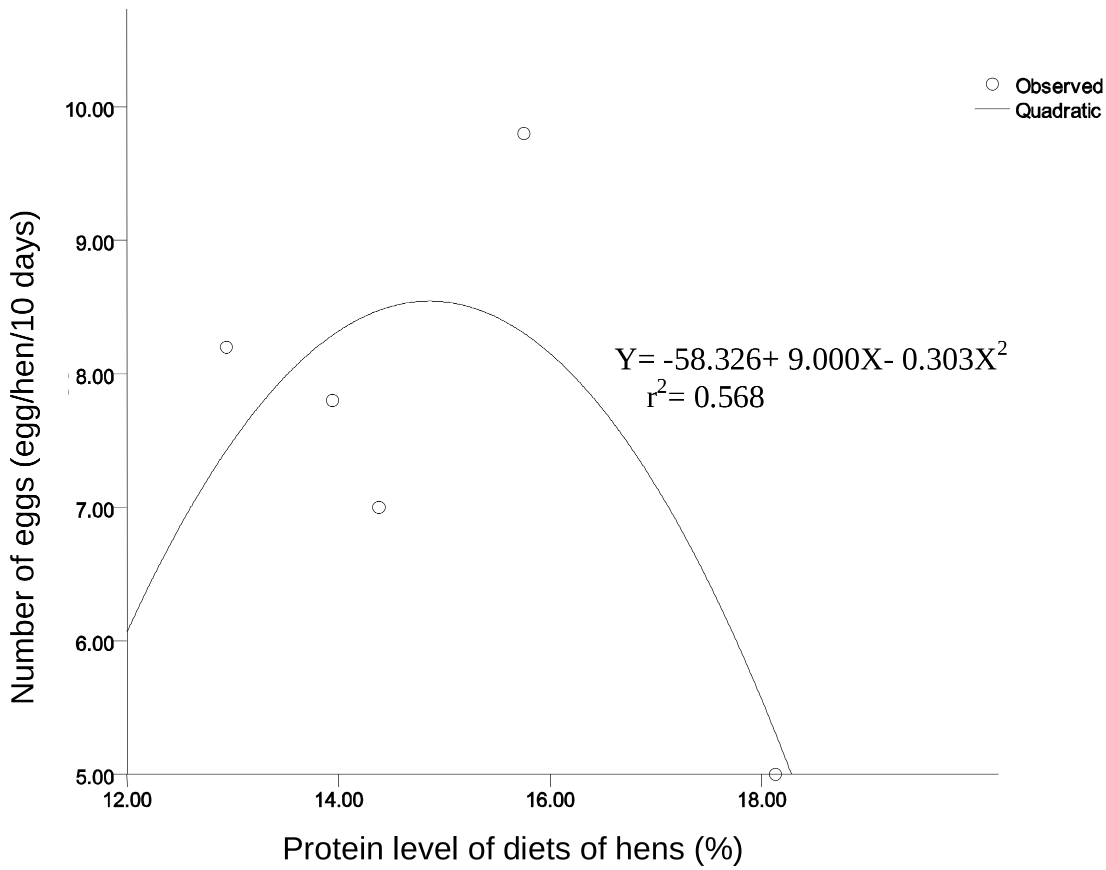

Figure 4.02 Effect of protein level of the diets of Naked neck hens on the number of eggs produced over 10 days

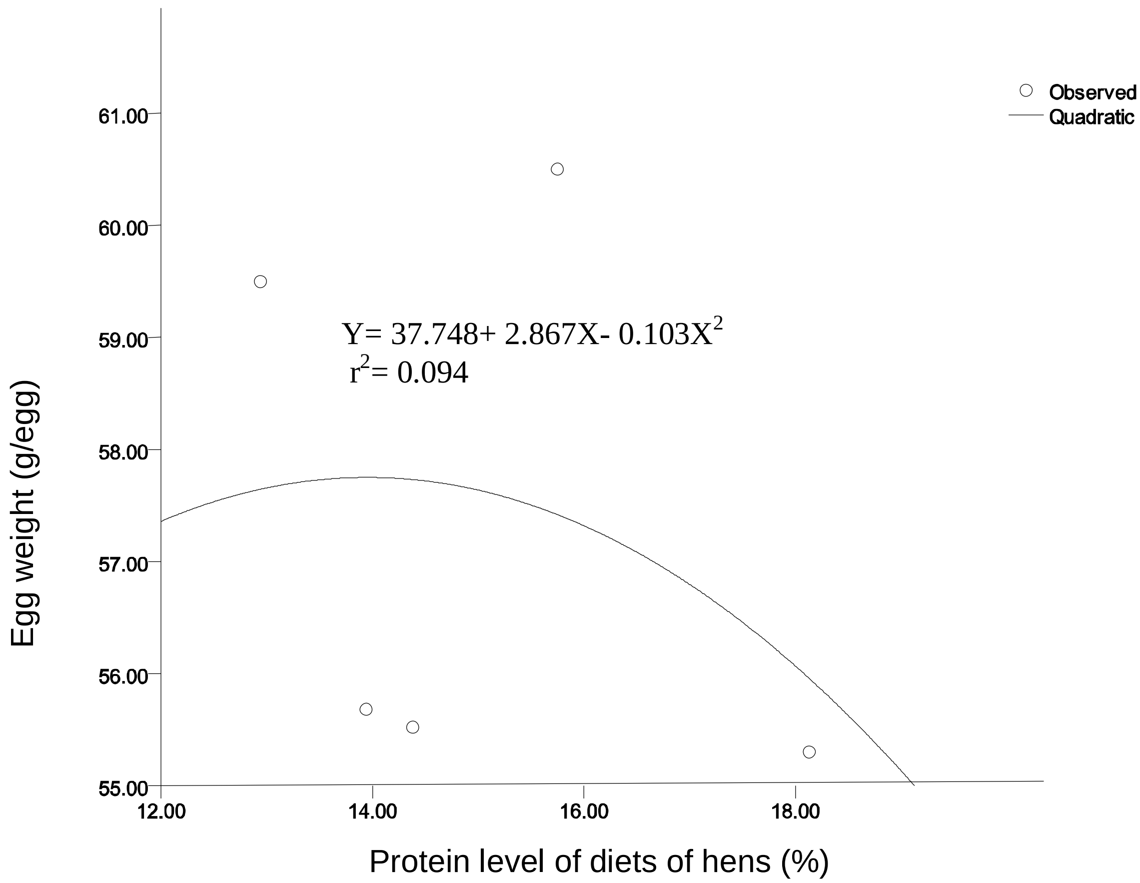

Figure 4.03 Effect of protein level of the diets of Naked neck hens on egg weight

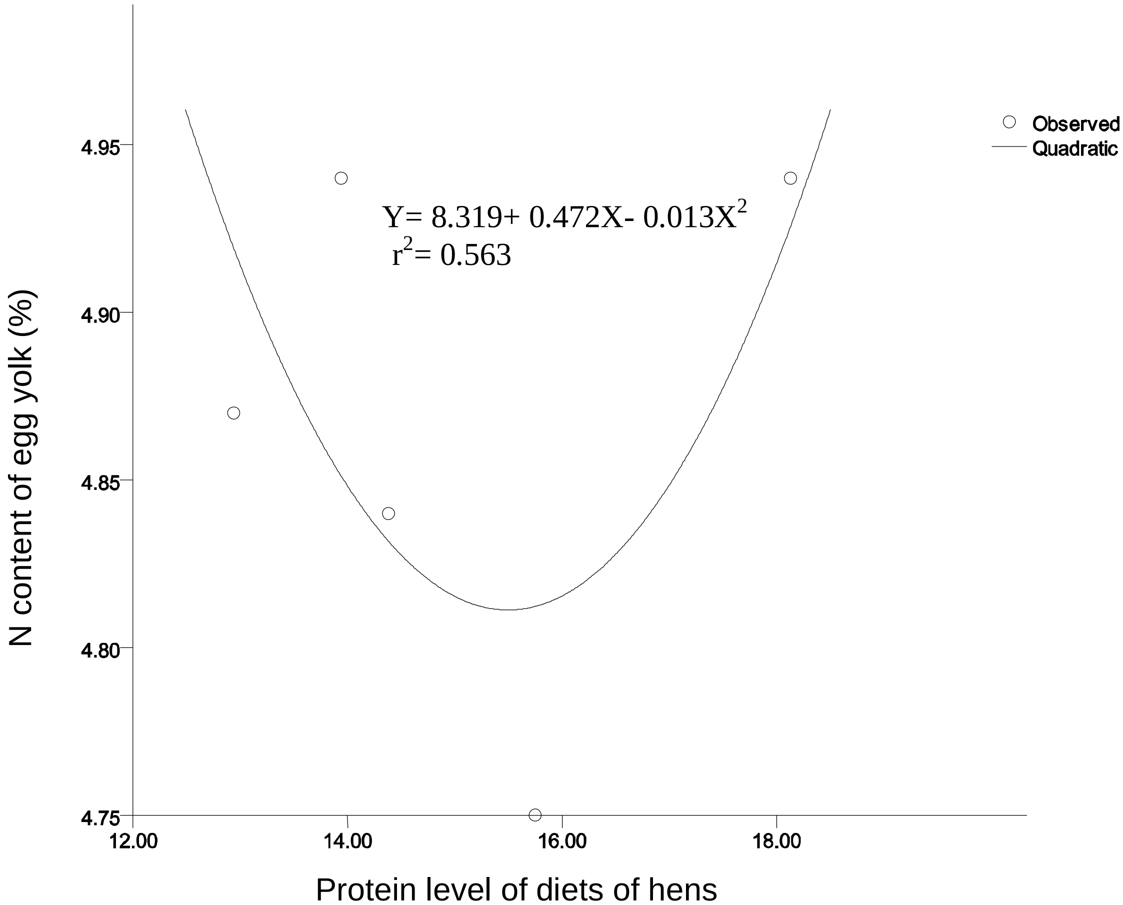

Figure 4.04 Effect of protein level of the diets of Naked neck hens on egg yolk nitrogen content

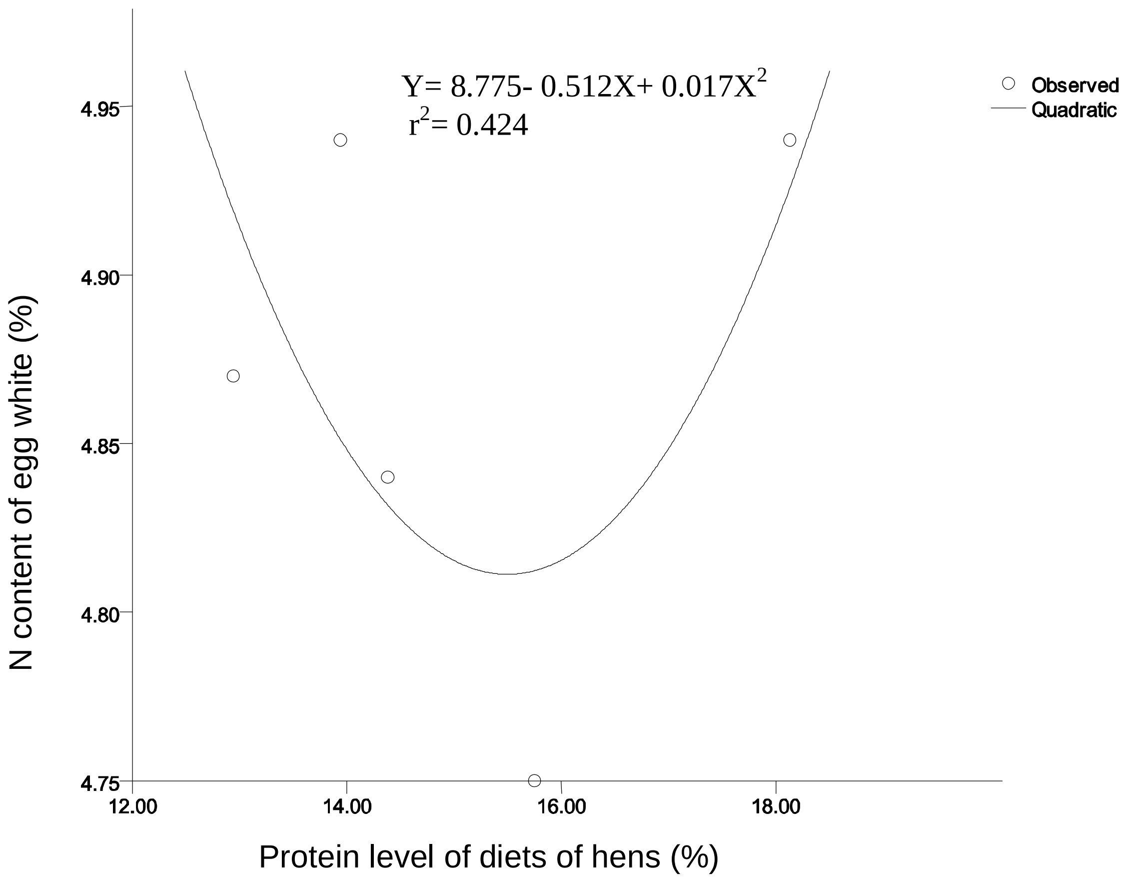

Figure 4.05 Effect of protein level of the diets of Naked neck hens on egg white nitrogen content

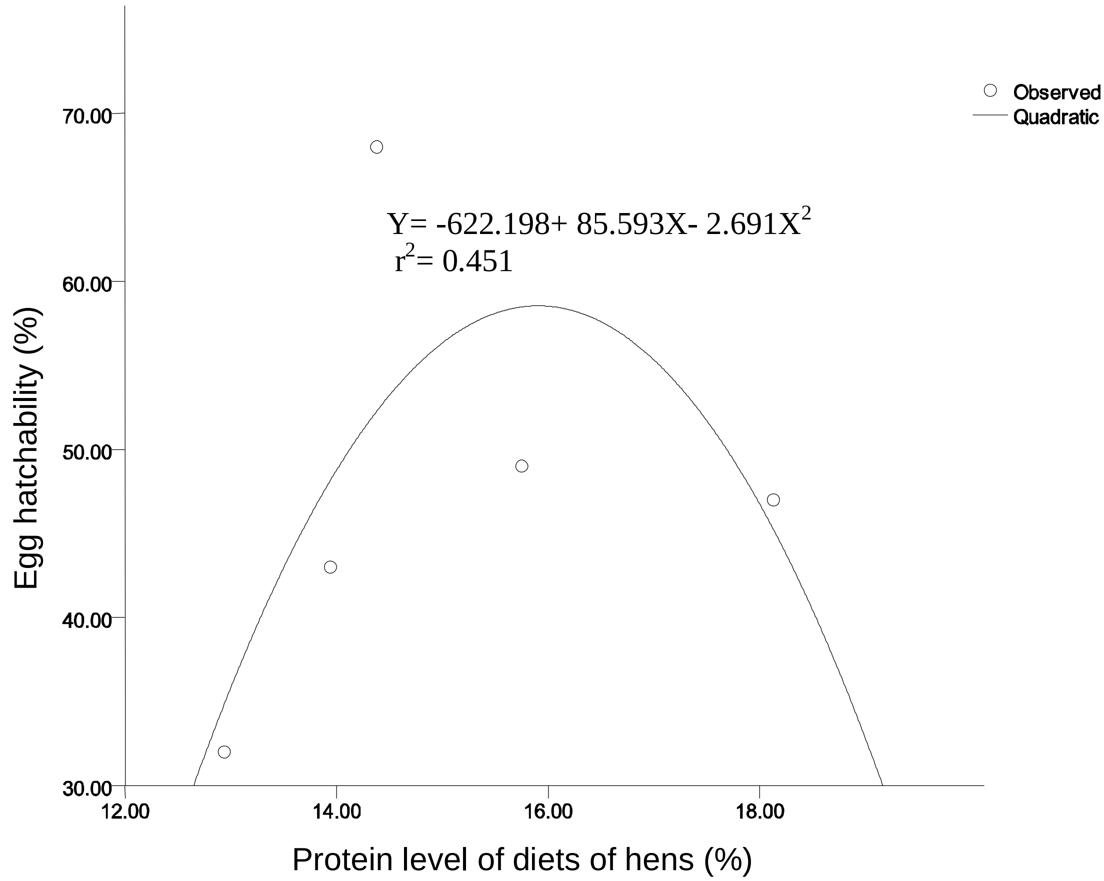

Figure 4.06 Effect of protein level of the diets of Naked neck hens on egg hatchability

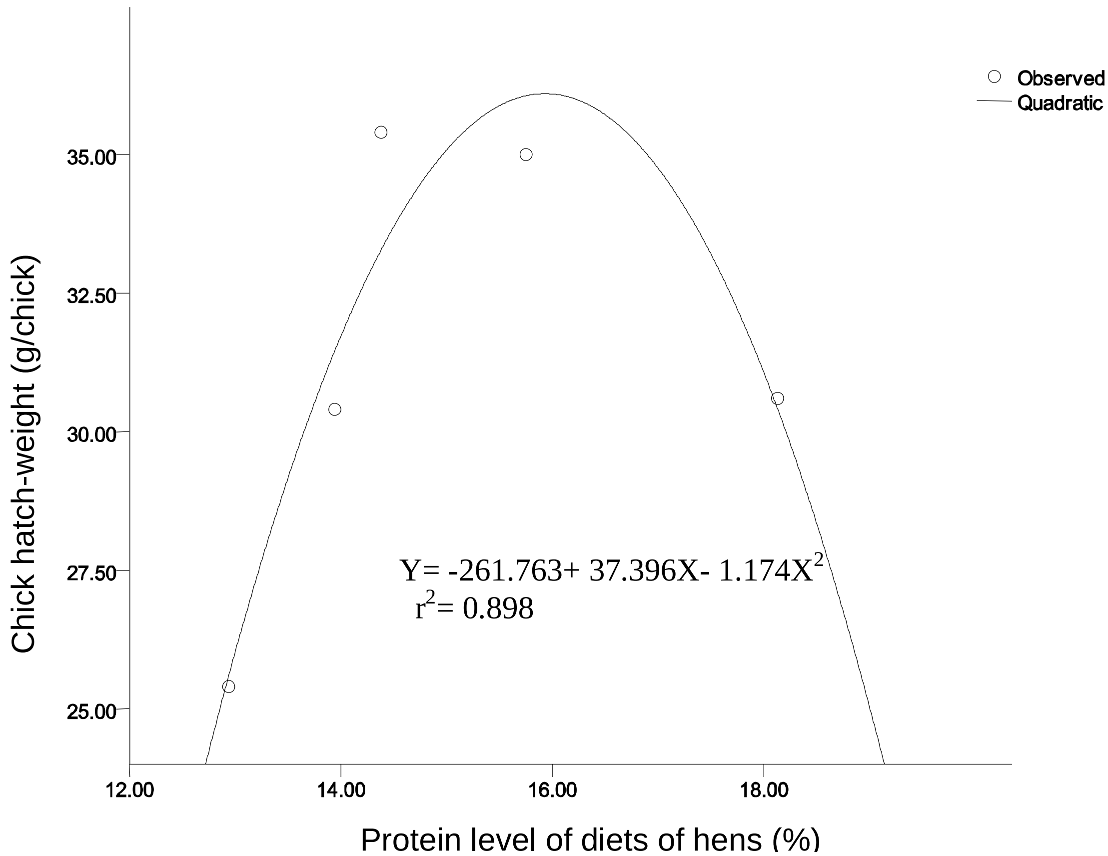

Figure 4.07 Effect of protein level of the diets of Naked neck hens on chick hatch-weight

Table 4.02 Protein levels (%) of the diets of Naked neck hens for optimal feed intake (g/bird/day), number of eggs produced over 10 days (eggs/bird/10 days),egg weight (g/egg), egg yolk nitrogen content (%), egg white nitrogen content (%), egg hatchability (%) and chick hatch-weight (g/chick)

Trait	Formula	r^2	CP*	Optimal y-level	P
Feed intake	$Y=-404.446+ 67.121X- 2.277X^2$	0.623	14.7	90.2	0.376
No of eggs	$Y= -58.326+ 9.000X- 0.303X^2$	0.568	14.9	8.5	0.432
Egg weight	$Y= 37.748+ 2.867X- 0.103X^2$	0.094	13.9	57.7	0.906
Egg white N	$Y= 8.319+ 0.472X- 0.013X^2$	0.563	18.2	12.6	0.597
Egg yolk N	$Y= 8.775- 0.512X+ 0.017X^2$	0.424	15.1	4.9	0.517
Hatchability	$Y=-622.198+ 85.593X- 2.691X^2$	0.451	15.9	58.4	0.549
Hatch- wt	$Y=-261.763+ 37.396X- 1.174X^2$	0.898	15.9	36.0	0.102

*: % CP for optimal variable

P: Probability level

Results of the effect of protein level of the diets of Naked neck hens on feed intake, growth rate, feed conversion ratio, mortality and live weight of their chicks from a day up to seven weeks of age are presented in Table 4.03. Chickens from hens fed a diet having 14.38 % CP had a higher (P<0.05) feed intake than those from eggs produced by hens fed a diet having 12.94 % CP. Feed intakes were similar (P>0.05) in chickens from eggs produced by hens fed diets having 13.94, 14.38, 15.75 and 18.13 % CP. Similarly, chickens from eggs produced by hens fed diets having 12.94, 13.94, 15.75 and 18.13 % CP had similar (P>0.05) intakes. Chickens from eggs produced by hens fed a diet having 12.94 % CP had a higher (P<0.05) feed conversion ratio than those from eggs produced by hens fed a diet having 14.38 % CP. However, chickens from eggs produced by Naked neck hens fed diets having 12.94, 13.94, 15.75 and 18.13 % CP had similar (P>0.05) feed conversion ratios. Chickens from eggs produced byhens fed diets having 13.94, 14.38, 15.75 and 18.13 % CP had similar (P>0.05) feed conversion ratios.

Live weights at 49 days were higher (P>0.05) for chickens from eggs produced by hens fed a diet having 14.38 % CP than those from hens fed a diet having 12.94 % CP (Table 4.03). However, chickens from eggs produced by hens fed diets having 13.94, 14.38 and 15.75 % CP had similar (P>0.05) live weights. Similarly, chickens from eggs produced by hens fed diets having 12.94, 13.94, 15.75 and 18.13 % CP had the same (P>0.05) live weights.

Feed intake, growth rate, feed conversion ratio, live weight and mortality of Naked neck chickens were optimized at different dietary protein levels for Naked neck hens of 15.8 (r^2 = 0.298), 16.1 (r^2 = 0.236), 16.1 (r^2 = 0.077), 14.3 (r^2 = 0.617) and 15.4 % CP (r^2 = 0.615), respectively (Figures 4.08 to 4.12, respectively and Table 4.05).

Results of the effect of protein level of the diets of Naked neck hens on dry matter intake, dry matter digestibility, live weight, nitrogen retention and apparent metabolisable energy of Naked neck chickens at seven weeks of age are presented in Table 4.06. Protein level of the diets of Naked neck hens had no effect (P>0.05) on live weight, dry matter intake, dry matter digestibility, apparent metabolisable energy and nitrogen retention of their progenies at seven weeks of age. Dry matter intake, dry matter digestibility, live weight, nitrogen retention and apparent metabolisable energy of Naked neck chickens were optimized at different protein levels in the diets of hens of 17.1 (r^2 = 0.710), 16.5 (r^2 = 0.777), 15.4 (r^2 = 0.160), 15.8 (r^2 = 0.756) and 14.1 % CP (r^2 = 0.331), respectively (Figures 4.13 to 4.17, respectively and Table 4.06)

Table 4.03 Effect of protein level of the diets of Naked neck hens on feed intake (g/bird/day), growth rate (g/bird/day), feed conversion ratio (g DM feed/g live weight gain) and mortality (%) of their chicks from a day old up to seven weeks of age

Variable	Treatment					SE
	$P_{12.94\ \%}$	$P_{13.94\ \%}$	$P_{14.38\%}$	$P_{15.75\ \%}$	$P_{18.13\ \%}$	
Feed intake	34.3^{b}	40.9^{ab}	49.9^{a}	39.1^{ab}	40.5^{ab}	4.024
Growth rate	7.7	7.8	7.6	7.8	7.7	0.334
Mortality	0.0	8.3	0.0	0.0	14.6	5.348
FCR	6.7^{a}	5.5^{ab}	4.5^{b}	5.0^{ab}	5.3^{ab}	0.688
Live weight	525.2^{b}	571.7^{ab}	648^{a}	572.9^{ab}	519.8^{b}	34.559

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

SE : Standard error

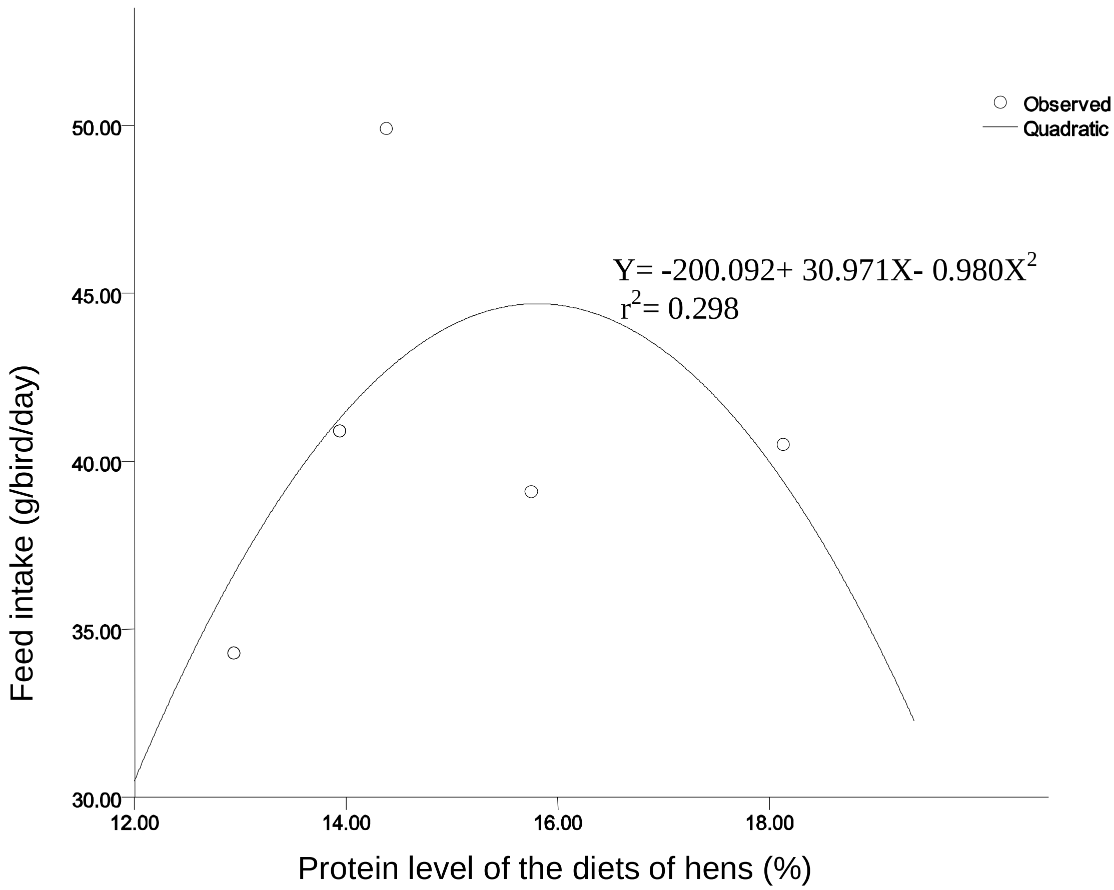

Figure 4.08 Effect of protein level of the diets of Naked neck hens on feed intake of their chicks from a day old up to seven weeks of age

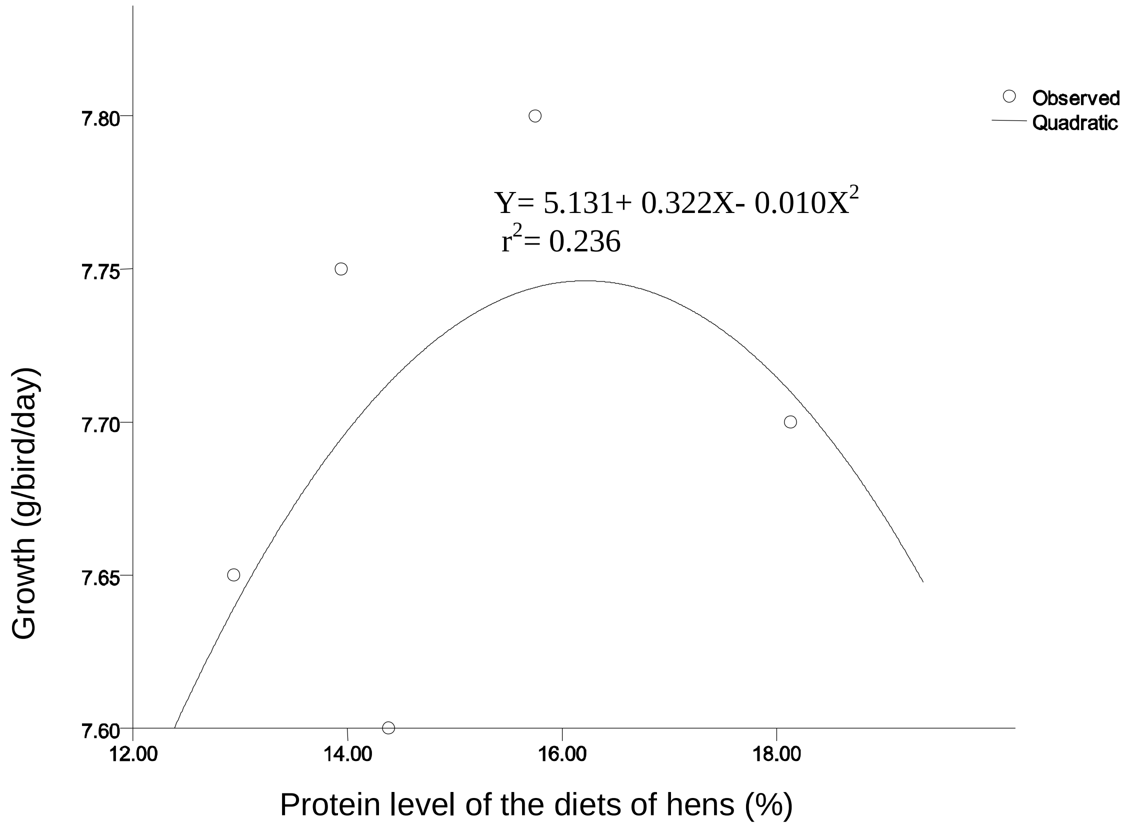

Figure 4.09 Effect of protein level of the diets of Naked neck hens on growth rate of their chicks from a day old up to seven weeks of age

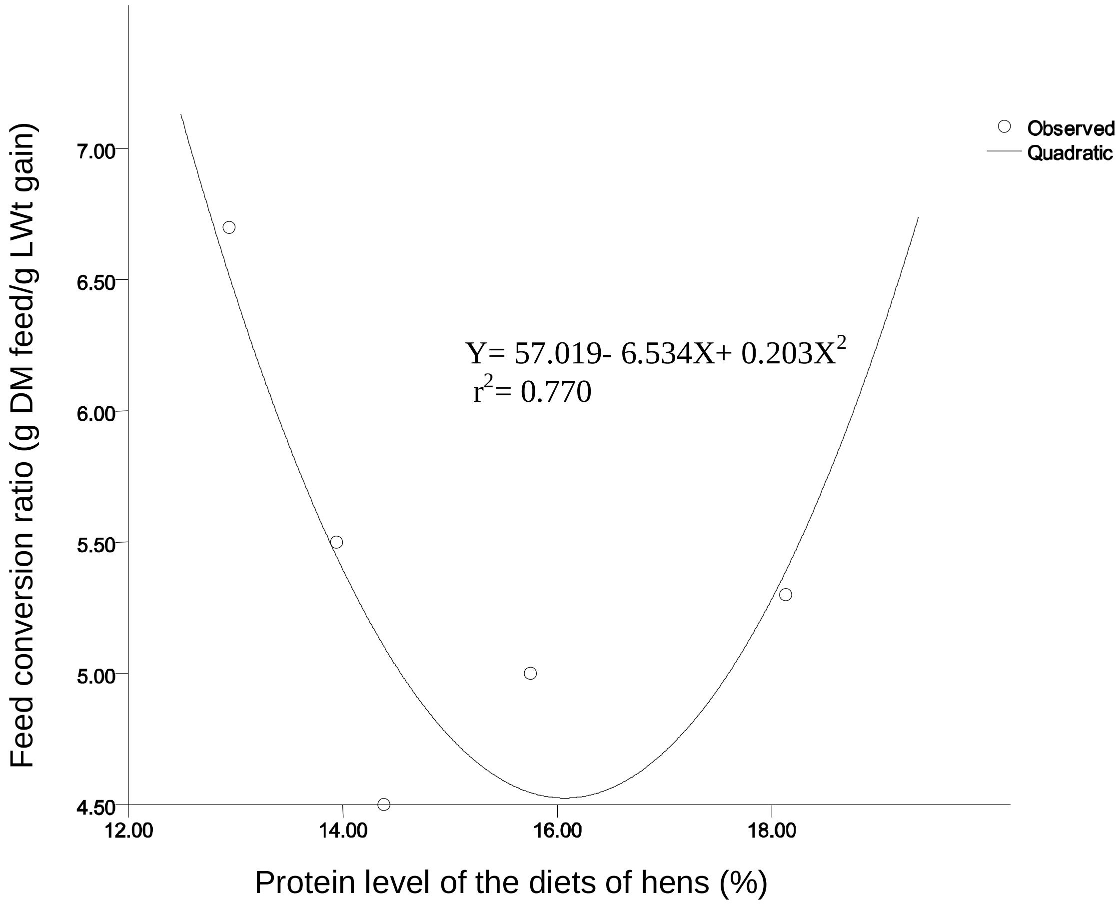

Figure 4.10 Effect of protein level of the diets of Naked neck hens on feed conversion ratio of their chicks from a day old up to seven weeks of age

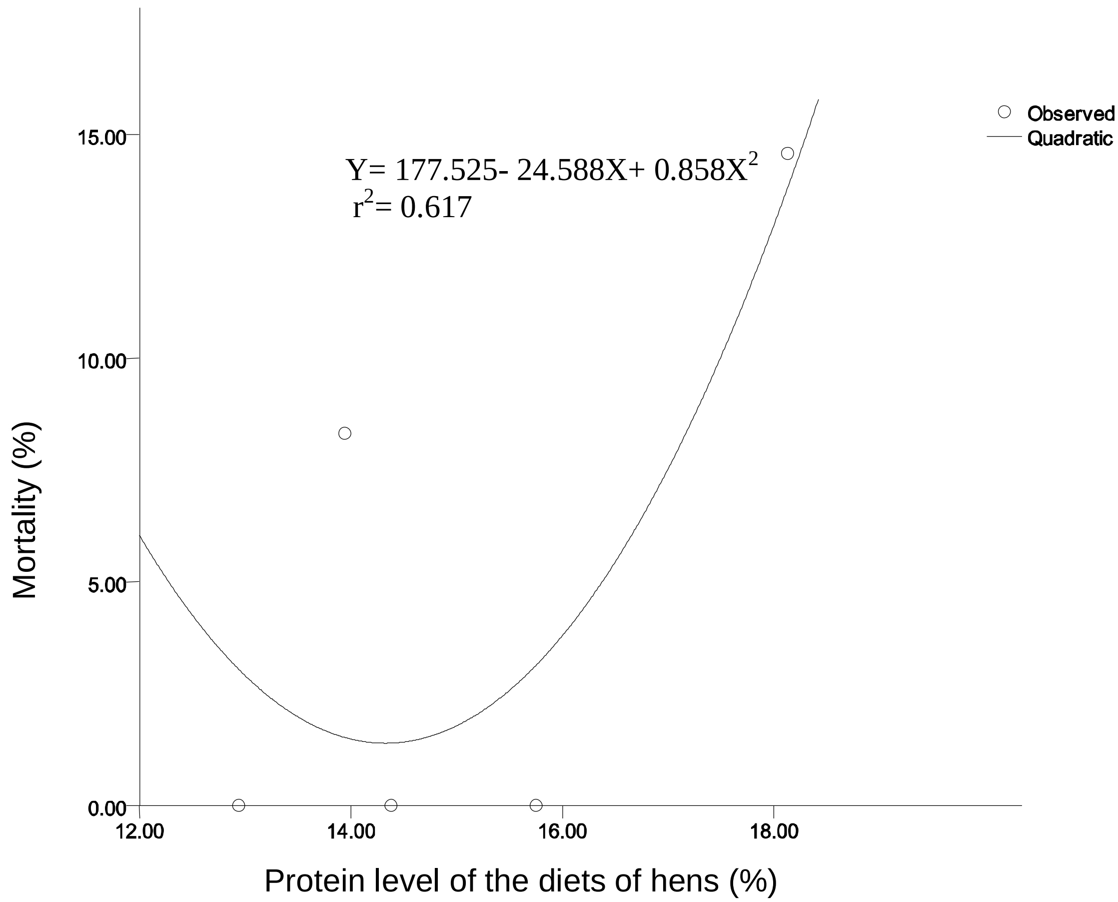

Figure 4.11 Effect of protein level of the diets of hens on mortality of their chicks from a day old up to seven weeks of age

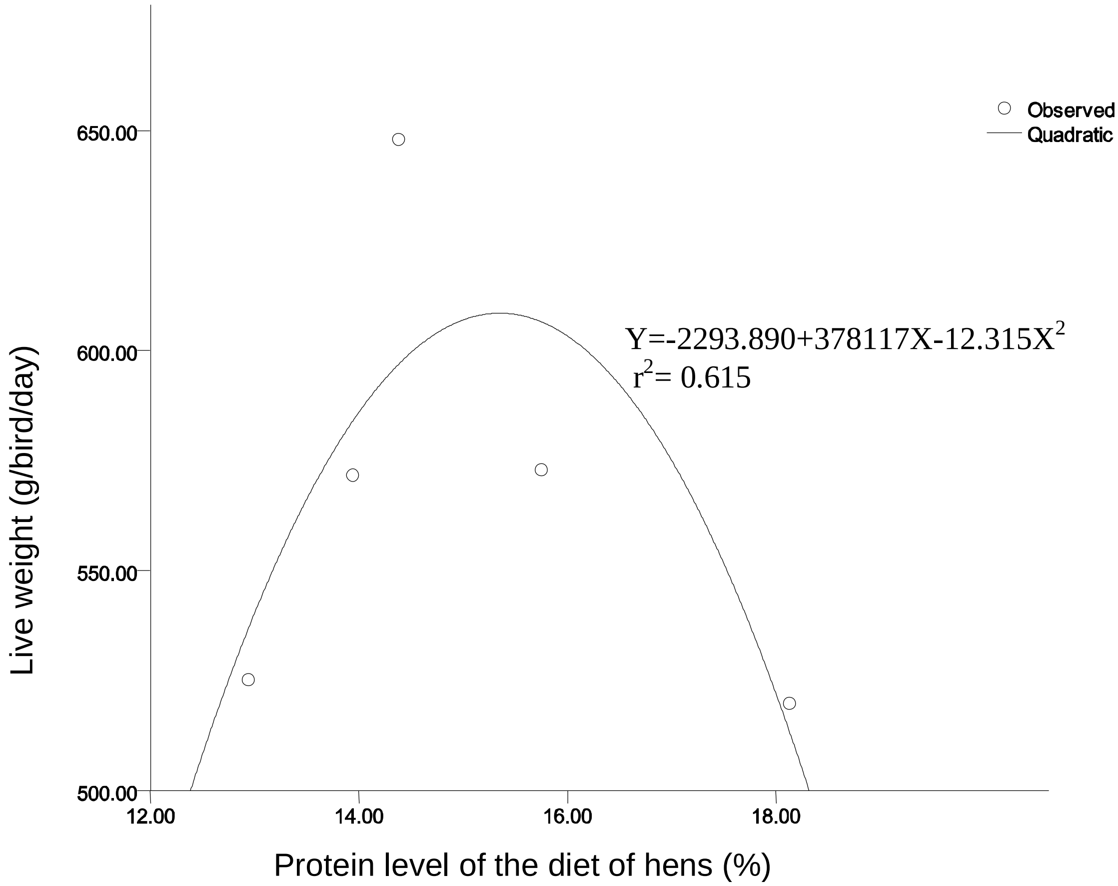

Figure 4.12 Effect of protein level of the diets of Naked neck hens on live weight of their chicks from a day old up to seven weeks of age

Table 4.04 Protein levels of the diets of Naked neck hens for optimal feed intake (g/bird/day), growth rate (g/bird/day), feed conversion ratio (g DM feed/g Lwt gain) and mortality (%) of their chicks from a day old up to seven weeks of age

Trait	Formula	r^2	CP*	Optimal y-level	P
Intake	$Y=-200.092+30.971X0.980X^2$	0.298	15.8	44.6	0.703
Growth	$Y= 5.131+ 0.322X- 0.010X^2$	0.236	16.1	7.7	0.949
FCR	$Y= 57.019- 6.534X+ 0.203X^2$	0.077	16.1	4.4	0.230
Mortality	$Y= 177.525- 24.588X+ 0.858X^2$	0.617	14.3	1.38	0.382
Live wt	$Y=-2293.890+378117X12.315X^2$	0.615	15.4	608.48	0.385

* : CP level for optimal variable

P : Probability level

r^2 : coefficient regression

Table 4.05 Effect of protein level of the diets of Naked neck hens on dry matter intake (g/bird/day), dry matter digestibility (%), apparent metabolisable energy (MJ/kg DM), nitrogen retention (g/bird/day) and live weight (g/bird) of their progenies at seven weeks of age

Variable	Treatment					SE
	$P_{12.94\%}$	$P_{13.94\%}$	$P_{14.38\%}$	$P_{15.75\%}$	$P_{18.13\%}$	
Live weight	760	716.7	733.3	770.0	700.0	33.829
DM intake	62.5	60.6	67.4	76.4	72.3	7.882
DM digestibility	45.7	47.8	49.7	59.7	53.6	8.375
Apparent ME	13.8	14.4	13.8	14.1	13.9	0.491
N retention	0.80	1.02	1.06	1.67	1.02	0.402

^{a,b,c} : means in the same row sharing a common superscripts are significantly different (P<0.05)

SE : Standard error

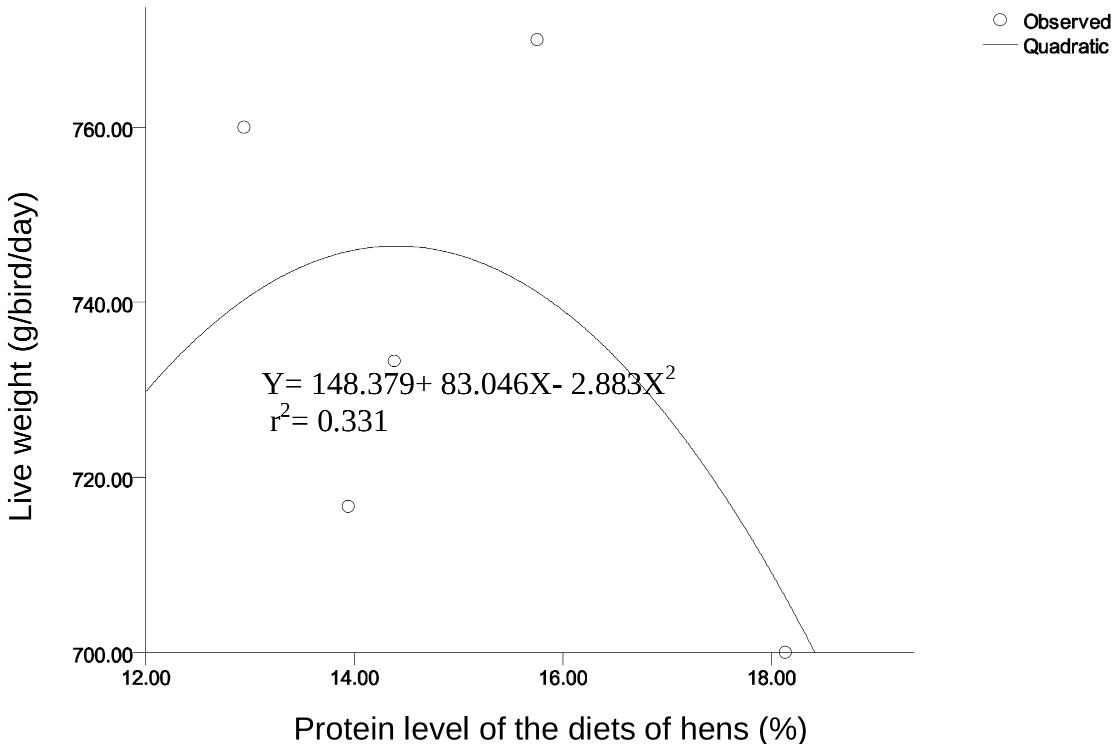

Figure 4.13 Effect of protein level of the diets of Naked neck hens on live weight of their progenies at seven weeks of age

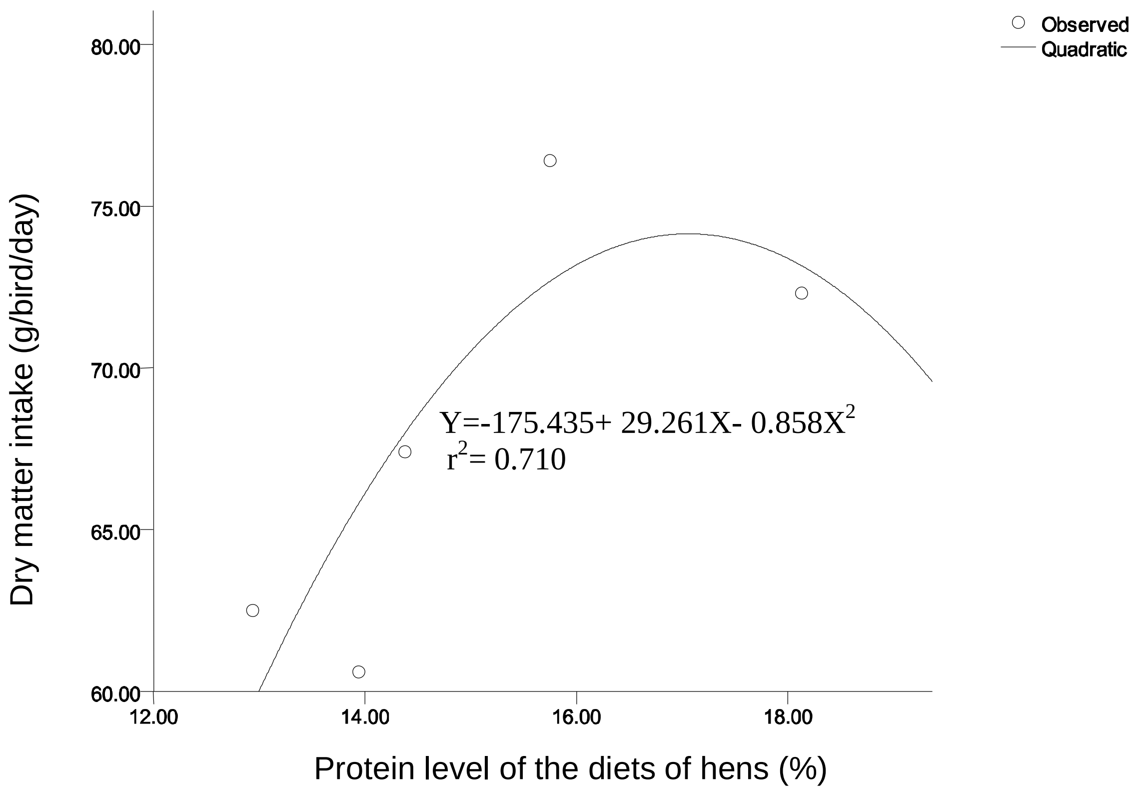

Figure 4.14 Effect of protein level of the diets of Naked neck hens on dry matter intake of their progenies at seven weeks of age

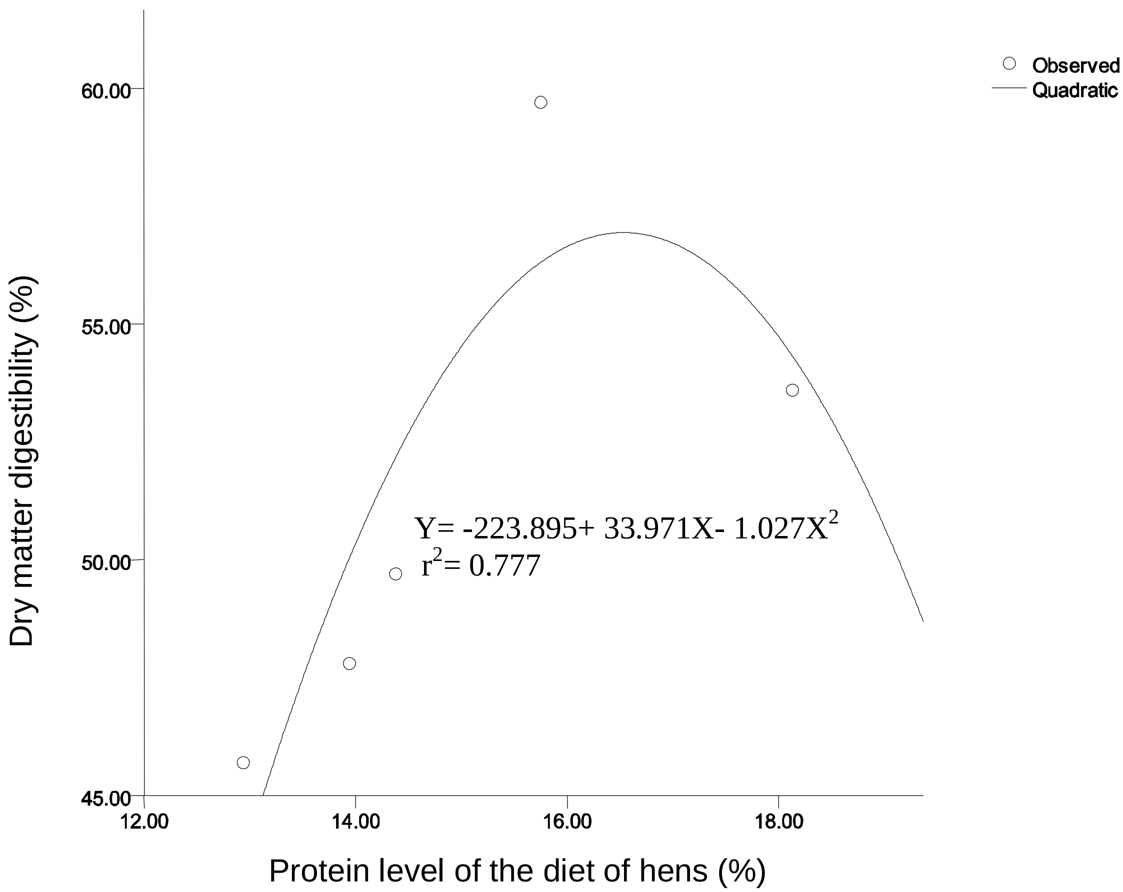

Figure 4.15 Effect of protein level of the diets of Naked neck hens on dry matter digestibility of their progenies at seven weeks of age

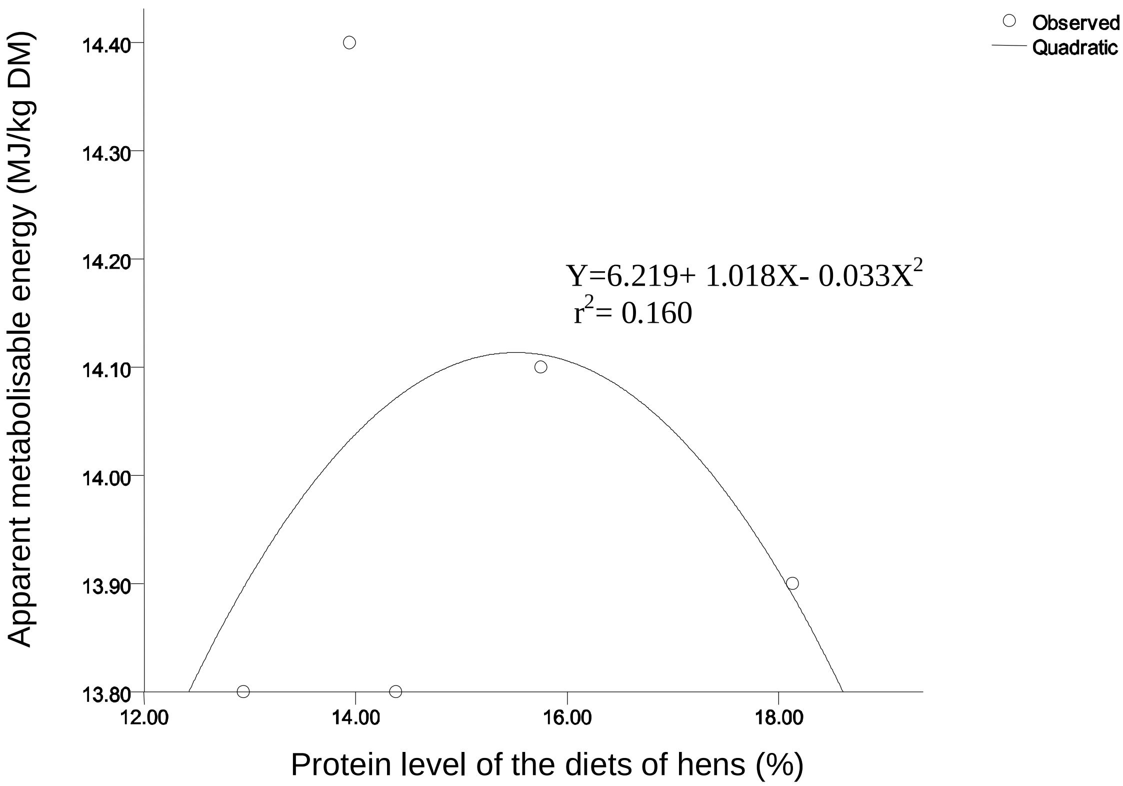

Figure 4.16 Effect of protein level of the diets of Naked neck hens on apparent metabolisable energy of their progenies at seven weeks of age

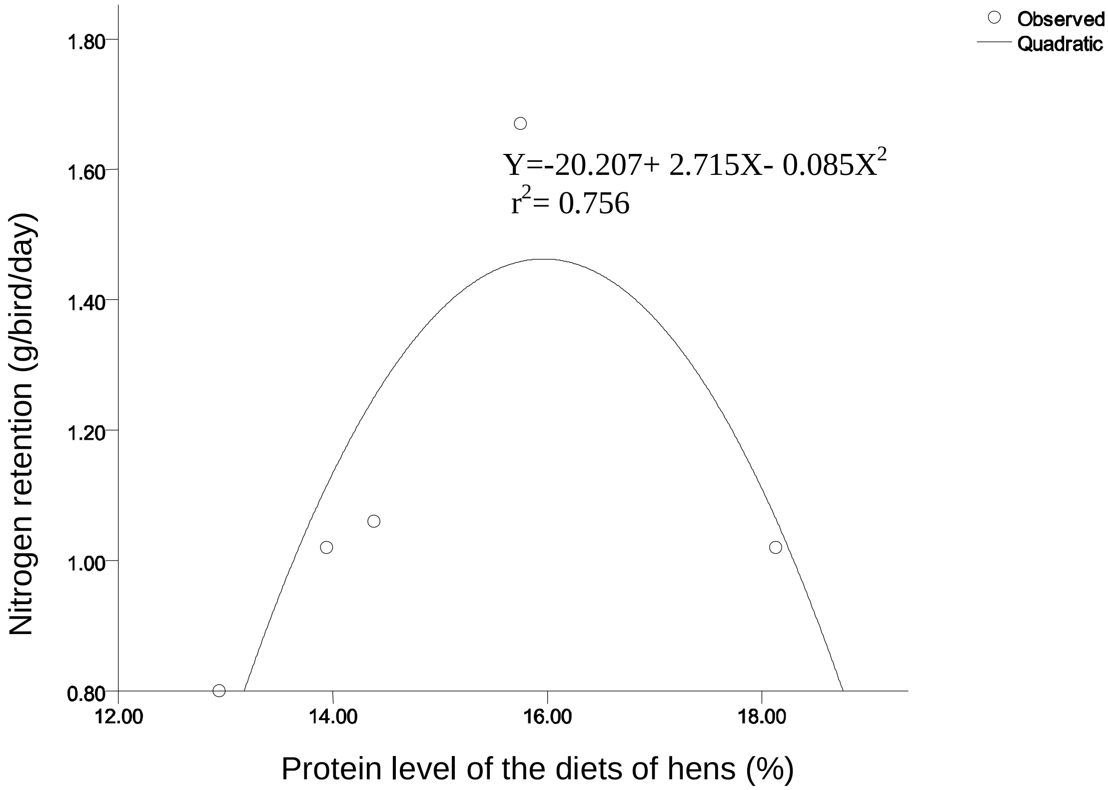

Figure 4.17 Effect of protein level of the diets of Naked neck hens on nitrogen retention of their progenies at seven weeks of age

Table 4.06 Protein levels of the diets of Naked neck hens for optimal dry matter intake (g/bird/day), dry matter digestibility (DMD) (%), apparent metabolisible energy (AME) (MJ/kg DM), nitrogen retention (g/bird/day) and live weight (g/bird/day) of their progenies at seven weeks of age

Trait	Formula	r^2	CP*	Optimal y-level	P
DM intake	$Y= -175.435+ 29.261X- 0.858X^2$	0.710	17.1	74.0	0.290
DMD	$Y=-223.895+33.971X- 0.1027X^2$	0.777	16.5	57.0	0.223
AME	$Y= 6.219+1.018X- 0.033X^2$	0.160	15.4	14.1	0.840
N retention	$Y= -20.207+ 2.715X- 0.085X^2$	0.756	15.8	1.5	0.244
Lwt	$Y= 148.379- 83.046X+ 2.883X^2$	0.331	14.4	746.4	0.669

* : CP level for optimal variable

P : Probability level

r^2 : coefficient regression

Results of the effect of protein level of the diets of Naked neck hens on feed intake, growth rate and feed conversion ratio of their progenies between eight and 13 weeks of age are presented in Table 4.07. Protein level of the diets of Naked neck hens had no effect (P>0.05) on feed intake, growth rate and feed conversion ratio of their progenies between eight and 13 weeks of age.

Results of the effect of protein level of the diets of hens on live weight, carcass weight, breast meat yield, breast meat nitrogen content and fat pad weight of their male chickens at 13 weeks of age are presented in Table 4.08. Protein level of the diets of hens had no effect (P>0.05) on live weight, breast meat yield, breast meat nitrogen content and fat pad weight of their male chickens at 13 weeks of age. However, level of protein of the diet of hens had effect (P<0.05) on carcass weight of their male chickens at 13 weeks of age. Male chickens hatched from eggs produced by hens fed a diet having 12.94 % CP had higher ($P<0.05$) carcass weight than those hatched from eggs produced by hens fed diets having 13.94 and 18.13 % CP. However, male chickens hatched from eggs produced by hens fed diets having 12.94, 14.38 and 15.75 % CP had similar ($P>0.05$) carcass weights. Similarly, chickens from eggs produced by hens fed diets having 13.94, 14.38, 15.75 and 18.13 % CP had the same ($P>0.05$) carcass weights. Carcass weight of Naked neck chickens was negatively and strongly correlated (r^2 = 0.853) with protein level of the diet of hens. Live weight, breast meat yield, breast meat nitrogen content and fat pad weight of male Naked neck chickens were optimized at different protein levels of the diets of hens of 18.9 (r^2= 0.666), 15.6 (r^2 = 0.81), 15.4 (r^2 = 0.786) and 17.7 (r^2 = 0.775) % CP, respectively (Figures 4.18 and 4.20 to 4.22, respectively and Table 4.09).

Results of the effect of protein level of the diets of Naked neck hens on live weight, carcass weight, breast meat, breast meat nitrogen content and fat pat weight of their female chickens at 13 weeks of age are presented in Table 4.08. Protein level of the diet of Naked neck hens had no effect ($P>0.05$) on breast meat weight, breast meat nitrogen content and fat pad weight of their female chickens at 13 weeks of age. Female chickens hatched from eggs produced by Naked neck hens fed a diet having 15.75 % CP had higher ($P<0.05$) live weights at 13 weeks of age than those hatched from eggs produced by hens fed diets having 13.94 and 18.13 % CP. Female chickens hatched from eggs produced by Naked neck hens fed diets having 12.94, 14.38 and 15.75 % CP had similar ($P>0.05$) live weights. Similarly, female chickens hatched from eggs produced by hens fed diets having 12.94, 13.94, 14.38 and 18.13 % CP had the same ($P>0.05$) live weights at 13 weeks of age. Female chickens hatched from eggs produced by hens fed a diet having 15.75 % CP had higher ($P<0.05$) carcass weights than those from hens fed diets having 13.94 and 18.13 % CP. Female chickens from hens fed diets having 12.94, 14.38 and 15.75 % CP had similar ($P>0.05$) carcass weights. Similarly, female chickens hatched from eggs produced by hens fed diets having 12.94, 13.94, 14.38 and 18.13 % CP had the same (P>0.05) carcass weights. Live weight, carcass weight, breast meat yield, breast meat nitrogen content and fat pad weight of Naked neck hen were optimized at different protein levels of the diets of hens of 15.7 (r^2 = 0.249), 15.4 (r^2 = 0.180), 15.8 (r^2 = 0.059), 15.1 (r^2 = 0.882) and 16.1 (r^2 = 0.405) % CP, respectively (Figures 4.23 to 4.27, respectively and Table 4.09).

Male Naked neck chickens had higher (P<0.05) live weights, carcass weights and breast meat yields than female chickens. However, there were no significant (P>0.05) differences between sexes in breast meat nitrogen contents and fat pad weights (Table 4.08).

Results of the effect of protein level of the diet of Naked neck hens on live weight, dry matter intake, dry matter digestibility, apparent metabolisable energy and nitrogen retention of their male progenies at 13 weeks of age are presented in Table 4.10. Male chickens hatched from eggs produced by hens fed a diet having 13.94 % CP had higher (P<0.05) dry matter intakes than those hatched from hens fed diets having 18.13 and 12.94 % CP. However, chickens hatched from hens fed diets having 13.94, 14.38 and 15.75 % CP had similar (P>0.05) dry matter intakes. Similarly, male chickens hatched from eggs produced by hens fed diets having 12.94, 14.38, 15.75 and 18.13 % CP had the same (P>0.05) dry matter intakes. Dry matter intake, dry matter digestibility, apparent metabolisable energy, nitrogen retention and live weight of male Naked neck chickens were optimized at different protein levels of the diets of 15.3 (r^2 = 0.710), 17.5 (r^2 = 0.535), 15.4 (r^2 = 0.153), 22.8 (r^2 = 0.065) and 15.6 (r^2 = 0.528) % CP, respectively (Figures 4.28 to 4.32, respectively and Table 4.11).

Table 4.07 Effect of protein level of the diet of Naked neck hens on feed intake (g/bird/day), growth rate (kg), feed conversion ratio (g DM feed/g Lwt gain) and mortality (%) of their progenies from eight to 13 weeks of age

	Variable		
Treatment	Intake	FCR	Growth rate
Males			
$P_{12.94\%}$	115.8	5.2	22.3
$P_{13.94\%}$	152.6	10.4	15.8
$P_{14.38\%}$	119.1	5.3	25.3
$P_{15.75\%}$	126.1	5.9	22.3
$P_{18.13\%}$	122.8	9.8	14.8
SE	17.915	1.823	3.463
Female			
$P_{12.94\%}$	109.4	5.9	19.0
$P_{13.94\%}$	104.5	8.0	15.5
$P_{14.38\%}$	101.4	5.3	19.3
$P_{15.75\%}$	134.9	7.1	19.0
$P_{18.13\%}$	118.8	11.5	13.8
SE	16.629	2.313	2.275
Sex			
Males	127.3	7.6	20.1
Females	113.8	7.3	17.3
SE	7.729	0.931	1.310

SE : Standard error

Table 4.08 Effect of protein level of the diet of Naked neck hens on live weight (g/bird), carcass weight (g/bird), breast meat yield (g), breast meat nitrogen content (%) and fat pad (g) of their progenies at 13 weeks of age

	Variable				
Treatment	Live wt	Carcass wt	Breast meat	Breast meat N	Fat pad
Males					
$P_{12.94}$	1698	1179^{a}	250	13.7	39.4
$P_{13.94}$	1650	1249^{b}	252	13.5	41.4
$P_{14.38}$	1555	1030^{ab}	252	13.6	31.7
$P_{15.75}$	1618	1065^{ab}	250	13.4	26.3
$P_{18.13}$	1528	900^{b}	243	13.7	26.3
SE	110.51	75.92	24.67	0.18	11.05
Females					
$P_{12.94}$	1184^{ab}	822^{ab}	188	13.5	33.2
$P_{13.94}$	1093^{b}	719^{b}	167	13.6	50.8
$P_{14.38}$	1175^{ab}	769^{ab}	187	13.7	29.5
$P_{15.75}$	1345^{a}	916^{a}	196	13.6	69
$P_{18.13}$	1128^{b}	727^{b}	180	13.4	43.3
SE	63.08	54.56	15.01	0.116	14.184
Sex					
Males	1610^{a}	1053^{a}	240^{a}	13.6	45.15
Females	1185^{b}	790^{b}	184^{b}	13.5	33.01
SE	40.24	29.56	9.13	0.67	5.69

$_{a,\ b,c}$: Means in the same column not sharing a common superscript are significantly different ($P< 0.05$).

SE : Standard error

Live weight (g/bird)

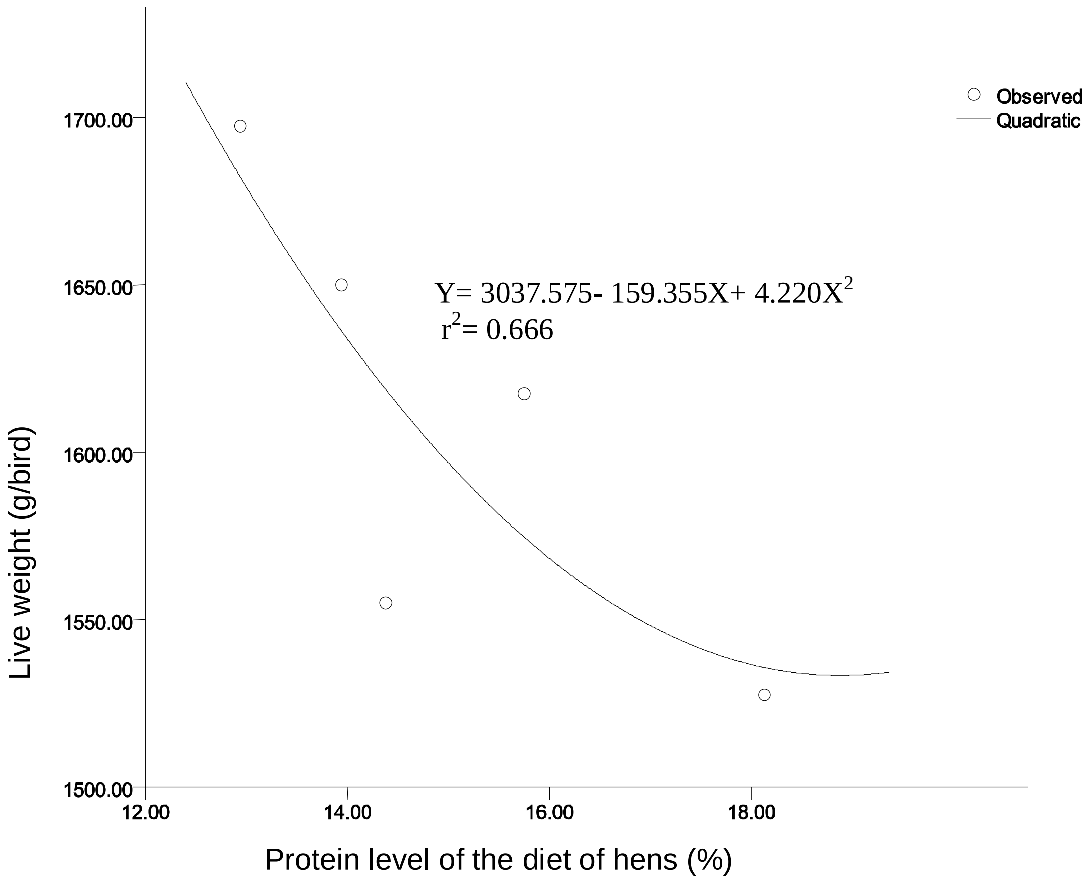

Figure 4.18 Effect of protein level of the diet of Naked neck hens on live weight of their male progenies at 13 weeks of age

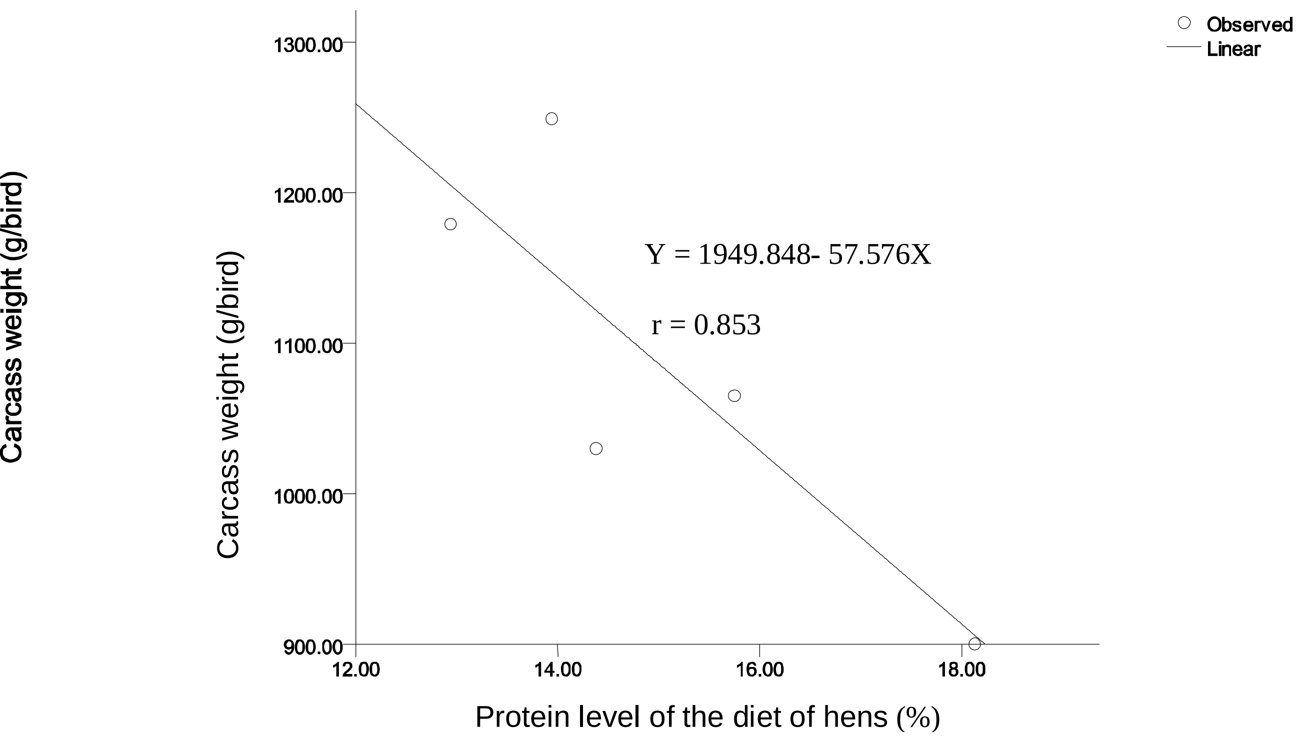

Figure 4.19 Relationship between protein level of the diet of Naked neck hens and carcass weight of their male progenies at 13 weeks of age

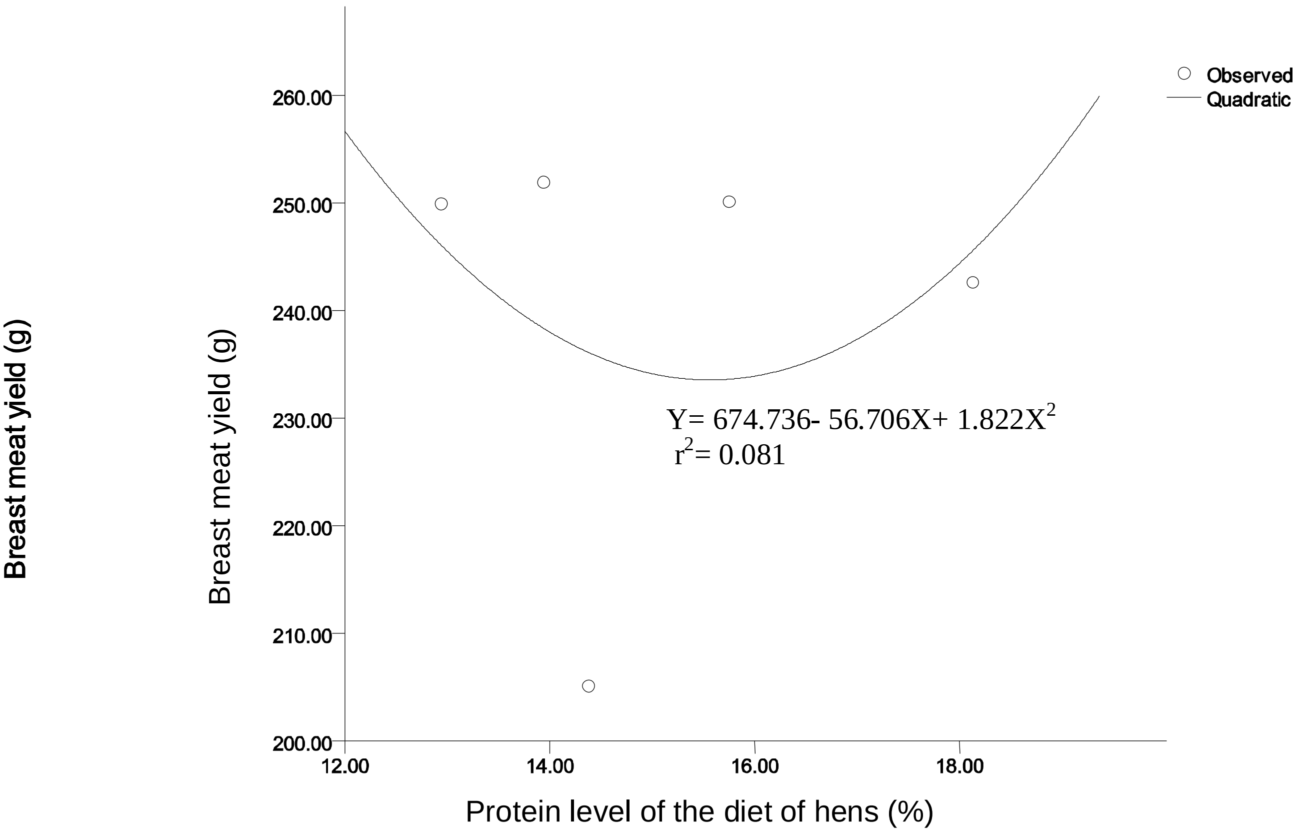

Figure 4.20 Effect of protein level of the diet of hens on breast meat yield of their male progenies at 13 weeks of age

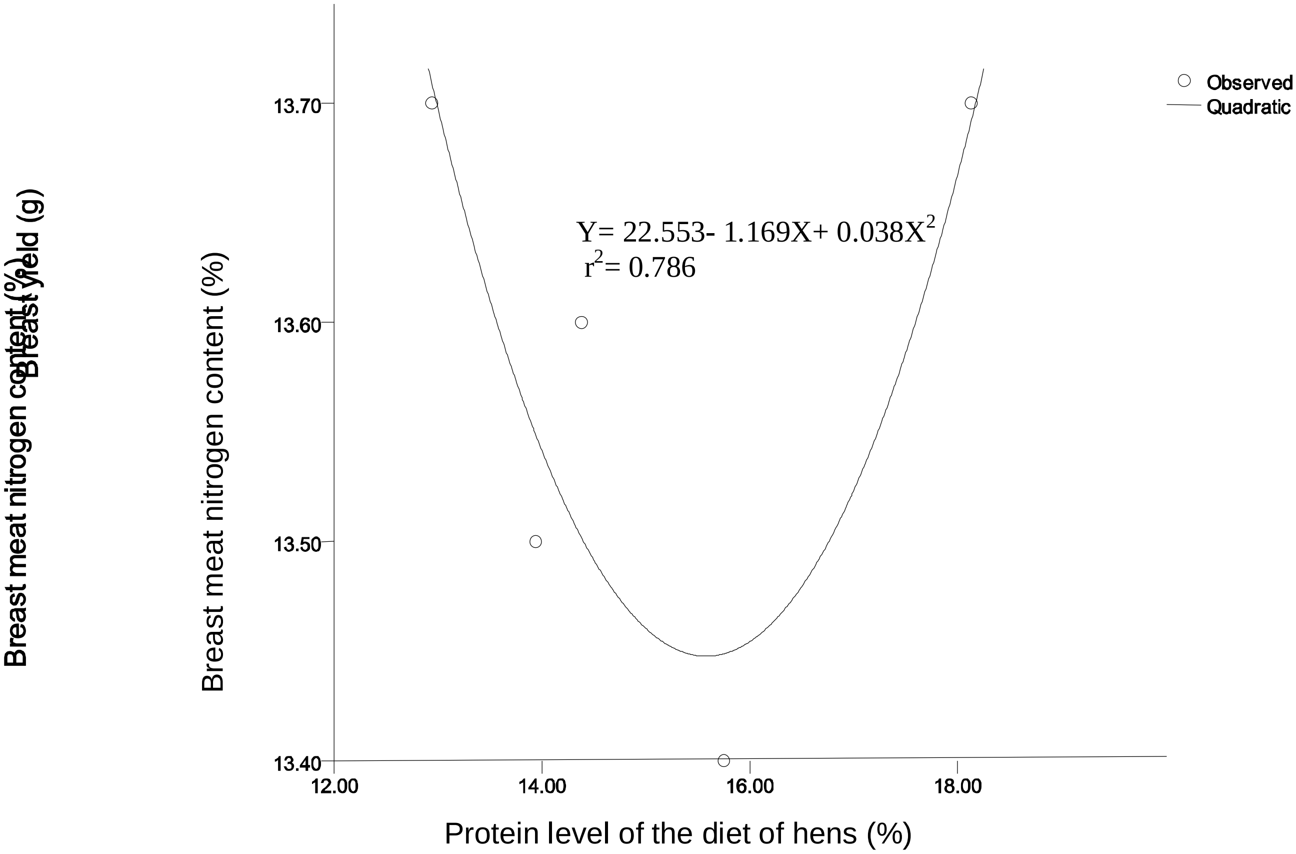

Figure 4.21 Effect of protein level of the diet of Naked neck hens on breast meat nitrogen content of their male progenies at 13 weeks of age

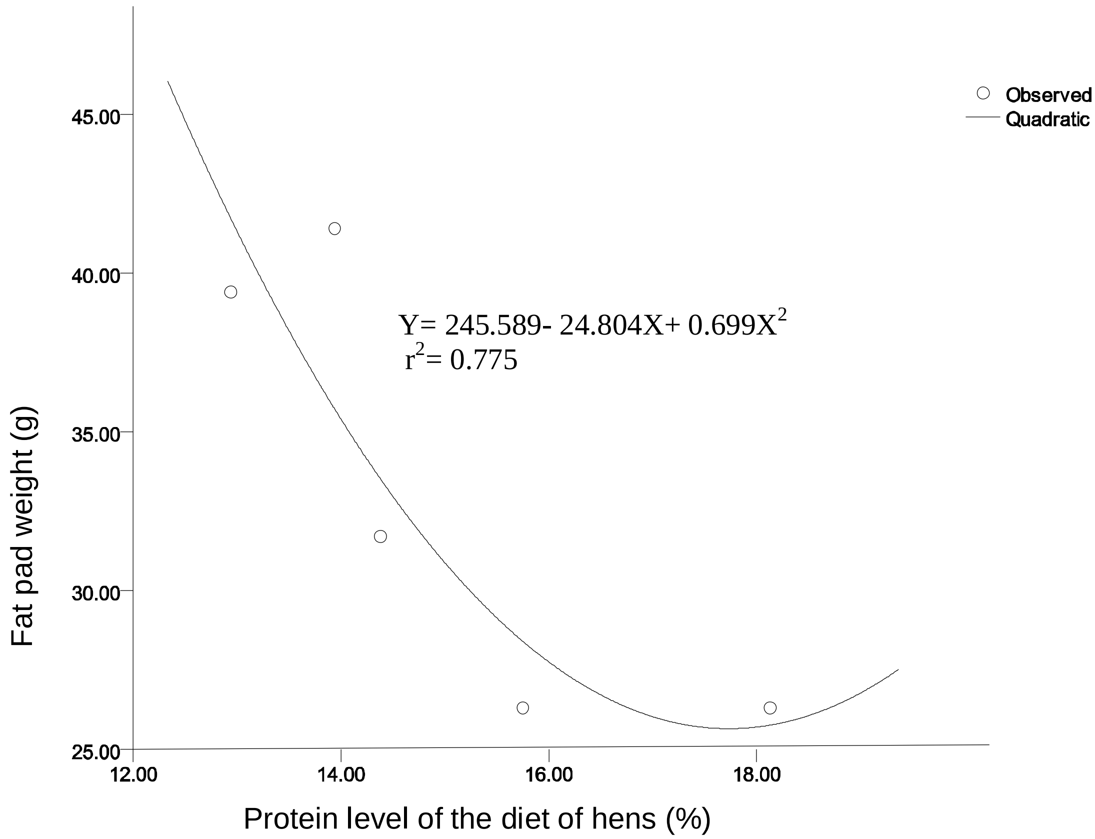

Figure 4.22 Effect of protein level of the diet of hens on fat pad weight of their male progenies at 13 weeks of age

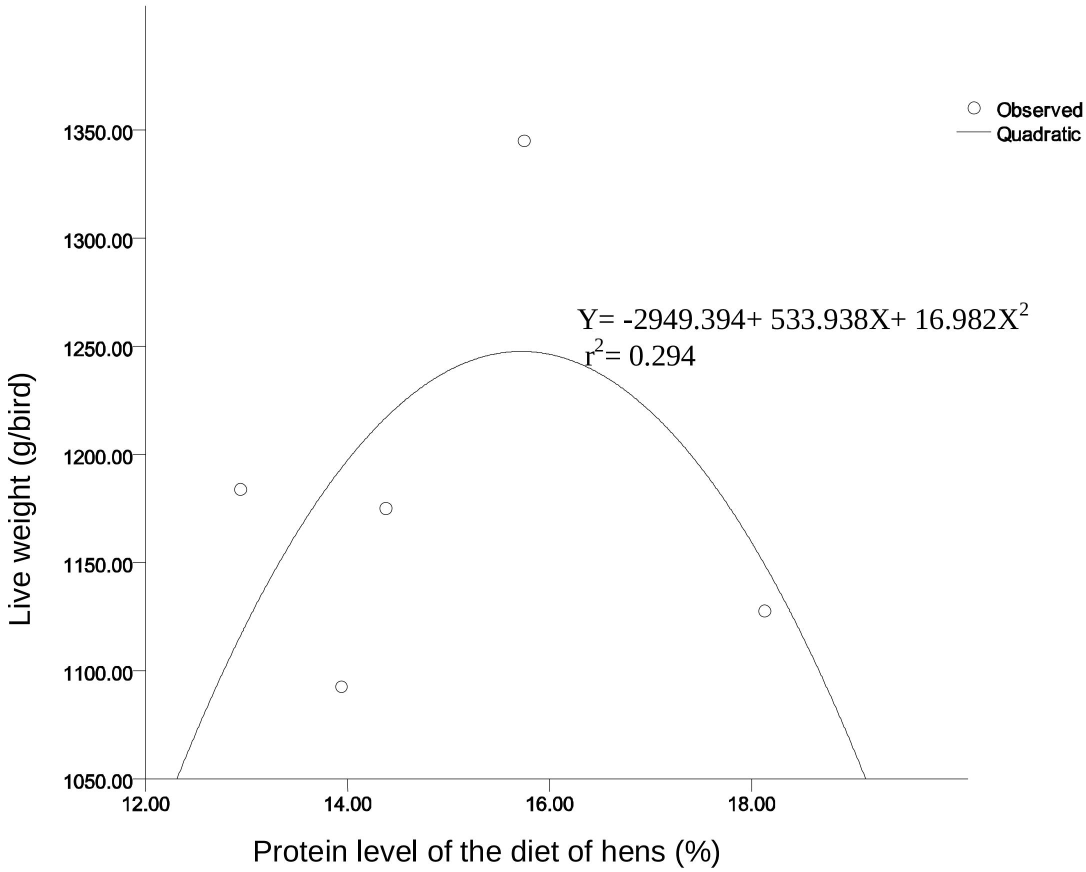

Figure 4.23 Effect of protein level of the diet of hens on live weight of their female progenies at 13 weeks of age

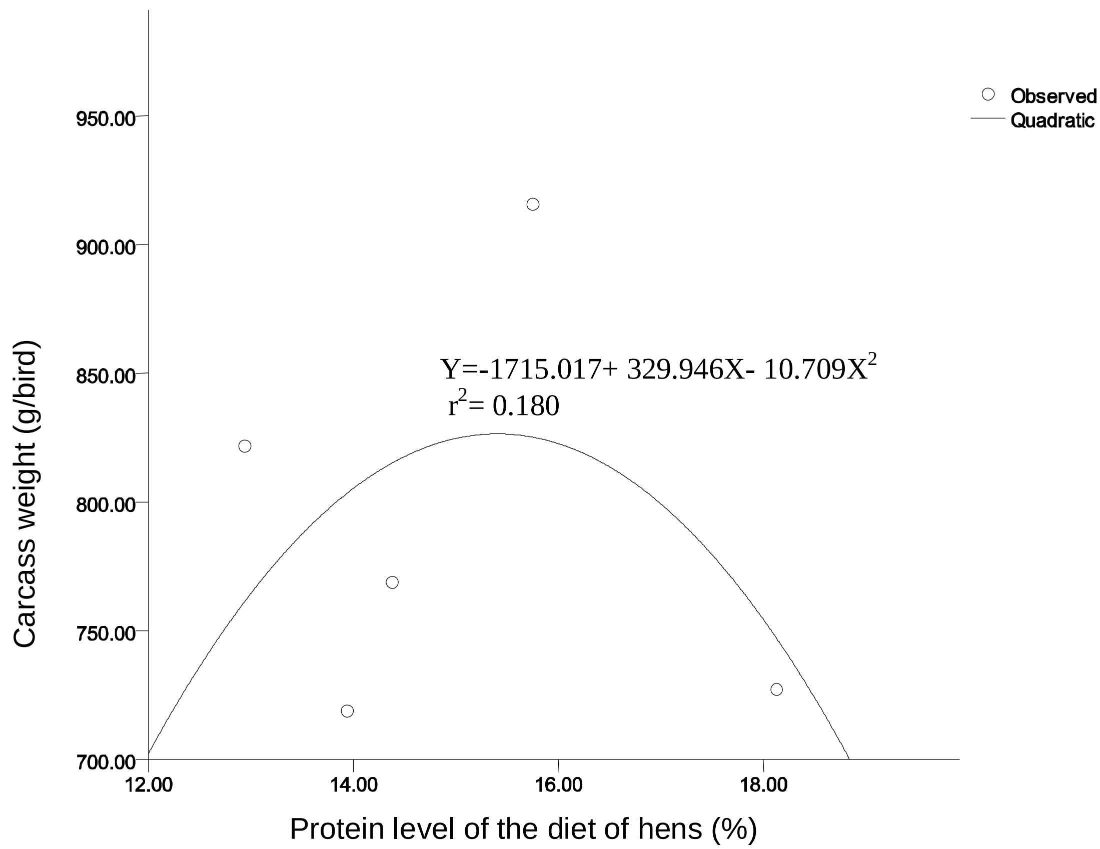

Figure 4.24 Effect of protein level of the diet of hens on carcass weight of their female progenies at 13 weeks

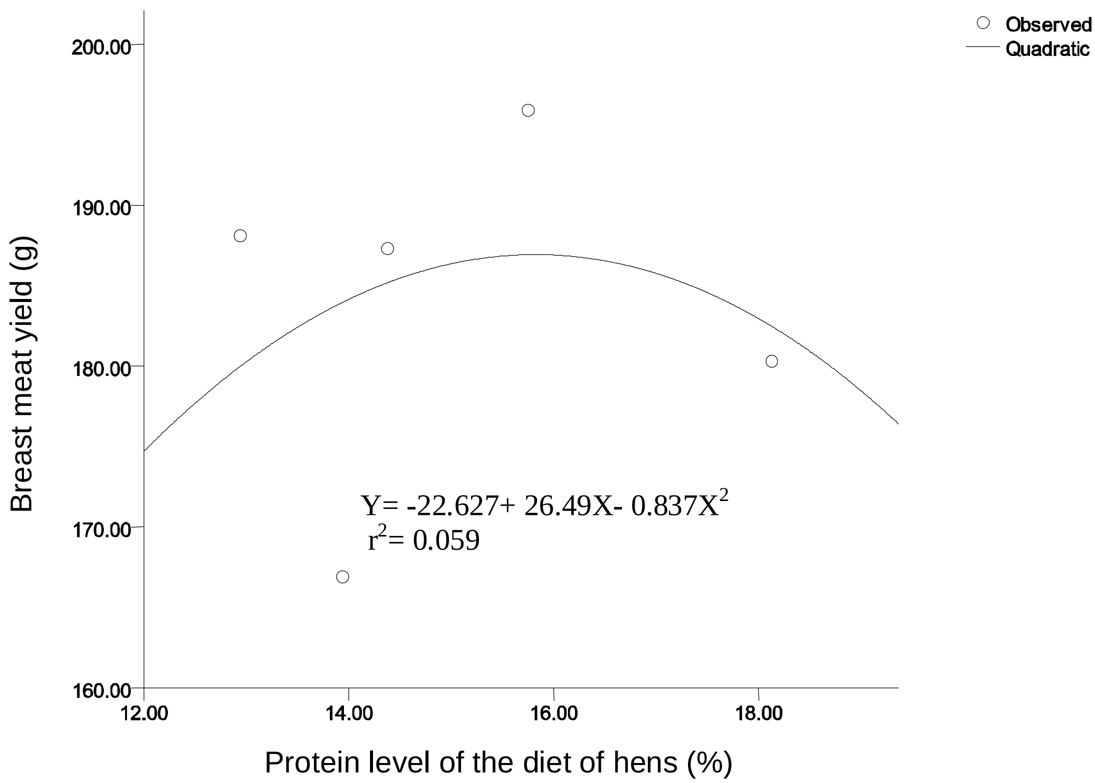

Figure 4.25 Effect of protein level of the diet of hens on breast meat yield of their female progenies at 13 weeks of age

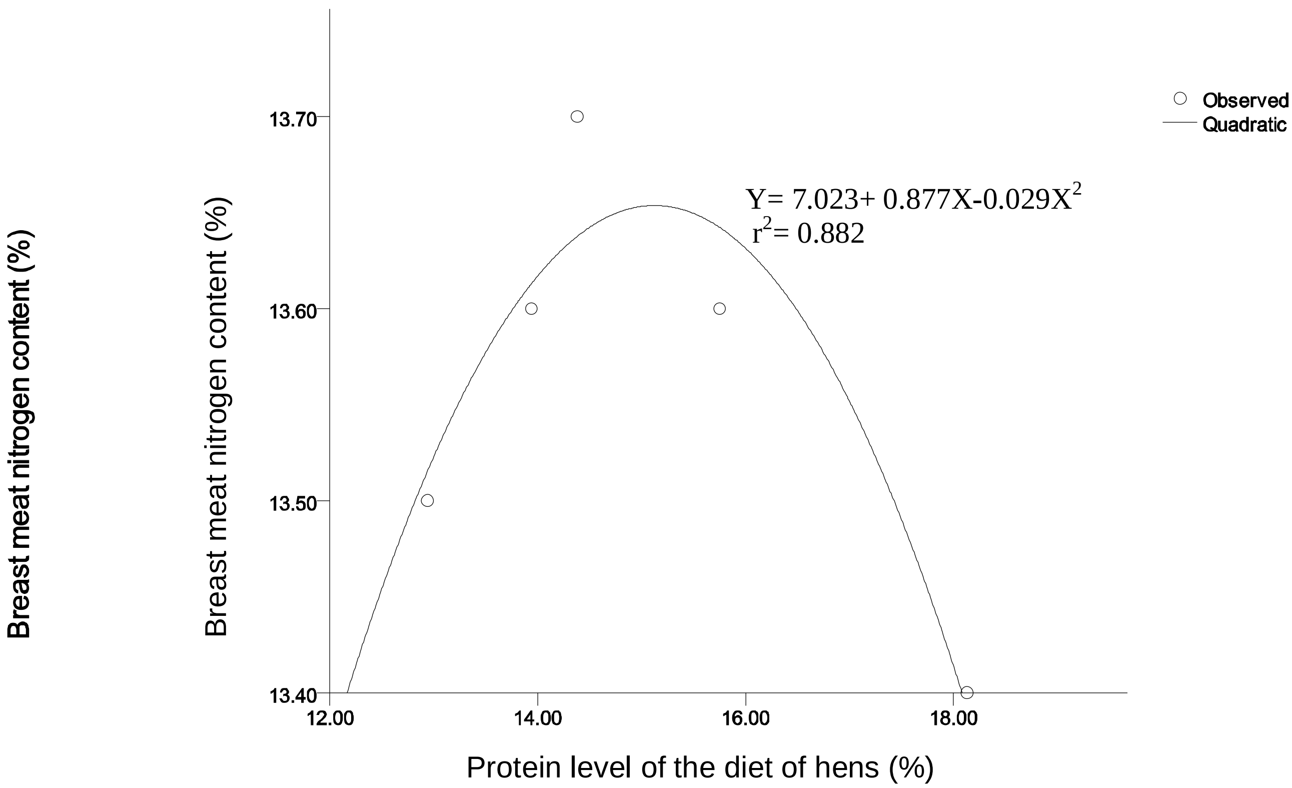

Figure 4.26 Effect of protein level of the diet of hens on breast meat nitrogen content of their female progenies at 13 weeks of age

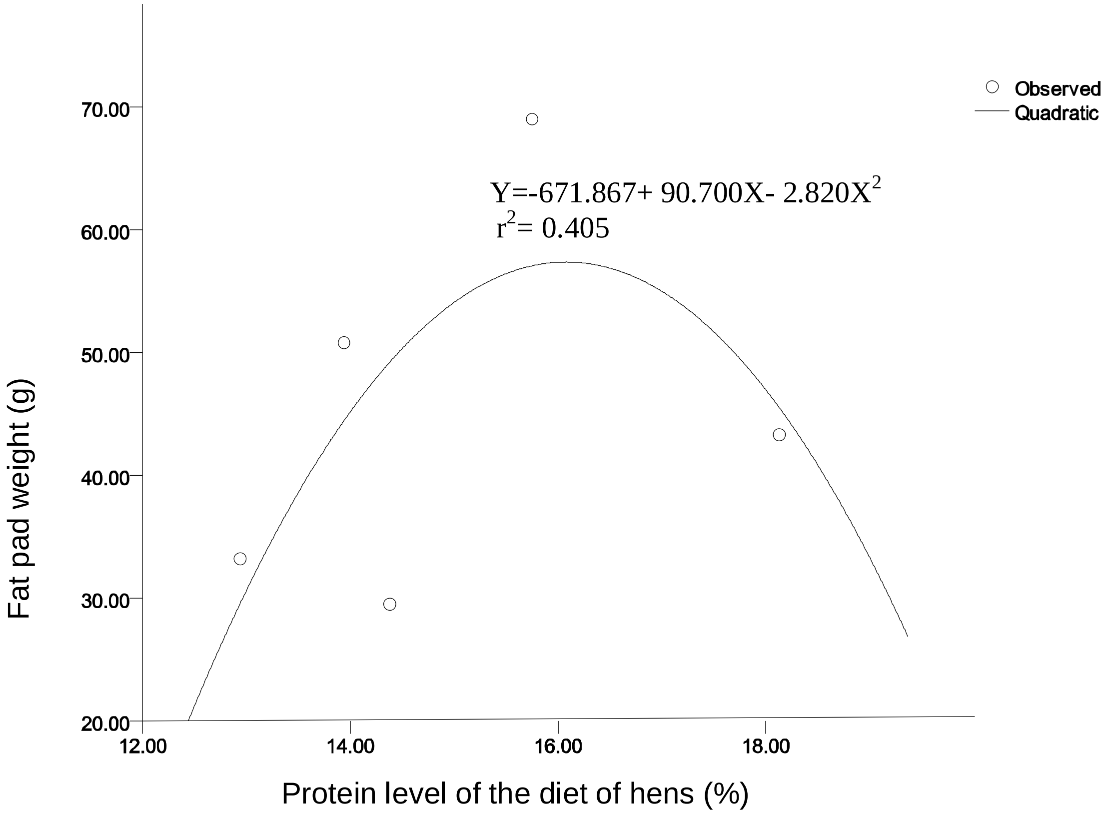

Figure 4.27 Effect of protein level of the diet of hens on fat pad weight of their female progenies at 13 weeks of age

Table 4.09 Protein levels of the diets of Naked neck hens for optimal live weight (g/bird), carcass weight (g/bird), breast meat yield (g), breast meat nitrogen content (%) and fat pad weight (g) of their progenies at 13 weeks of age

Trait	Formula	r^2	CP*	Optimal y-level	P
Males					
Live weight	$Y=3037.575-159.355X+4.220X^2$	0.666	18.9	1533.2	0.334
Breast yield	$Y= 674.736- 56.706X+ 1.822X^2$	0.081	15.6	233.5	0.008
Meat nitrogen	$Y= 22.553- 1.169X+ 0.038X^2$	0.786	15.4	13.1	0.214
Fat pad	$Y= 245.589- 24.804X+ 0.699X^2$	0.775	17.7	25.6	0.225
Females					
Live wt	$Y=2949.394+533.938X+16.982^2$	0.294	15.7	1619.3	0.706
Carcass wt	$Y=-1715.017+329.946X10.709X^2$	0.180	15.4	826.4	0.820
Breast yield	$Y= -22.627+ 26.49X- 0.837X^2$	0.059	15.8	186.9	0.941
Meat nitrogen	$Y= 7.023+ 0.877X- 0.029X^2$	0.882	15.1	13.7	0.118
Fat pad	$Y=-671.867+ 90.700X- 2.820X^2$	0.405	16.1	57.4	0.595

* : % CP for optimal variable

P : Probability level

Table 4.10 Effect of protein level of the diets of Naked neck hens on dry matter intake (g/bird/day), dry matter digestibility (%), nitrogen retention (g/bird/day), apparent metabolisable energy (MJ/kg DM) and live weight (kg/bird) of their male progenies at 13 weeks of age

	Treatment					
Variable	$P_{12.94\%}$	$P_{13.94\%}$	$P_{14.38\%}$	$P_{15.75\%}$	$P_{18.13\%}$	SE
DM intake	88^{b}	106^{a}	100^{ab}	94^{ab}	91^{b}	4.313
DM Digestibility	67.6	71.2	74.6	71.0	74.7	6.333
Apparent ME	13.4	14.3	13.5	12.9	14.0	0.505
N retention	2.586	3.207	3.078	2.262	2.732	0.306
Live weight	1303.3	1416.7	1290	1670	1233	152.687

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

SE : Standard error

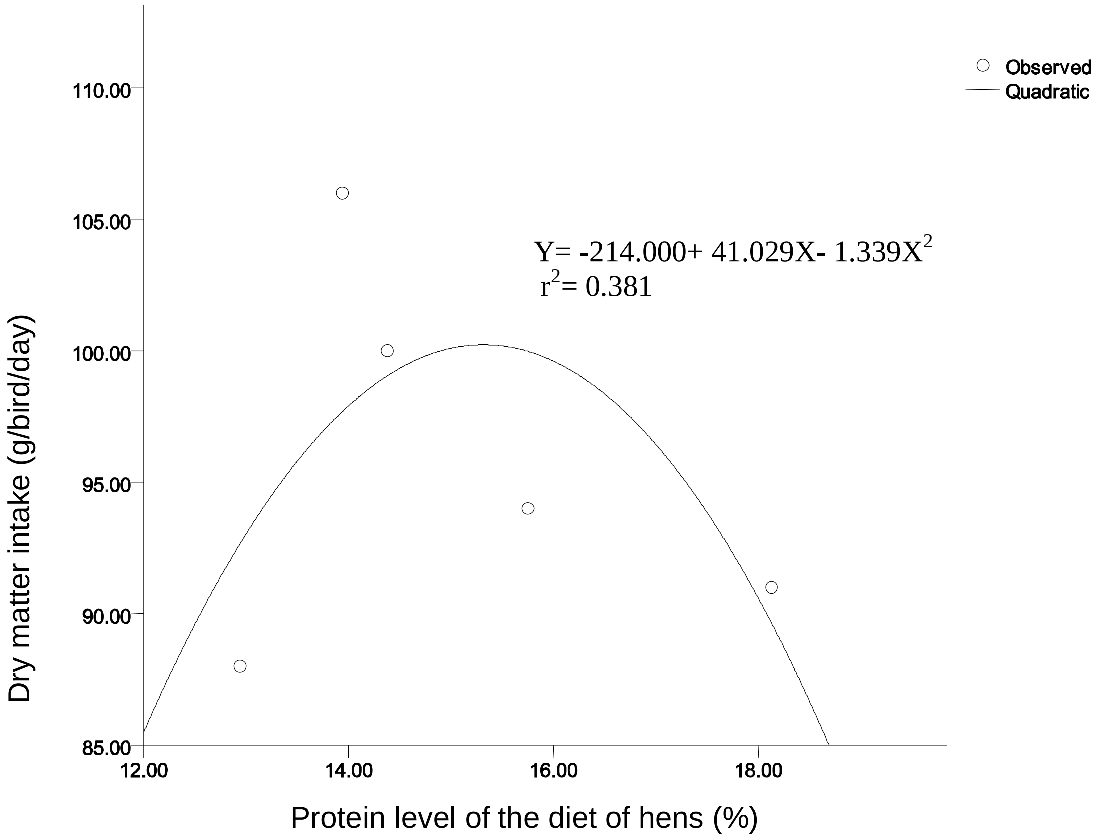

Figure 4.28 Effect of protein level of the diet of Naked neck hens on dry matter intake of their male progenies at 13 weeks of age

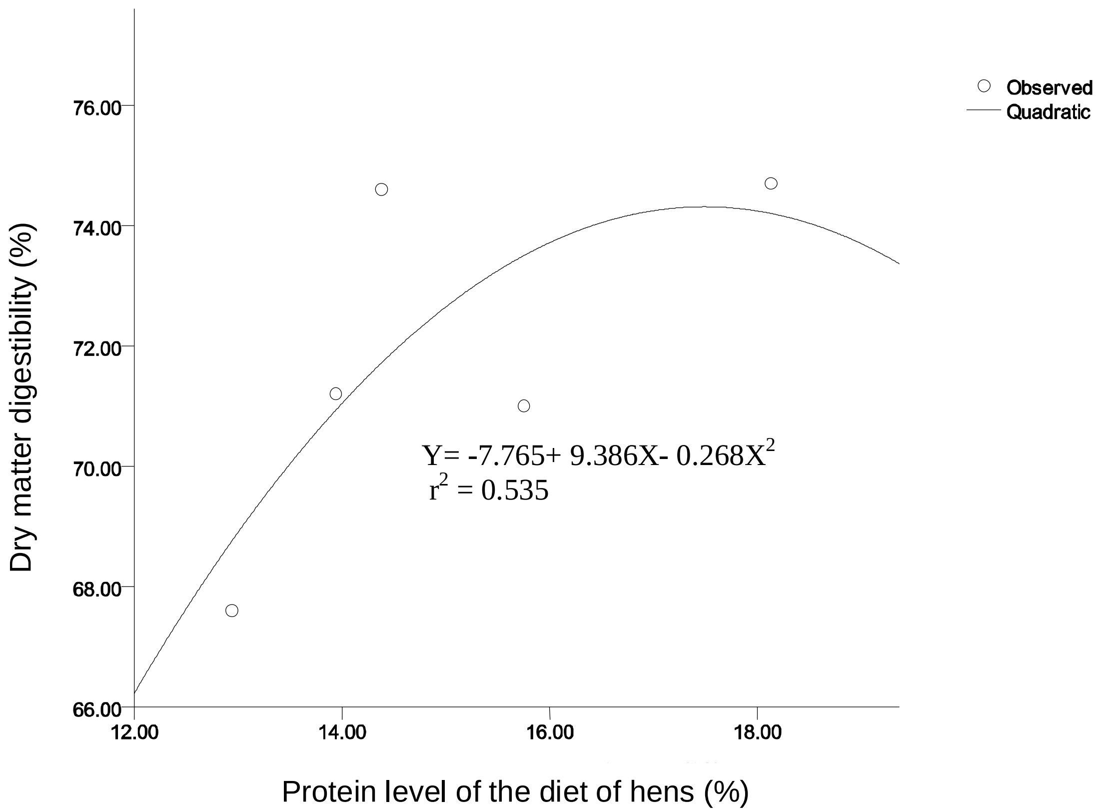

Figure 4.29 Effect of protein level of the diet of Naked neck hens on dry matter digestibility of their male progenies at 13 weeks of age

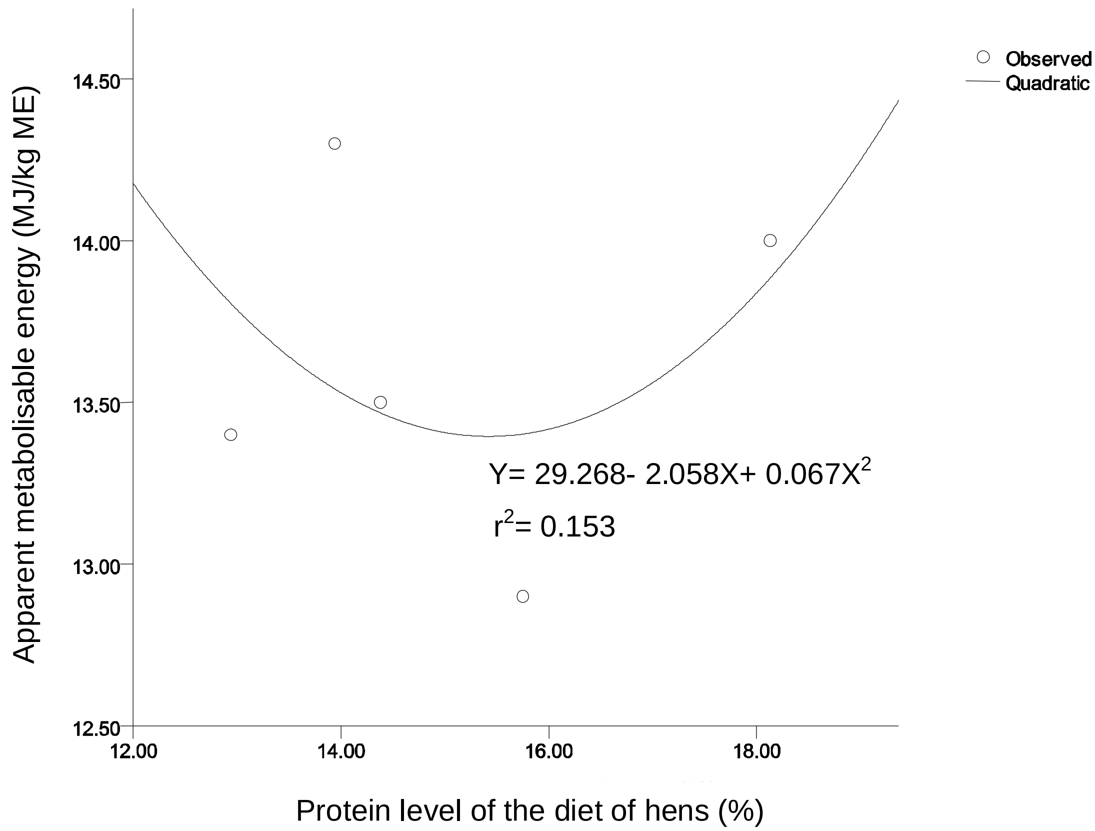

Figure 4.30 Effect of protein level of the diet of Naked neck hens on apparent metabolisable energy of their male progenies at 13 weeks of age

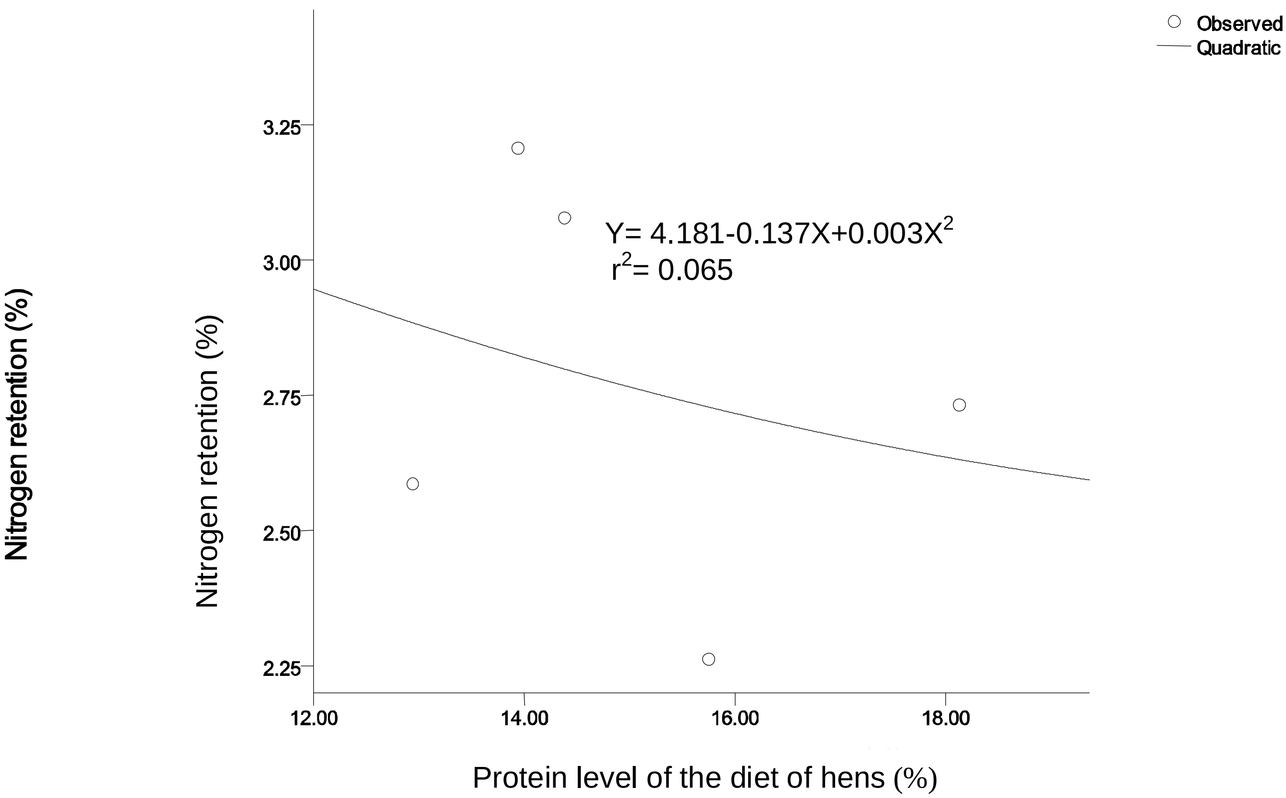

Figure 4.31 Effect of protein level of the diet of Naked neck hens on nitrogen retention of their male progenies at 13 weeks of age

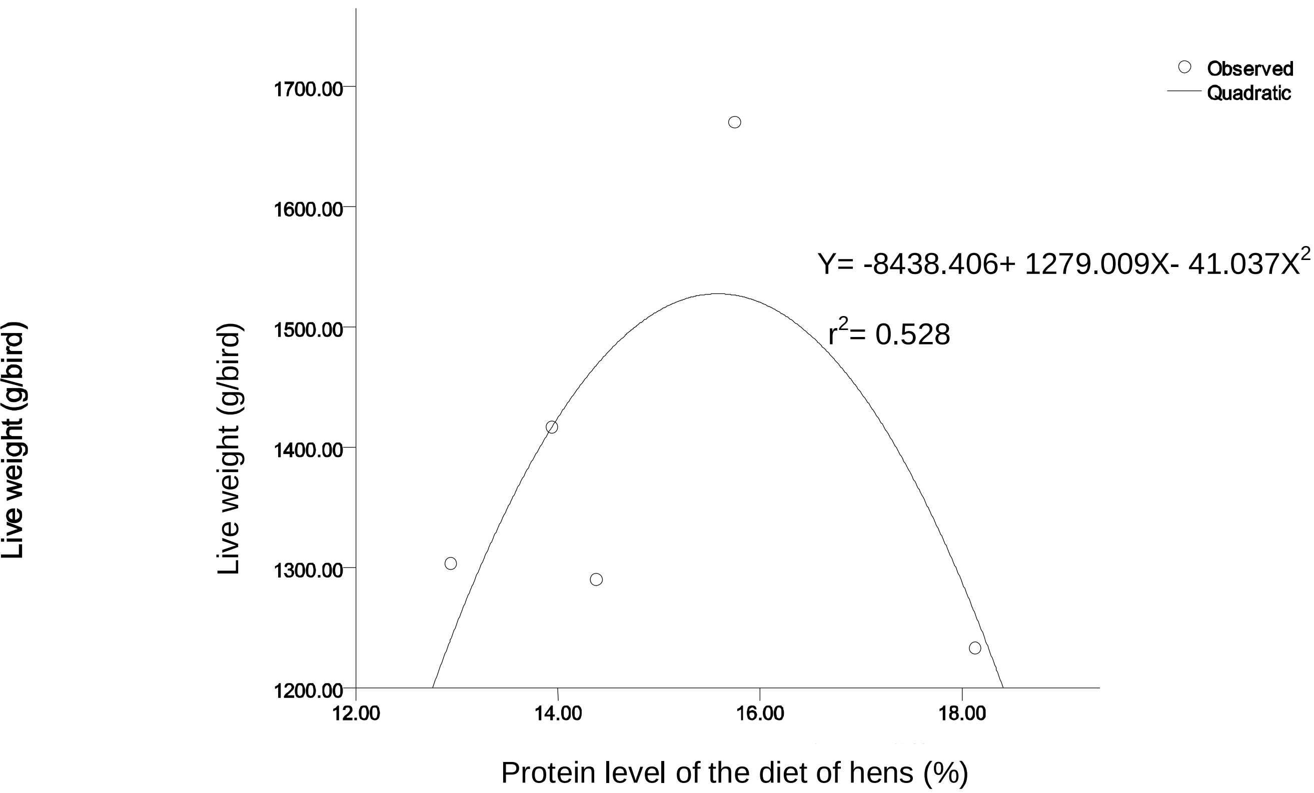

Figure 4.32 Effect of protein level of the diet of Naked neck hens on live weight of their male progenies at 13 weeks of age

Table 4.11 Protein levels of the diets of Naked neck hens for optimal dry matter intake (g/bird/day), dry matter digestibility (DMD) (%), apparent metabolisible energy (AME) (MJ/kg DM), nitrogen retention and live weight (kg/bird) of their male progenies at 13 weeks of age

Trait	Formula	r^2	CP*	Optimal y-level	P
DM intake	$Y= -214.000 + 41.029X- 1.339X^2$	0.710	15.3	100.3	0.290
DMD	$Y= -7.765 + 9.386X- 0.268X^2$	0.535	17.5	74.4	0.465
AME	$Y= 29.268 - 2.058X+ 0.067X^2$	0.153	15.4	13.5	0.847
N retention	$Y= 4.181 - 0.137X+ 0.003X^2$	0.065	22.8	2.62	0.935
LWT	$Y=-8438.406+1279.009X-41.037X^2$	0.528	15.6	1527.3	0.472

* :% CP for optimum level

P : Probability level

CHAPTER 5

DISCUSSION, CONCLUSIONS AND RECOMMENDATION

5.1 DISCUSSION

Increasing protein level from 12.94 to 15.75 % increased feed intake of Naked neck hens from 88 to 99 g per hen per day. However, the optimal dietary protein value for feed intake was calculated 14.7 % (r^2 = 0.623). These results are similar to those of Gunawardana *et al.* (2008) and Parsons *et al*. (1993) who found that increasing dietary protein level increased feed intake from 93.2 to 98.8 g per commercial laying hen per day, resulting in a 6.01 % increase of feed intake. Wu *et al.* (2005) also found that increasing dietary protein level from 14 to 16 % increased feed intake from 102.9 to 105.6 g per hen per day. Increased feed intake was also reported by (Yakout *et al.,* 2000) with increasing protein levels in commercial laying hens. Similarly, Bunchasak and Silapsom (2005) reported that commercial laying hens fed diets having low crude protein had significantly low feed intakes. These results are, however, not supported by the findings of Kingori *et al*. (2010) who observed that feed intake of laying indigenous chickens was not influenced by the level of dietary protein. Hussein (2000) observed that White Leghorn pullets fed diets with 160 g CP per kg DM had significantly higher feed intakes than those fed the 190 g CP per kg diet during the first six weeks of laying.

Higher dietary protein levels tended to decrease the number of eggs produced. However, the optimal value for egg production was calculated 14.9 % (r^2 = 0.568). The results are in agreement with the findings of Leeson and Lopez (1994) who reported that excessive dietary crude protein level may depress egg production. Hussein (2000) found that reducing protein levels from 19 to 16 % in laying hen diets significantly increased egg production. The present results are, however, not supported by the findings of Keshavarz and Nakajima (1995) who observed that egg production in commercial egg laying chicken breeds increased due to increasing dietary protein levels, although feed consumption was not influenced by these dietary changes. Similarly, Liu *et al*. (2005) and Wu *et al*. (2005) found that increasing protein level in the diet improved egg production of Leghorn hens. Increasing egg production during the early laying period was also noted in hens fed a high protein prelay diet (Lilburn and Myers-Miller, 1990). Zootecnica International (2008) found that egg production was reduced by 5.5 % when crude protein was reduced from 19 to 13 %. Feeding intermediate levels of 17 and 15 % CP allowed for production comparable to feeding commercial laying hens with the 19 % CP diet. Gunaratne (1999) indicated that a protein level of 11.5 % might be enough for indigenous hens to achieve maximum egg production. Kingori *et al.* (2010) observed that egg production was similar for indigenous hens offered diets containing between 100 and 140 g of CP per kg.

The results of the present study indicate that increasing the protein level in the diets of Naked neck hens decreased egg weight. The optimal dietary protein value for egg weight was calculated to be 13.9 % (r^2 = 0.094). These results are in agreement with those of Gunawardana *et al.* (2009) who reported that eggs produced by hens fed the high-protein diet (16.1 % CP) were significantly heavier than those of hens fed the low-protein diet (15.5 % CP) . Leeson (1989), Parsons *et al*. (1993), Keshavarz (1995), and Sohail *et al*. (2003) reported that eggs produced by hens fed a higher protein level (19.8.% CP) were heavier than those from hens fed a lower-protein diet (17.4 % CP). The present results are, however, not supported by the findings of Cho *et al*. (2004) who reported no increase in egg weight in commercial layers offered diets having protein levels of 15 to 19.5 %. Liu *et al*. (2005) and Wu *et al*. (2005) also observed that increasing dietary protein level from 16.06 to 17.38 % increased egg weight. Joseph *et al.* (2000) observed that feeding a diet of 16 or 18 % CP to broiler breeder hens resulted in the production of larger eggs when compared with birds fed a 14 % CP diet. Higher dietary levels of protein have also shown to increase early egg weight in commercial laying hens (Summers, 1993; Summers and Leeson, 1994). Gunawardana *et al.* (2008) and Shrivastav *et al.* (1993) indicated that increasing dietary protein from 13.8 to 17.1 % increased egg weight by 2.38 g. Egg weight was decreased from 55.21 to 52.20 g as dietary level protein decreased from 19 to 13 % CP (Zootechnica International, 2008).

Egg white nitrogen content tended to increase with decreasing protein level in the diet of hens. However, the optimal dietary protein value for egg white nitrogen content was calculated to be 18.2 % (r^2 = 0.563). Wu *et al.* (2007) found that as dietary protein level increased from 160.7 to 173.9 g per kg, percent albumen and its nitrogen content increased. In the present study the higher nitrogen content of the egg yolk was obtained from hens fed a 15.75 % CP diet. However, the optimal dietary protein level for egg yolk nitrogen content was calculated to be 15.1 % (r^2 = 0.424). Akbar *et al.* (1983) found that higher protein levels in the diet increased yolk nitrogen content in eggs from commercial laying hens.

In the present study, the highest egg hatchability values were obtained from hens fed a diet containing 14.38 % CP. However, the optimal dietary protein value for egg hatchability was calculated to be 15.9 % (r^2 = 0.451). Leeson and Lopez (1994) observed that low hatchability is associated with high protein levels in the diets of hens, especially when energy intake is low. Breeder hens fed a low-energy-high-protein diet tended to produce eggs with lower hatchability (Pearson and Herron, 1982; Leeson and Summers, 1991). Similarly, Vo *et al*. (1994) found higher hatchability values in brown-egg laying hens fed high protein diets.

The results of the present study indicate that lower and higher protein diets tended to decrease chick hatch-weight. However, the optimal dietary protein value for chick hatch-weight was found to be 15.9 % (r^2 = 0.898). Aitken *et al.* (1969) also found that lower dietary protein levels for hens decreased chick hatch-weight. Contrary to the results of the present findings, Lopez and Leeson (1994) observed higher chick weight as a percent of total egg weight for offspring of hens fed high dietary protein.

Naked neck hens fed diets with different protein levels produced chicks with different feed intake, live weights and feed conversion ratio. However, the optimal dietary protein values for feed intake, live weight and feed conversion ratio were calculated to be 15.8 (r^2 = 0.298), 15.4 (r^2 = 0.615) and 16.1 % (r^2 = 0.077), respectively. No studies were found on the performance of chicks from indigenous hens fed different protein levels. However, Zollitsch *et al* (1997) and Lopez- Ferrer *et al.* (2001) found that chicks hatched from breeder hens fed diets with high polyunsaturated fatty acid concentrations had higher feed intake as compared to chicks hatched from breeder hens fed diets low in polyunsaturated fatty acids. In the present study protein level in the diet of hens had no effect on growth rate of chicks from day old up to seven weeks of age. However, the optimal value for growth rate was found to be 16.1 % (r^2 = 0.236). These results are supported by Kidd *et al.* (1992) who found no improvements in growth responses from progenies of broiler breeder hens fed different levels of inorganic and organic zinc sources. In the present study, protein level of the diet of hens had no effect on mortality of chicks from a day old to seven weeks of age. However, mortality of the chicks decreased from 14.6 to 0.0 % with the decreasing levels of protein. The reasons for this are not clear. However, Kidd *et al.* (2005) also found that mortality of chicks were not affected by breeder hen diet.

Results of the present study indicate that protein level of the diet of hens had no effect on live weight, dry matter intake, dry matter digestibility, apparent metabolisible energy and nitrogen retention of Naked neck chicks at seven weeks of age. However the optimal dietary protein values for live weight, dry matter intake, dry matter digestibility, apparent metabolisible energy and nitrogen retention were calculated to be 17.1 (r^2 = 0.710), 16.5 (r^2 = 0.777), 15.4 (r^2 = 0.160), 15.8 (r^2 = 0.756) and 14.4 % (r^2 = 0.331), respectively. This has implication on ration formulation for hens. Thus, diet protein level for optimal productivity may depend on the variable one is interested in. No information was found on the diet digestibility, apparent metabolisible energy, dry matter intake, live weight and nitrogen retention of the progenies from indigenous naked neck hens fed different protein levels.

The present study indicates that protein level of the diet of hens had no effect on feed intake, growth rate and mortality of male progenies between eight and 13 weeks of age. No studies were found on the effect of protein level of the diet of Naked neck hens on productivity of their male progenies. However, Kidd *et al.* (2005) found that male progenies from hens receiving the highest energy diet (450 Kcal/kg ME) had better growth rates at 41 days of age compared with hens on the lowest energy diet (325 Kcal/kg ME). Poulos *et al*. (2001) found that dams' diet had no effect on average daily gain or feed intake in male progenies.

Results of the present study indicate that protein level of the diet of hens had no effect on feed intake, growth rate and mortality of female chicks between eight and 13 weeks of age. However, Spratt and Leeson (1987) found that energy intake of broiler breeder hens had no effect on growth of female offsprings; but body weights of 20-day old male offsprings were 575, 586, and 601 g for low, medium and high energy intake, respectively. Bellinger *et al.* (2004) found that although maternal low protein exposed female rats tended to have lower energetic efficiency and feed conversion ratios than control females, this difference did not achieve statistical significance. No studies were found on the effect of protein level of the diet of Naked neck hens on productivity of their female progenies.

In the present study, protein level of the diet of Naked neck hens had no effect on live weight, breast meat yield, breast meat nitrogen content and fat pad weight of their male progenies. The optimal dietary protein values for live weight, breast meat yield, breast meat nitrogen content and fat pad weight of their male chicks were calculated to be 18.9 (r^2 = 0.666), 15.6 (r^2 = 0.081), 15.4 (r^2 = 0.786) and 17.1 % (r^2 = 0.775), respectively. However, Peebles *et al.* (2002) found higher broiler weights at 43 days old in male offsprings of breeder hens fed on a low energy ration. Kidd *et al.* (2005) found that males had more relative fat and breast meat when their parents received higher L-carnitine level. Carcass weight of the male progenies increased with the decreasing dietary protein levels. No studies were found on the effect of protein level of the diet of Naked neck hens on carcass characteristics of indigenous chickens.

Results indicate that, protein level of the diet of Naked neck hens improved live weight and carcass weight of their female progenies at 13 weeks of age. The optimal protein values of the diet of naked neck hens for live weight and carcass weight of their female progenies were calculated to be 15.7 (r^2 = 0.294) and 15.4 % (r^2 = 0.180), respectively. However, Peebles *et al.* (1999; 2002) found that progeny from hens fed on diets with maize oil had increased carcass yield in comparison to the progeny of hens fed on diets containing poultry oil or lard. Such studies indicate that hen dietary protein, energy and fat sources can have an impact on progeny carcass composition. Denise *et al.* (2009) found that maternal diet and body weight during pregnancy strongly influence subsequent body weight and behavioural parameters of female offsprings, and, in turn, offspring body weight was correlated with some aspects of their behaviour. In the present study, it was observed that protein level of the diet of Naked neck hens had no effect on breast meat yield, breast meat nitrogen content and fat pad weight of their female progenies. The optimal dietary protein values of the diets of hens for breast meat yield, breast meat nitrogen content and fat pad weight of their female progenies were calculated to be 15.8 (r^2 = 0.059), 15.1 (r^2 = 0.882) and 16.1 % (r^2 = 0.405), respectively. No studies were found on the effect of protein level of the diet of Naked neck hens on carcass characteristics of their female progenies.

Decreasing protein level of the diet of Naked neck hens increased dry matter intake of their male progenies at 13 weeks of age. Protein level of the diet of Naked neck hens had no effect on dry matter digestibility, apparent metabolisible energy, nitrogen retention and live weight of their male progenies at 13 weeks of age. However, the optimal dietary protein values for dry matter digestibility, apparent metabolisable energy, nitrogen retention and live weight were calculated to be 17.5 (r^2 = 0.535), 15.4 (r^2 = 0.153), 22.8 (r^2 = 0.065) and 15.6 % (r^2 = 0.528), respectively. In contrast, Brake *et al.* (2003) found that increasing crude protein and energy in the broiler breeder hen diet had effect on the body weight, particularly in the male progenies. No studies were found on the effect of protein level of the diet of hens on dry matter intake, dry matter digestibility, apparent metabolisible energy and nitrogen retention of indigenous chickens.

Results indicate that production values for male chicks were optimized at higher protein level than the female chicks.

5.2 Conclusion

The results of this study suggest that increasing protein level from 12.94 to 15.75 % increased feed intake from 88 to 99 g per Naked neck hen per day. However, feeding higher protein levels decreased the number of eggs produced and egg weight. Higher egg yolk nitrogen content and hatchability were obtained from hen fed 15 and 14 % CP, respectively. Egg white nitrogen content was observed to decrease with the decreasing protein level the diet of hens. Feeding higher and lower protein diets tended to decrease chick hatch-weight. Optimal protein values of the diets of Naked neck hens for feed intake, number of eggs produced, egg weight, egg white nitrogen content, egg yolk nitrogen content, egg hatchability and chick hatch-weight were calculated to be 14.7 (r^2 = 0.623), 14.9 (r^2 = 0.568), 13.9 (r^2 = 0.094), 18.2 (r^2 = 0.563), 15.1 (r^2 = 0. 424), 15.9 (r^2 = 0.451) and 15.9 % (r^2 = 0.898), respectively.

Results of the present study indicate that chicks from Naked neck hens fed different protein levels produced chicks with higher feed intake, live weight and improved feed conversion ratio between a day old and seven weeks of age. However, protein levels of the diet of Naked neck hens had no effect on growth and mortality of their chicks between a day old and seven weeks of age. The optimal protein values of the diet of Naked neck hens for feed intake, live weight, feed conversion ratio, growth and mortality of chicks between a day old and seven weeks of age were calculated to be 15.8 (r = 0.298), 15.4 (r = 0. 615), 16.1 (r = 0.077), 16.1 (r = 0.236) and 14.3 % (r = 0.617), respectively.

Results of the present study indicate that protein level of the diet of Naked neck hens had no effect on live weight, dry matter intake, dry matter digestibility, apparent metabolisible energy and nitrogen retention of their male progenies at seven weeks of age. However, optimal dietary protein values for live weight, dry matter intake, dry matter digestibility, apparent metabolisible energy and nitrogen retention were calculated to be 17.1 (r^2 = 0.710), 16.5 (r^2 = 0.777), 15.4 (r^2 = 0.160), 15.8 (r^2 = 0.756) and 14.4 % (r^2 = 0.331), respectively.

Protein level of the diet of Naked neck hens had no effect on feed intake, growth and feed conversion ratio of both their male and female progenies between eight and 13 weeks of age. Protein level in the diet of Naked neck hens had no effect on live weight, breast meat yield, breast meat nitrogen content and fat pad weight of their male progenies at 13 weeks of age. However, optimal protein values of the diets of Naked neck hens for live weight, breast meat yield, breast meat nitrogen content and fat pad weight of their male progenies were calculated to be 18.9 (r^2 = 0.666), 15.6 (r^2 = 0.081), 15.4 (r^2 = 0.786) and 17.1 % (r^2 = 0.775), respectively. However, carcass weight of the male progenies increased with the decreasing protein level of the diet of the hens.

Protein level of the diet of Naked neck hens improved live weight and carcass weight of their female progenies at 13 weeks of age. The optimal protein values of the diet of Naked neck hens for live weight and carcass weight of their female chicks were calculated to be 15.7 (r^2 = 0.294) and 15.4 % (r^2 = 0.180), respectively. It was observed that protein level in the diet of Naked neck hens had no effect on breast meat yield, breast meat nitrogen content and fat pad weight of their female progenies at 13 weeks of age. The optimal protein values of the diets of Naked neck hens for breast meat yield, breast meat nitrogen content and fat pad weight of their female progenies were calculated to be 15.8 (r^2 = 0.059), 15.1 (r^2 = 0.882) and 16.1 % (r^2 = 0.405), respectively.

Decreasing protein level of the diet of Naked neck hens increased dry matter intake of their male progenies at 13 weeks of age.Optimal protein value of the diet of Naked neck hens for dry matter intake was calculated to be 15.3 % (r^2 = 0.710). Protein level of the diet of Naked neck hens had no effect on dry matter digestibility, apparent metabolisible energy, nitrogen retention and live weight of their male chicks at 13 weeks of age. However, the optimal protein values of the diet of Naked neck hens for dry matter digestibility, apparent metabolisible energy, nitrogen retention and live weight were calculated to be 17.5 (r^2 = 0.535), 15.4 (r^2 = 0.153), 22.8 (r^2 = 0.065) and 15.6 % (r^2 = 0.528), respectively.

5.3 Recommendation

Based on the variations in optimal protein levels reached for the different parameters invastigated, it is recommended that more studies should be carried out to ascertain the appropriate levels of protein in the diets of Naked neck hens for optimal feed intake, egg production, hatchability , chick productivity and carcass characteristics of their progenies. Such information will help to improve the productivity of the Naked neck hens and their chicks (male and females) in the tropical environment of Limpopo, South Africa.

CHAPTER 6

REFERENCES

ARC. 2006., The Indigenous Chicken Breeds of South Africa. ARC, Irene, Pretoria.

ARC.1975. The Nutrient Requirements of Farm Livestock. Agricultural Research Council, London.

AITKEN, J. R., BIELY, J., NIKILAICZUK, N., BOBBLEE, A. R and SLINGER, J.,1969. Comparison of laying rations with and without animal protein at the Canadian random sample egg production test. *British Poultry Science 10: 247-253.*

AKBAR, M. K., GAVORA, J. S., FRIARS, G. W and GROWE, R. S, . 1983. Composition of eggs by commercial size categories: Effects of genetic group, age, and diet. *Poultry Science 62:925–933*.

ALEMU, Y., 1995. Poultry production in Ethiopia. *World's Poultry Science Journal 51:197-200.*

AOAC, 2002. Official method of Analysis. 17th edition. AOAC. Washington D.C

BELLINGER, L., LILLEY, C. and LANGLEY-EVANS S., 2004. Prenatal exposure to a maternal low protein diet programmes, a preference for high-fat food in the young adult rat. *British Journal of nutrition 92: 513-520*

BOWMAKER, J. E. and GOUSI R. E., 1989. Quantification of reproductive changes and nutrient requirement of broiler pullets at sexual maturity. *Poultry Science* 30: 663-675.

BRAKE, J., FAUST, M. and STEIN, J., 2003. Evaluation of transgenic event Bt 11hybrid corn in broiler chickens. *Poultry Science 82: 551–559.*

BRAKE, J., GARLICH, J. D. and PEEBLES E. D., 1985. Effect of protein and energy intake by broiler breeders during the pre-breeder transition period on subsequent reproductive performance. *Poultry Science 64: 2335-2340.*

BUNCHASAK, C., POOSUWAN, K., NUKRAEW, R., MARKVICHITIR, K. and CHOOTHESA, A., 2005. Effect of dietary protein on egg production and immune responses of laying hens during peak production period. *International Journal of Poultry Science 4: 701-708.*

BUNCHASAK, C. and SILAPSOM, T., 2005. Effect of adding methionine in low protein diet on production performance reproductive organs and chemical composition of laying hens under tropical condition. *International Journal of Poultry Science 5: 301-308*.

CALINI, F. and SIRRI D. F., 2007. Breeder nutrition and offspring performance. *Revista Brasileira de Ciência Avícola 9: 2.*

CAVE, N. A. G., 1984. Effect of dietary propionic and lactic acid on feed intake by chicks. *Poultry Science 63: 131-134.*

CHO, Y. M., SHIN, I. S. and YANG, C. J., 2004. Effect of feeding dried leftover food on productivity of laying hens. *Jouranal of Animal Science 17: 518-522.*

CLAUER, P. J., 1995. A small scale Agriculture alternative. United States, Department of Agriculture, Cooperative Research, Education and Extension services.

DAS, S. K., ADHIKARY, G. N., ISLAM, M. N., PAUL, B. K. and DAS, G. G., 2004. Artificial insemination by raw semen: its advantages and disadvantages in Deshi chickens (Gallus domesticus). *International journal of Poultry Science 3: 662-663.*

DENISE, A. W., JIUDE, M., PAIZLEE, T. S., CHERYL, S. R. and ROBERTS, R. M.,

2009. Maternal diet effect on body weight and behavior responses in offspring. *Biology of Reproduction 81: 491.*

FATTORI, T. R., WILSON, H. R., HARMS, R. H. and MILES, R. D., 1991. Response of broiler breeder females to feed restriction between recommended levels. *Growth and Reproductive Performance 70: 26-36.*

FAMINO, A. O., 1996. Effect of feeding varying protein and energy levels on the performance and egg quality of layers in the tropics. *International Journal of Animal. Science 11: 209-212.*

GUNARATNE, S. P., 1999. Feeding and nutrition of scavenging village chickens. Free communication 2. First INFDP/FAO Electronic Conference on Family Poultry.

GUNAWARDANA, P., ROLAND, D. A. and BRYANT, M. M., 2008. Performance comparison and lysine requirements of seven commercial brown layer strains during phase one. *International Journal of Poultry Science 7 (8): 806-812.*

GUNAWARDANA, P., ROLAND, D. A. and BRYANT, M. M., 2009. Effect of dietary energy, protein, and a versatile enzyme on hen performance, egg solids, egg composition, and egg quality of Hy-Line W-36 hens during second cycle, phase two. *Journal of Applied Poultry Research 18: 43-53.*

HARMS, R. H. and WILSON, H. R., 1980. Protein and sulphur amino acid requirements of broiler breeder hens. *Poultry Science 59 (2): 470-71.*

HUSSEIN, A. S., CANTOR, A. H., PESCATORE, A. J. and JOHNSON, T. H., 1996. Effect of dietary protein and energy levels on pullet's development. *Poultry Science 75: 973-978*.

HUSSEIN, A. S., 2000. The use of step down and modified constant protein feeding systems in developing pullets reared in hot climates. *Animal Feeds Science and Technology 85: 171-181.*

JOSEPH, N. S., ROBINSON, F. E., KORVER, D. R. and RENEMA, R. A., 2000. Effect of dietary protein intake during the pullet to breeder transition period on early egg weight and production in broiler breeders. *Poultry Science 79: 1790-1796.*

JOUBERT, J. J., 1996. The Story of the Indigenous Domestic Animals in South Africa. Agricultural Research Council, South Africa.

KARUNAJEEWA, H., 1972. Effect of protein and energy levels on laying performance of strains of different body weights. *Australian Journal of Experimental Agriculture 12: 385-391*.

KEMP, C.and KENNY, M., 2007. Breeder nutrition and chick quality. The poultry site, *International hatchery practice 19: 1-4.*

KESHAVARZ, K., 1995. Further investigations on the effect of dietary manipulations of nutrients on early egg weight. *Poultry Science 74: 62–74.*

KESHAVARZ, K. and NAKAJIMA, S., 1995. The effect of dietary manipulations of energy, protein, and fat during the growing and laying periods on early egg weight and egg components. *Poultry Science 74: 50–61.*

KIDD, M. T., ANTHONY, N. B., NEWBERRY, L. A. and LEE, S. R.,1992. Effect of zinc added to the broiler breeder diet on progeny immune response and *Eimeria tenella* challenge. *Poultry Science 71: 160. Abstract.*

KIDD, M. T., MCDANIEL, C. D., PEEBLES, E. D., BARBER, S. J., CORZO, A., BRANTON, S. L. and WOODWORTH, J. C., 2005. Breeder hen dietary L-carnitine affects progeny carcass traits. *British Poultry Science 46: 97-103.*

KIDD, M. T., 2006. Maternal nutrition effects on progeny development and performance. Mississippi State University. MS 39762- 9665. Proceedings of Nutrition Conference. *Annual Carolina Poultry Nutrition Conference*. pp 205- 209.

KINGORI, A .M., WACHIRA, A. M. and TUITOEK, J. K., 2010. Indigenous chickens production in Kenya: A review. *International Journal of Poultry science 9 (4): 309- 316).*

KULIKOV, L. V. and SARDA, R., 1987. Different protein levels in the feeding of laying hens. *Revista-Cubana-de-Ciencia-Avicola 14(1): 65-70.*

LEESON, S. and LOPEZ, G., 1994. Proceedings of the Midwest poultry federation convention. St Paul. Minnesota, USA.

LEESON, S., 1989. Energy intake and layer performance. California Nutrition Conference, California Grain and Feed Association, Fresno, California. pp 72-79.

LEESON, S. and SUMMERS, J. D., 1991. Commercial Poultry Nutrition. University Books, Ontario, Canada, ISBN: 964-91901-4-7.

LILBURN, M. S. and MYERA-MILLER, D. J., 1990. Dietary effects on body composition and subsequent production characteristics in broiler breeder hens*. Poultry Science 69: 1126-11.*

LIU, Z., WU, G. BRYANT M. M. and ROLAND, D. A., Sr., 2004. Influence of added synthetic lysine for first phase second cycle commercial leghorns with the methionine+cysteine/lysine ratio maintained at 0.75. *International Journal of Poultry Science 3: 220-227.*

LIU, Z., WU, G., BRYANT, M. M. and ROLAND, D. A., 2005. Influence of added synthetic lysine for first phase second cycle commercial leghorns with the methionine + cysteine/lysine ratio maintained at 0.75. *International Journal of Poultry Science 3: 220-227*.

LOPEZ, G. and LEESON, S., 1994. Egg weight and off-spring performance of older breeders fed low-protein diets. *Journal of Poultry Science* 3: 164-170.

LO´PEZ-FERRER, S., BAUCELLS, M. D., BARROETA, A. C., GALOBART, J. and GRASHORN, M. A., 2001. n-3 enrichment of chicken meat. 2. Use of precursors of long-chain polyunsaturated fatty acids: linseed oil. *Poultry Science 80: 753–761.*

MCDONALD, P., EDWARDS, R. A. and GREENHALGH, J. F. D., 1992. Evaluation of foods (A) Digestibility. In: Animal Nutrition, 4th edition. pp 200-216.

MWALUSANYA, N. A., KATULE A. M., MUTAYOBA S. K., MTAMBO, M. M. A., OLSEN, J. E. and MINGA, U. M., 2002. Productivity of local chickens under village management conditions. *Tropical Animal Health and Production 34: 405-416.*

NAGER, R. G., RÜEGGER, C. and VAN NOORDWIJK, A. J., 1997. Nutrient or energy limitation on egg formation: a feeding experiment in great tits. *Journal of Animal. Ecolology 66: 495–507*

NRC., 1984. Nutrient Requirement of Poultry. 8th revised edition, *National academy press*, Washington DC.

NOVAK, C., YAKOUT, H. M. and SCHEIDEIER, S. E., 2006. The effect of dietary protein level and to sulfur amino acid: lysine ratio on egg production parameters and egg yield in the Hi-line W- 98 hens. *Poultry Science 85: 2195-2206*.

O'BYRNE, G., 2002. Background Poultry. Fraser books. Thear, Katie Free- range

Poultry *Farming press books, UK. pp361-.368.*

PARSONS, C. M., KOELKOBECK, K. W., ZHANG, Y., WANG, X. and LEEPER, R. W., 1993. Effect of dietary protein and added fat levels on performance of young laying hens. *Applied Journal of Poultry Science 2: 214-220*.

PEEBLES, E. D., DOYLE, S. M., PANSKY, T., GERARD, P. D., LATOUR, M. A., BOYLE, C. R. and SMITH, T. W., 1999. Effects of breeder age and dietary fat on subsequent broiler performance. 2. Slaughter yield. *Poultry Science 78: 512–515*.

PEEBLES, E. D., ZUMWALT, C. D., GERARD, P. D., LATOUR, M. A. and SMITH, T. W., 2002. Market age live weight, carcass yield and liver characteristics of broiler offspring from breeder hens fed diets differing in fat and energy contents. *Poultry Science 81: 23-29.*

PEARSON, R. A. and HERRON, K. M., 1982. Effect of maternal energy and protein intakes on the influence of malformation and malpositions of the embryo and time of death during incubation*. British Poultry Science 23: 71-77.*

POULOS, S. P., MATTHEW, S., DOROTHY, B. H., MICHAEL., J. A. and Hausman, G. J., 2001. Pre- postnatal dietary conjucated linoleic acid alters adipose development, body weight gain and body composition in Sprague- Dawley Rats. *Journal of Nutrition 131: 2722- 2731*.

SAS., 2004. SAS User's Guide: Statistics. SAS Institute, Raleigh, North Carolina. USA.

SCHROEDER, J. W., 1994. Interpreting Forage Analysis. *Pioneer Hi-Bred International AS-1080.*

SOHAIL, S. S., BRYANT M. M. and ROLAND, Sr, D. A., 2003. Influence of dietary fat on economic returns of commercial Leghorns. *Journal of Applied Poultry Research 12: 356–361.*

SPRATT, R. S. and LEESON, S., 1987. Effect of protein and energy intake of broiler breeder hens on performance of broiler chicken offspring. *Poultry Science 66: 1489-1494*.

SHRIVASTAV, A. K., RAJU, M. V. L .N. and JOHN, J. S., 1993. Effect of varied dietary protein on certain production traits in breeding Japanese quail. *Indian Journal Poultry Science 28(1): 20-25.*

SUMMERS, J. D., 1993. Reducing nitrogen excretion of the laying hen by feeding lower crude protein diets. *Poultry Science 72: 1473–1478.*

SUMMERS, J. D. and LEESON, S., 1994. Laying hen performance as influenced by protein intake to sixteen weeks of age and body weight at point of lay. *Poultry Science 73: 495–501.*

TADELLE, D., ALEMU, Y. and PETERS, K. L., 2000. Indigenous chickens in Ethiopia: Genetic potential and attempts at improvement. *World's Poultry Science Journal* 56: 45-54.

TEKETEL, F., 1986. Studies on the meat production potentials of some local strains of chickens in Ethiopia. PhD Thesis, J L Giessen University, Germany

VO, K. V., ADEFOPE, N. A. and WAKEFIELD, T. Jr., 1994. Effect of dietary protein restriction and sulphur amino acid supplementation on reproductive efficiency of Brown- egg type layers. *Poultry Science* 73: 163 (Abstract).

WHITEHEAD, C. C., PEARSON, R. A. and HERRON, K. M., 1985. Biotin requirement of broiler breeders fed diets of different protein content and effect of insufficient biotin on the viability of progeny. *British Poultry Science 26: 73 -82.*

WIKIBOOK., 2008. Proteins. Anatomy and Physiology of Animals/ Chemicals

WU, G., BRYANT, M. M., VOITLE, R. A. and ROLAND, D. A., 2005. Performance comparison and nutritional requirements of five commercial layer strains in phase IV. *Journal of Poultry Science 4: 182-186*.

WU, G., GUNAWARDANA, P., BRYANT, M. M. and ROLAND, D. A., 2007. Effect of dietary energy and protein on performance, egg composition, egg solids, egg quality and profits of Hy-line W- 36 hens during phase 2. *International Journal of Poultry Science 6: 739-744.*

YAKOUT, H., NOVAK, C. and SHEIDELER, S., 2000. Dietary protein level and variable TSAA: Lysine ratios: Effects on laying hens performance. *Poultry Science 91: 93.*

ZOLLITSCH, W., KNAUS, W., AICHINGER, F. and LETTNER, F., 1997. Effects of different dietary fat sources on performance and carcass characteristics of broilers. *Animal Feed Science Technology 66: 63–73.*

ZOOTECHNICA INTERNATIONAL., 2008. Using low protein diets efficiently. *Worlds Poultry Journal.*

ZOU, S. and WU Y., 2005. Effect of protein and supplemental fat on performance of laying hens. *International Journal of Poultry Science 4(12): 980-986.*