PERFORMANCE OF JAPANESE QUAILS (*Coturnix coturnix japonica*) FED DIETS CONTAINING DIFFERENT PROTEIN AND ENERGY LEVELS

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MTECH/SAAT/2017/6812

DEPARTMENT OF ANIMAL PRODUCTION

FEDERAL UNIVERSITY OF TECHNOLOGY

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ABSTRACT

A study which lasted 70 days was conducted to determine the performance of Japanese quails (*Coturnix coturnix japonica*) fed diets containing four different protein and four energy levels. Five hundred and seventy six (576) Japanese quail aged two weeks were used for this experiment. Battery cages with 48 different compartments were used. The Japanese quails were randomly distributed into 16 treatments and each treatment was replicated three (3) times and 12 quails per replicate using a 4 x 4 factorial arrangement in a complete randomized design. The Japanese quails were fed on sixteen diets consisting of four levels of energy (2600, 2800, 3000 and 3200 Kcal ME/kg) and four levels of protein (20, 22, 24 and 26 % CP) during growth and laying performance phases. Data on growth performance (weight gain, feed intake and feed conversion ratio), apparent nutrient digestibility, carcass characteristics and egg production and quality were determined. All data collected were subjected to two-way Analysis of Variance (ANOVA); significant means were separated by using Duncan's Multiple Range Test at ($P<0.05$). Growth performance results showed no ($P>0.05$) effect on Japanese quails neither were their interactions. The digestibility results showed that the dry matter, crude protein, crude fibre, ether extract, ash, and nitrogen free extract digestibility were significantly affected ($p<0.05$) by both dietary protein and energy treatments. Egg production parameters were not influenced ($P>0.05$) by varying dietary protein and energy levels. However, the external characteristics were influenced ($P<0.05$). The results showed that birds on low protein of 22 % CP and energy of 2600 Kcal ME/kg had better external characteristics, egg length (2.67 cm), egg width (2.18 cm) and egg shape index (0.82). On the internal parameters, birds on 2800 Kcal ME/kg had better yolk weight (2.21g), albumen weight (4.80 g), yolk height (0.70 cm), albumen height (0.79 cm) and yolk index (0.40). Interaction results showed that different dietary protein and energy treatments had no effect ($P>0.05$) on all the growth and egg production performance parameters measured. Birds on high 26 % CP level and low energy of 2600 Kcal ME/kg had better crude fibre, ether extract and ash results. Internal egg interaction results showed that birds on low energy 2600 and 2800 kcal and medium CP levels of 22 and 24 % had better egg length, egg width and egg shape index. Similarly, birds on low protein - low energy (22 % CP & 2800 kcal) had better internal egg yolk weight, yolk height, yolk diameter and yolk index interaction results. It was concluded that for improved nutrient digestibility, low protein 22 % CP with low energy 2600 kcal is recommended. However, for improved external and internal egg characteristics a range of 20 - 22 % CP and 2600 - 2800 kcal energy is recommended.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

The world population is growing at an alarming rate. According to population reference bureau (PRB) projects population will more than double to 2.6 billion by 2050 and will account for about 58 percent of the global population increase by that date. With this population, there has been increased concern over dietary protein supply, particularly in addressing malnutrition and undernourishment in the world (Jaka *et al*., 2018). If there is to be progress in food security then effort must be placed on identification of alternative food resources that can meet to pace of the population growth (Rosen *et al.*, 2016). The incorporation of game birds has been recommended, particularly for developing countries (Geldenhuys *et al*., 2013). The existence of a diversity of fowl species producing meat and eggs may provide a wide array of nutrient constituents (Geldenhuys *et al*., 2013; Chepkemoi *et al*., 2016). Identification and promotion of alternative poultry egg sources may also boost egg supply and contribute to an enhanced nutrient provision in human diets (Geldenhuys *et al*.,2013). Furthermore, the variation in egg quality and taste among poultry species may also provide consumers with a wider selection pool for choice eggs. One of the game birds that has these characteristics is quail.

Quail has attained economic importance as an agricultural species producing eggs and meat that are enjoyed for their unique flavor. They have low maintenance cost because of their small body size (80-300 g), short generation interval having three to four generations in a year. Quail birds are resistance to diseases and they have high egg production, thus they are an excellent laboratory animal. However, the nutritional requirement of this bird in the tropics have not been well established. Studies has shown that the nutrient of birds varies from species to species and from one location to another. Presently, in Nigeria, the diets fed to quail are mostly based on 24 and 20 % of crude protein for rearing and production, respectively, as recommended by NRC (1994). Furthermore, Babatunde *et al.* (2016) indicated that a diet of 26 % crude protein and 3200 kcal metabolizable energy/kg is suitable for optimum performance of Japanese quail in terms of weight gain, however, these authors did not obtain the requirement for laying. There are also variations in the dietary crude protein and energy recommendations for quails.

Woodard *et al*. (1973) reported that quail can be raised on turkey starter diets containing 25 – 28 % crude protein while Lee *et al*. (1977) on the other hand indicated that dietary crude protein level of 24 % is needed in starter diet for quail and the protein content may be reduced to 20 % by 3rd week of age. Nwokedi *et al*. (2010) observed that when four crude protein levels of 20, 22, 24 and 26% were evaluated for Japanese quails, birds on 20 % crude protein level resulted in best performance from 1 to 42 days of age. Murakami *et al*. (1993a) discovered that 18% crude protein was adequate at the laying phase this is, however, lower than the 20% recommended by NRC (1994) and 22.42% recommended by Pinto *et al*. (1998).

Energy though not a nutrient, however, it must be adequately supplied by the diet to make efficient use of dietary protein. It has been reported that most birds eat to satisfy their energy requirement, thus, Babatunde *et al*. (2016) reported that production results are determined not by protein amount, but first of all by energy to protein ratio. Report on Reda *et al*. (2015) indicated that crude protein and energy levels of 22 % and 2900 kcal ME/kg, respectively, as adequate during the first few weeks of growth. While Jahanian and Edriss (2015) reported CP and energy levels of 26 % and 3000 kcal ME/kg, respectively, for the same period.

For the review above, that there are variations in the Japanese quail requirements for energy and protein. The variation might be attributed to region (climatic), breed of quails, time of rearing among others. Furthermore, the optimal dietary energy and protein at different phases were not well established. This study will therefore, determine the effect of four different energy (2600, 2800, 3000 and 3200 Kcal) and four dietary protein levels of 20, 22, 24 and 26 % on the performance and egg characteristics of Japanese quail raised under intensive management system in Nigeria (a tropical country).

1.2 Statement of Research Problem

There is growing demands for animal protein to meet the growing population of the world. One of the fastest growing poultry birds is quail. Although the nutrient requirements of Japanese quail have been documented to a greater extent in some regions (Ayasan and Okan, 2006); however, it has not been well documented in the tropics. There are variations in both the dietary crude protein and energy reports (Nwokedi *et al*., 2010; Reda *et al*., 2015; Jahanian and Edriss, 2015).

1.3 Justification

Adequate energy must be supplied by the diet to make efficient use of dietary protein. It has been discovered that production results are determined not by protein amount, but first of all by energy to protein ratio (Babatunde *et al*., 2006). Alaganawy *et al*. (2014) reported that adequate amino acid balance is the most important nutrient for Japanese quails, while Reda *et al*. (2015) reported crude protein and energy levels of 22% and 2900 kcal ME/kg, respectively, as adequate during the first few weeks of growth. Jahanian and Edriss (2015) reported CP and energy levels of 26% and 3000 kcal ME/kg respectively, for the same period. Japanese quail requirements for energy and protein in Nigeria (a tropical country) as well as the efficiency of feed utilization are still poorly documented. Adequate energy must be supplied by the diet to make efficient use of dietary protein. It has been discovered that production results are determined not by protein amount, but first of all by energy to protein ratio (Zofia *et al*., 2006). Alaganawy *et al*. (2014) reported that adequate amino acid balance is the most important nutrient for Japanese quails, while Reda *et al*. (2015) reported crude protein and energy levels of 22% and 2900 kcal ME/kg, respectively, as adequate during the first few weeks of growth. Jahanian and Edriss (2015) reported CP and energy levels of 26% and 3000 kcal ME/kg respectively, for the same period. Japanese quail requirements for energy and protein in Nigeria (a tropical country) as well as the efficiency of feed utilization are still poorly documented.

Quail has attained economic importance as an agricultural species producing eggs and meat that are enjoyed for their unique flavour. They have low maintenance cost because of their small body size (80-300 g), short generation interval having three to four generations in a year. Quail birds are resistant to diseases and they have high egg production. This bird can help bridge the gap in the animal protein intake.

There are variations in the nutrient requirements reported for this bird, thus, determining the optimal dietary protein, energy and their interaction on the productivity of Japanese quail is the justification for this work.

1.4 Aim

The aim of this study was to determine the levels of feeding different dietary protein and energy levels to achieve optimum growth performance and egg production in Japanese quails.

1.5 Objectives

The objectives of this research project work were to determine the effect of feeding diets containing different levels of metabolizable energy and crude protein (CP) on :

1. Growth performance, apparent nutrient digestibility and carcass traits of Japanese quails.
2. Laying performance and quality characteristics of Japanese quails.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Japanese quail

Japanese quail (*Coturnix coturnix japonica*) is one of the diversified poultry species reared for commercial egg and meat production. It is blessed with the unique characteristics of fast growth, early sexual maturity, high rate of egg production, short generation interval and shorter incubation period that makes it suitable for diversified animal agriculture. They are fairly resistant to diseases, and impart less worry for vaccination. Because of low volume, low weight, less feed input and space requirements, the commercial quail farming for table egg and meat production can be started with much lower capital investment as compared to chicken and duck with almost the same profit margin. With shorter reproduction cycle and earlier marketing age, it offers fast monetary circulation ultimately yielding quicker returns. The meat production performance of Japanese quails has also been improved during recent years due to genetic selection. Therefore, there is need of updating optimal nutritional requirements of Japanese quails with the improvement in genetic makeup to exploit production potentiality, (Sarabmeet and Mandal, 2015)

The Japanese quail, *Coturnix coturnix japonica*, is a species that originated from East Asia. First considered a subspecies of the common quail, it was distinguished as its own species in 1983. The Japanese quail has played an active role in the lives of humanity since the 12th century, and continues to play major roles in industry and scientific research. Where it is found, the species is abundant across most of its range. Currently, there are a few true breeding mutations of the Japanese quail. The breeds from the United States are: Texas A and M, English white, golden range, red range, Italian, Manchurian, Tibetan, rosetta, scarlett, roux dilute and golden tuxedo (Babatunde *et al*., 2016).

The populations of the Japanese quail are mainly found in East Asia and Russia. This includes India, Korea, Japan, and China. Though several resident populations of this quail have been shown to winter in Japan, most migrate south to areas such as Vietnam, Cambodia, Laos, and southern China. This quail has also been found to reside in many parts of Africa, including Tanzania, Malawi, Kenya, Namibia, Madagascar, and the area of the Nile River Valley extending from Kenya to Egypt. Japanese quail are largely localized to East and Central Asia, in such areas as Manchuria, southeastern Siberia, northern Japan, and the Korean Peninsula.

The Japanese quail is primarily a ground-living species that tends to stay within areas of dense vegetation in order to take cover and evade predation. Thus, its natural habitats include grassy fields, bushes along the banks of rivers, and agricultural fields that have been planted with crops such as oats, rice, and barley. It has also been reported to prefer open habitats such as steppes, meadows, and mountain slopes near a water source (Janice, 2018).

The morphology of the Japanese quail differs depending on its stage in life. As chicks, both male and female individuals exhibit the same kind of plumage and colouring. Their heads are tawny in colour, with small black patches littering the area above the beak. The wings and the back of the chick are a pale brown, the back also having four brown stripes running along its length. A pale yellow-brown stripe surrounded by smaller black stripes runs down the top of the head (Janice, 2018).

The plumage of the Japanese quail is sexually dimorphic, allowing for differing sexes to be distinguished from one another. Both male and female adults exhibit predominantly brown plumage. However, markings on the throat and breast, as well as the particular shade of brown of the plumage, can vary quite a bit. The breast feathers of females are littered with dark spots among generally pale feathers. Contrastingly, male breast feathers show off a uniform dark reddish-brown color that is devoid of any dark spots. This reddish-brown coloration also appears in the male cheek, while female cheek feathers are more cream colored. Some males also exhibit the formation of a white collar, whereas this does not occur in any female members of the species. It is important to note that while this coloration is very typical of wild populations of *Coturnix japonica*, domestication and selective breeding of this species has resulted in numerous different strains exhibiting a variety of plumage colours and patterns (Janice, 2018).

Males tend to be smaller than females. Wild adults weigh between 90 and 100 grams while their domesticated counterparts typically weigh between 100 and 120 grams. However, weight among domesticated lines varies considerably, as commercial strains bred for meat production can weigh up to 300 grams (Janice, 2018).

2.2 Protein Requirements of Japanese quail

Protein provides the amino acids for tissue growth and egg production. Hence, the requirement for protein is mainly requirement for amino acids. The dietary protein and amino acids requirement of quail is influenced by age, egg production and metabolizable energy content and the ingredients used to formulate the diets. The type of protein to be fed to quails must be provided from a high quality source. Protein quality is generally based on amino acid composition of the feedstuff and the availability of these amino acids from the feedstuff following digestion in the gut. Amino acids are considered as the building blocks of proteins

Out of 19 total amino acids required by a Japanese quail, 13 are considered as essential, because they cannot be produced in the quail's body and must be supplied in the diet. Six are considered as nonessential, because they are synthesized by the body and need not be supplied in the diet. The 13 essential amino acids are: arginine, cystine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, tyrosine and valine (Soares *et al*., 2017).

The NRC (1994) recommended protein levels of 24 and 20 % for quails in the rearing and production periods, respectively. A lot of researches were conducted varying the recommended levels at different environments. Quail flocks were successfully raised on turkey starter diets containing 25-28 % crude protein (Soares *et al*., 2017).

Runjun and Sethi (2014), have shown that a dietary crude protein level of 24 % is needed in starter diet for quail and the protein content may be reduced to 20 % by 3rd week of age. Four crude protein levels (20, 22, 24 and 26 %) were evaluated for Japanese quails and it was found that after lysine, methionine and cysteine requirements were met, 20 % crude protein level resulted in best performance in term of body weight gain, carcass characteristics FCR etc from 1 to 42 days of age.

Abbasali *et al*. (2017), reported an improved egg weight and feed conversion per egg mass were observed when protein level of diet was increased above 18 %, whereas feed intake, laying rate, feed conversion per dozen egg, shell percentage and shell thickness were not significantly affected. Abbasali *et al*. (2011), study the effects of two energy levels (2,850 and 2,950 kcal/ME/kg) and five protein levels (16, 18, 20, 22 and 24 %) in the diet of quails during the production phase and recommended 22.42 % protein. Runjun and Sethi (2014), reported better egg production with 0.62 % Methionine+Cystine compared to 0.52; 0.57; 0.67 and 0.72 %

Methionine+Cystine. During production, quails after 5 weeks of age require 0.375 % of methionine and 0.30 % available Cystine in a diet with 20 % CP.

Runjun and Sethi (2014), reported that, intake levels of 79.5mg available methionine were required for maximum egg production. Evaluated methionine levels in diets for quails in the early laying period. Quails with 19.2% CP, 0.48% methionine and 0.69% Methionine + Cystine, with other diets containing 16% CP, 0.28-0.43 methionine and 0.55 to 0.69% Methionine + Cystine, it was observed that performance was better when Methionine + Cystine levels in the diet were increased. Although egg characteristics were not affected, shell thickness was poorer with higher methionine levels.

2.3 Energy Requirements for Japanese quail Production and high egg Characteristics

Energy is an essential component of Japanese quail diet that must be supplied in adequate amount to meet up the bird's requirements for maintenance, optimum growth, egg production and reproduction. Energy requirement of quails depends on age of the birds, reproductive status and ambient temperature. The main sources of energy are cereal grains which are the main ingredients for most diets. Fat such as animal tallow, lard or vegetable oils are added to the diet if high energy is required. Sung-Taek *et al.* (2012) reported no significant difference in energy and lysine levels in egg weight. Brand *et al.* (2003) explains that if energy is limiting, birds can compensate by reducing egg size or the number of eggs laid or by increasing the laying interval and spreading the loss of egg formation over a longer period. the findings of Abdel-Azeem. (2011), Agboola *et al.* (2016) and Yusuf *et al.* (2016) who reported no significant difference in shape index due to feeding of different levels of energy and lysine in Japanese quails.

2.4 Egg production in Japanese quail

Japanese quail are hardy birds that thrive in small cages and are inexpensive to keep. They are affected by common poultry diseases but are fairly disease resistant. Japanese quail mature in about 6 weeks and are usually in full egg production by 50 days of age. With proper care, hens should lay 200 eggs in their first year of lay. Life expectancy is only 2 to 2 1/2 years (Tuleun *et al*., 2013).

If the birds have not been subjected to genetic selection for bodyweight, the adult male quail will weigh about 100–140 g, while the females are slightly heavier, weighing from 120–160 g. The females are characterized by light tan feathers with black speckling on the throat and upper breast. The males have rusty brown throat and breast feathers. Males also have a cloacal gland, a bulbous structure on the upper edge of the vent that secretes a white, foamy material. This unique gland can be used to assess the reproductive fitness of the males (Tuleun *et al*., 2013).

2.5 Effect of Different Energy Levels on Growth Performance of Japanese Quail

Japanese quail can derive energy from simple carbohydrates, fat and protein. They cannot digest and utilize some complex carbohydrates, such as fibre, so feed formulation is often a system used based on available energy. Metabolizable energy (ME) is the conventional measure of the available energy content of feed ingredients and the requirements of poultry. This takes account of energy losses in the faeces and urine. Birds eat primarily to satisfy their energy needs, provided that the diet is adequate in all other essential nutrients. The energy level in the diet is therefore a major determinant of poultry's feed intake. When the dietary energy level changes, the feed intake will change, and the specifications for other nutrients must be modified to maintain the required intake. For this reason, the dietary energy level is often used as the starting point in the formulation of practical diets for poultry (Seyed *et al*., 2011).

The most necessary nutrient required for growth is energy even though energy itself is not changed into meat or eggs but used as fuel for getting high production (Garba *et al*., 2010). Mahmoud *et al*., (2016), reported that, a number of scientists have made efforts to attain the optimum level of energy which provides better growth with minimum possible cost, they have proven that by increasing energy levels of feed, feed conversion ratio can be improved, thereby giving high growth performance of the Japanese quail.

An energy level requirement of 2,600 to 3,000 ME kcal/kg diet for growing and laying quails has been reported for temperate region Soares *et al*. (2017)., whereas, findings under our tropical condition indicated that metabolizable energy for growing quails is 2,800 ME kcal/kg, while that of laying quails is 2,550 ME kcal/kg Agboola *et al*. (2016)

2.5.1 Feed intake

Abbasali *et al*. (2017), reported from a research work that dietary energy levels did not affect average feed intake by young Japanese quails, except from day 29 to day 49. However, decreasing the energy level content of finisher diet (29-49 days of age) from 2900 to 2700 kcal/kg resulted in an increase of average feed intake from 24 to 25.7 g per day. Also Barque *et al*. (1994), reported that feed intake of Japanese quails increased linearly with the decrease in dietary energy levels from 3000 to 2900 and 2700 kcal ME/kg during 0-3 weeks of age.

2.5.2 Weight gain

The average live body weight in Japanese quail chicks fed on 2600 to 3000 kcal ME/kg were found to be similar at 14, 28 and 49 days of age Abbasali *et al*. (2017).

2.6 Effect of Different Energy Levels on Egg Quality Characteristics of Japanese Quails

At the different energy levels to be used for these research work, the external and internal egg quality characteristics of the Japanese quail will be observed and measured. For external egg quality characteristics, egg weights are often weighed using a mettler electronic balance while egg length and width are measured using vernier calliper. Egg shape index can be derived from the egg width and length. Egg shell thickness is measured for individual dry egg shells at three different locations to the nearest 0.01 mm using a micrometer screw gauge (Tuleun *et al*., 2013).

For internal egg quality characteristics, the albumen height and width are usually measured to the nearest 0.1cm using a sperometer. Yolk weight is measured by separating the yolk from the albumen using an egg yolk separator and then weighed with an electronic sensitive balance. Yolk height is measured by inserting a thin glass rod into the centre of the yolk and the height estimated using a rule and yolk width was taken as a diameter with a pair of vernier calliper (Tuleun *et al*., 2013).

2.7 Effect of Different Protein Levels on Growth Performance of Japanese Quails

Protein are not alike, they vary according to their origin (animal, vegetable), their amino acid composition (particularly their relative content of essential amino acids), their digestibility and texture. Japanese quails, as such as other poultry, require certain minimal quantities of amino acids from a biologically available source as part of a large protein nitrogen intake. The required amounts of these amino acids vary with age, physiological condition and state of health of the quail Seyed *et al*. (2016).

Seyed *et al*. (2016), reported that, a well known dietary protein level influences the body growth and composition of quails. Several reports indicated that starter diets for Japanese quail should contain protein content of 24 % this may become 20 % at several weeks later. A level of 24 % of crude protein is recommended for Japanese quails in the rearing period. Among diet nutrients, protein has the highest heat increment thus, diets with low protein level were recommended in order to reduce heat production in the Japanese quail under heat stress.

2.7.1 Feed intake

The average feed intake increased as the quails are fed with diets containing low crude protein than that diets containing high crude protein in the starter period (Abbasali *et al*., 2017).

2.7.2 Weight gain

Seyed *et al*. (2016), observed that growth depression due to low protein diets may be due to low amino acid profile of such diets. Crude protein levels have effect on body weight and feed conversion as impaired with decreasing protein levels in the diet.

2.8 Effect of Different Protein Levels on digestibility of Japanese Quails

Digestibility studies are necessary, particularly when improvements in performance and profitability are desired. These improvements can be obtained by adjusting diet formulation, considering the effect of bird age in the digestibility of nutrients and energy of the feeds.

In Japanese quails, during the rearing period, Omidiwura *et al*. (2016) did not find any effect of protein levels on the digestibility of DM and CP. According to Ratriyanto *et al*. (2017), reported that, dietary 18.0 and 19.5 % crude protein (CP) decreased EE digestibility by 7.10 and 7.56 %, respectively, as there is a better EE utilization at lower dietary CP levels. In addition, according Ratriyanto *et al*. (2017), the effect of CP level on nutrient digestibility can be attributed to an imbalance between protein and energy in the diet.

2.9 Effect of Different Protein Levels on Egg Quality Characteristics of Japanese Quail

At the different protein levels to be used for these research work, the external and internal egg quality characteristics of the Japanese quail will be observed and measured. For external egg quality characteristics, egg weights are often weighed using a mettler electronic balance while egg length and width are measured using vernier calliper. Egg shape index can be derived from the egg width and length. Egg shell thickness is measured for individual dry egg shells at three different locations to the nearest 0.01 mm using a micrometer screw gauge (Tuleun *et al*., 2013).

Gunawardana *et al*. (2008) reported there was no significant effect of energy content of the diet on egg shell proportion in SCWL fed diets varying in AME_n content from 2,750 to 3,050 kcal/kg. who worked on Effect of energy and protein on performance, egg components, egg solids, egg quality, and profits in molted Hy-line W-36 hens.

For internal egg quality characteristics, the albumen height and width are usually measured to the nearest 0.1cm using a vernier calliper. Yolk weight is measured by separating the yolk from the albumen using an egg yolk separator and then weighed with an electronic sensitive balance. Yolk height is measured by inserting a thin glass rod into the centre of the yolk and the height estimated using a rule and yolk width was taken as a diameter with a pair of vernier calliper (Tuleun *et al*., 2013)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The research work was conducted at the old Teaching and Research Farm of the Department of Animal Production, Federal University of Technology, Bosso Campus, Minna, Niger State Nigeria. Minna lies between latitude 9^{O} 28 to 9^{O} 37 N and longitude 6^{O} 23 to 6^{O} 33 E with annual rainfall of 1000 - 1500 mm and a temperature range of 28^{O}C- 30^{O}C. The mean annual rainfall varies from 1102.6 to 1361.7mm. The vegetation is Southern Guinea Savannah agro climatological vegetation. It has an altitude of 147m above sea level (GPS).

3.2 Experimental Birds

A total of five hundred and seventy-six (576) Japanese quail aged two weeks were obtained from the National Veterinary Research Institute, VOM, Nigeria, were used for this experiment. Battery cages with 48 different compartments was used. The 576 Japanese quail were randomly distributed into 16 treatments and each treatment was replicated three (3) times. There were 12 quails per replicate.

3.3 Experimental Diet and Design

A 4 (dietary energy levels) x 4 (dietary crude protein levels) factorial arrangement in a completely randomized design was used, making up 16 experimental units. Treatments one to four were fed diets 1 - 4 which contain 2600, 2800, 3000, and 3200 Kcal metabolizable energy (ME) respectively at 20% crude protein (CP). Treatments five to eight were fed diets 5 - 8 which contained 2600, 2800, 3000 and 3200 Kcal metabolizable energy (ME) at22% CP. Treatments nine to twelve were fed diets 9 - 12 which will contain 2600, 2800, 3000 and 3200 Kcal metabolizable energy (ME) respectively at 24% crude protein (CP). While treatments thirteen to sixteen were fed diets 13 – 16 which contain 2600, 2800, 3000 and 3200 Kcal metabolizable energy (ME) respectively at 26 % crude protein (CP). Each experimental treatment was replicated three times with twelve quails per replicate. Thus, a total of 576 quails were used. The Experimental layout and the ingredients composition are presented in Figure 3.1 and Table 3.1, respectively.

CP	**ME**	**TREATMENT**
20	2600	T1 **CP**20 **ME**2600
	2800	T2 **CP**20 **ME**2800
	3000	T3 **CP**20 **ME**3000
	3200	T4 **CP**20 **ME**3200
22	2600	T5 **CP**22 **ME**2600
	2800	T6 **CP**22 **ME**2800
	3000	T7 **CP**22 **ME**3000
	3200	T8 **CP**22 **ME**3200
24	2600	T9 **CP**24 **ME**2600
	2800	T10 **CP**24 **ME**2800
	3000	T11 **CP**24 **ME**3000
	3200	T12 **CP**24 **ME**3200
26	2600	T13 **CP**26 **ME**2600
	2800	T14 **CP**26 **ME**2800
	3000	T15 **CP**26 **ME**3000
	3200	T16 **CP**26 **ME**3200

Figure 3.1 Experimental Layout Design

Key

CP = Crude Protein

ME = Metabolizable Energy

Table 3.1a Composition % of the experiment diets for growing phase

Ingredient	T1	T2	T3	T4	T5	T6	T7	T8
Maize	46.00	47.00	45.00	50.00	41.00	44.00	46.00	47.00
Groundnut Cake 44%	4.00	4.00	4.00	4.00	6.00	6.00	6.00	6.00
Full fat soya	34.00	32.00	31.00	30.00	38.00	31.00	31.00	31.00
Fish meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Rice offal	8.00	7.00	8.00	2.00	7.00	8.00	5.00	2.00
Limestone	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Palm oil	0.00	2.00	4.00	6.00	0.00	2.00	4.00	6.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vit. Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DI-Methione	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis								
CP	20.00	20.00	20.00	20.00	22.00	22.00	22.00	22.00
ME	2600	2800	3000	3200	2600	2800	3000	3200
%EE	8.37	10.06	11.78	13.26	8.52	9.00	11.31	13.86
%CF	7.72	7.64	7.82	7.80	7.84	7.67	7.72	8.02
Avail P %	0.47	0.46	0.46	0.45	0.50	0.47	0.49	0.48
%Lysine	1.29	1.28	1.31	1.29	1.39	1.42	1.43	1.42

Key: CP = Crude protein, **ME =** Metabolism energy, **EE =** Ether extract, **CF =** Crude fibre, **Avail P=** Available protein

Table 3.1b Composition % of the experiment diets for growing phase

Ingredient	**T9**	**T10**	**T11**	**T12**	**T13**	**T14**	**T15**	**T16**
Maize	43.00	44.00	44.00	40.00	40.00	41.00	40.00	40.00
Groundnut Cake 44%	8.00	8.00	8.00	8.00	10.00	10.00	10.00	10.00
Full fat soya	35.00	32.00	31.00	31.00	35.00	31.00	31.00	31.00
Fish meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Rice offal	6.00	6.00	5.00	7.00	7.00	8.00	7.00	5.00
Limestone	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Palm oil	0.00	2.00	4.00	6.00	0.00	2.00	4.00	6.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vit. Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DI-Methione	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis								
CP	24.00	24.00	24.00	24.00	26.00	26.00	26.00	26.00
ME	2600	2800	3000	3200	2600	2800	3000	3200
%EE	7.70	8.47	10.77	14.22	7.52	9.54	11.97	14.40
%CF	7.83	7.72	7.86	7.94	7.67	7.78	7.94	7.81
Avail P %	0.50	0.50	0.52	0.49	0.65	0.55	0.60	0.65
%Lysine	1.41	1.47	1.54	1.54	1.60	1.60	1.65	1.69

Key: CP = Crude protein, **ME =** Metabolism energy, **EE =** Ether extract, **CF =** Crude fiber, **Avail P=** Available protein

Table 3.2a Composition (%) of the experimental diets for laying phase

Ingredient	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**
Maize	44.00	43.00	45.00	50.00	40.00	44.00	46.00	47.00
G/Cake 44%	4.00	4.00	4.00	4.00	6.00	6.00	6.00	6.00
Full fat so	34.00	33.00	30.00	30.00	37.00	31.00	31.00	31.00
Fish meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Rice offal	9.00	9.00	8.00	1.00	8.00	8.00	4.00	1.00
Limestone	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Palm oil	0.00	2.00	4.00	6.00	0.00	2.00	4.00	6.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vit. Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DI-Methione	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis								
CP	20.00	20.00	20.00	20.00	22.00	22.00	22.00	22.00
ME	2600	2800	3000	3200	2600	2800	3000	3200
%EE	8.37	10.06	11.78	13.26	8.52	9.00	11.31	13.86
%CF	6.82	7.04	6.80	6.80	6.94	7.07	6.72	6.92
Avail P %	0.47	0.46	0.46	0.45	0.50	0.47	0.49	0.48
%Lysine	1.29	1.28	1.31	1.29	1.39	1.42	1.43	1.42

Key: CP = Crude protein, **ME** = Metabolism energy, **EE** = Eater extract, **CF** = Crude fiber, **Avail P=** Available

Table 3.2b Composition (%) of the experimental diets for laying phase

Ingredient	T9	T10	T11	T12	T13	T14	T15	T16
Maize	40.00	44.00	44.00	40.00	40.00	40.00	40.00	40.00
G/Cake 44%	8.00	8.00	8.00	8.00	10.00	10.00	10.00	10.00
Full fat so	35.00	32.00	31.00	31.00	35.00	31.00	31.00	31.00
Fish meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Rice offal	8.00	5.00	4.00	6.00	6.00	8.00	6.00	4.00
Limestone	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Palm oil	0.00	2.00	4.00	6.00	0.00	2.00	4.00	6.00
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vit. Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DI-Methione	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis								
CP	24.00	24.00	24.00	24.00	26.00	26.00	26.00	26.00
ME	2600	2800	3000	3200	2600	2800	3000	3200
%EE	7.70	8.47	10.77	14.22	7.52	9.54	11.97	14.40
%CF	6.83	6.92	7.06	7.04	6.87	6.98	7.04	7.11
Avail P %	0.50	0.50	0.52	0.49	0.65	0.55	0.60	0.65
%Lysine	1.41	1.47	1.54	1.54	1.60	1.60	1.65	1.69

Key: CP = Crude protein, **ME =** Metabolism energy, **EE =** Eater extract, **CF =** Crude fiber, **Avail P=** Available

3.4 Source of Experimental Ingredients

Maize, full fat soya, rice offal, palm oil and salt were purchased locally from Gwadabe Market, Minna. Groundnut cake, fish meal, bone meal, vitamin - premix and methionine are purchased at Farida Shop No. 7, GidanMatasa, BossoLowcost, Minna.

3.5 Management and Medication of Experimental Birds

Feed and water were given *ad libitum* throughout the experimental period. the cages were clean everyday and the water trough was also washed daily. The birds were given anti stress (glucose) as soon as they arrive. Before the arrival of the birds, the house was well clean and disinfected with broad spectrum virucidal disinfectant (Vinko Kill) 150ml: 30 liters of water to avoid transmission of diseases to the newly brought birds.

3.6 Experiment one (Growth phase)

A total of 576, two weeks old unsexed Japanese quail were used for this phase of the experiment. The birds were allotted to 16 dietary treatments with three replicates and each replicate having 12 birds making 36 birds per treatment.

Data on body weight, feed intake were measured and was used for calculating the body weight gain, feed intake and feed conversion ratio according to the procedure of Peter *et al.* (2006).

3.6.1 Weight change

The initial weight of the quails in each replicate were determined. Using aMettler analytical balance (Mettler Instruments Limited, model type PM 2000, Switzerland) at the start of the experiment and weekly thereafter. An empty carton was weighed to determine its weight before using it to weigh the birds in each replicate. The weight of the carton was subtracted from the weight of carton and birds, this weight was then divided by the number of birds in the replicate to get the average initial weight per bird.

3.6.2 Feed intake

The feed was weighed daily for each replicate and the quantity consumed for the day was obtained by subtracting the left over from the quantity supplied. Weekly record of average feed consumption (g) per bird was obtain for each replicate by dividing the total quantity of feed consumed (g) by the number of quail birds in each replicate.

3.6.3 Feed conversion ratio

Feed conversion ratio (FCR) were calculate on weekly basis by dividing the quantity of feed consumed by the weight gain of the birds in each replicate in grams.

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Total feed intake (g)}}{\text{Total weight gain (g)}} \quad \text{.................... Equation (1)}$$

3.6.4 Apparent digestibility trial

Digestibility study was carried out at the fourth week of the growing phase of the experiment by using total collection method. Two male birds in each of the replicate were weighed, isolated and placed in metabolic cages for seven days. The birds were allowed to acclimatize for three days and this was followed by four days of total collection period. Feed and water were given *ad libitum* and the total droppings were collected daily and air-dried before taken it to the oven for dry matter determination. Five grams each of the faecal collected and feed were analyzed for their proximate contents using AOAC (2000) methods. Results from the proximate analysis were used to estimate the apparent nutrient digestibility using the following equation.

Apparent nutrient digestibility (%) = $\frac{\text{Nutrient in feed ingested} - \text{nutrient in faeces voided}}{\text{Nutrient in feed ingested}} \times 100$ .... Equation (2)

3.6.5 Carcass characteristics

Carcass analysis was carried out on the last day of the fourth week of the experiment. When the birds were six weeks of age, a total of 96 quail birds were selected with two birds from each replicate and were kept off-feed for 12 hours (6pm - 6am), water was provided. The weights of the birds were taken before and after slaughtering through the jugular vein around the neck. After slaughtering the birds were scald in warm water at temperature of 70^{o}C for 10 second. They were then eviscerated. The measurement of the carcass traits were expressed as the percentage (%) of live weight according to Reda *et al.* (2015) who worked on effect of dietary protein, energy ans lysine intake on growth performance and carcass characteristics of growing Japanese quails.

3.7 Experiment two (Laying phase)

A total of 336, six weeks old female Japanese quails were used for this phase of the experiment. They were sexed by vent anatomy and plumage colour as described by. Shim (2005) and Mizutani (2003). The birds were allotted to 16 dietary treatments as described in experiment one, with three replicates and each replicate having 7 birds making 21 birds per treatment.

Data on feed intake, egg production and egg quality parameters were taken.

3.7.1 Feed Intake

Feed were weighed daily for the birds in each replicate and the quantity consumed for the day was obtained by subtracting the left over from the quantity supplied as described in experiment one.

3.7.2 Hen-day Egg Production (HDEP)

Hen-day production was calculated as the number of eggs laid per replicate on daily basis using the formulas reported by Bawa *et al*. (2010).

$$\text{HDEP} = \frac{\text{Total number of eggs laid in a day}}{\text{Total number of birds alive x Numbers of days in lay}} \times 100 \quad \text{.................. Equation (3)}$$

3.7.3 Hen-Housed Egg Production (HHEP)

Hen-Housed egg Production (HHEP) were calculated for each replicate using the formula

$$\text{HHEP} = \frac{\text{Total number of eggs laid in a day}}{\text{Number of birds stocked initially x Number of days in lay}} \times 100 \quad \text{................ Equation (4)}$$

3.7.4 Feed Conversion Ratio in terms of Feed Consumed per dozen eggs

Feed conversion ratio per gram egg mass were calculated as the ratio between the feed consumed and the egg weighed by Malik *et at*. (2010)

$$\text{FCR (per kg egg weight)} = \frac{\text{Average feed intake(g)}}{\text{(Averge egg weight (g)x Number of eggs laid)}} \quad \text{................ Equation (5)}$$

3.7.5 Egg Weight (g)

Eggs was collected from each replicate on daily basis and individually weighed using sensitive digital top load scale (Mettler Instrument Limited, model type PM 2000, Switzerland).

3.7.6 Egg Width (cm)

The egg width was measured using a vernier caliper(Metric vernier caliper). The width was measured between two ends of the widest cross-sectional region and the average taken as described by Adeyemo *et al*. (2009).

3.7.7 Egg Length (cm)

The egg length was measured with the help of a vernier caliper. The length was measured as the distance between the broad end and the narrow end of the egg.

3.7.8 Egg Shape Index

Two external parameters (egg width and length) were used to calculate the egg shape index as described by Adeyemo *et al*. (2009).

Egg shape index = $\frac{\text{Egg width (cm)}}{\text{Egg length (cm)}}$ .... Equation (6)

3.7.9 Yolk Height(mm), diameter (mm) and Index

Egg were carefully broken unto a clean smooth flat-surface. The yolk height was measured at the highest point of the yolk on the flat surface using a spherometer without removing the yolk from the albumen. The yolk diameter was measured using a vernier caliper.

Yolk index was calculated as the ratio of the yolk height to the yolk diameter (Bawa *et al*. 2010).

Yolk index = $\frac{\text{Height of yolk (cm)}}{\text{Diameter of yolk (cm)}}$ .... Equation (7)

3.7.10 Albumen Height(mm)

This were measured by using a tripod micrometer calibrated in 0.01 mm. The dimension was taken between the yolk edge and the external edge of the thick albumen as described by Markos *et al*. (2017)

3.7.11 Haugh Unit

The values obtained from the albumen height together with the egg weight were used to calculate the Haugh unit. The Haugh unit of egg was calculated using the formula of Haugh as reported by Oluyemi and Robert (2000).

HU = 100log (H+7.57 - 1.7 W0.37)

Where:

H = albumen height (mm)

W = weight of egg in gram

3.7.12 Yolk (mm)

Egg was carefully broken into a flat dish. The length yolk will be measured from the points where they meet to the point it ends by using a pair of vernier caliper.

3.7.13 Albumen Weight and Yolk Weight (g)

Egg was carefully broken unto a petri dish and the yolk and albumen was placed in separate petri dishes which was weighed before use. The difference in the weight of each Petri dish before after the introduction of the yolk and albumen was taken as weight of the yolk and albumen, respectively. The weight were taken with the aid of Mettler analytical balance (Mettler Instruments Limited, model type PM 2000, Switzerland)

3.7.14 Shell weight (g)

The shell weight was taken after air drying. The Mettler analytical balance made by Mettler Instruments Limited, model type PM 2000, Switzerland was used; calibrated in grams.

3.7.15 Shell Thickness

The shells of broken eggs were air-dried and then further broken into smaller pieces. The shell's membrane was manually removed and the thickness of the egg shell were measured from three different portion of the shell using a micrometer screw gauge, expressed in millimeters. (Adeyemo *et al.,* 2009).

3.8 Proximate Analysis

This is to determine the dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE), ash and nitrogen free extract (NFE) of the experiment diets used in both growing phase and laying phase of the experiment as well as the droppings for the digestibility trial which was carried out in Animal Production laboratory in Federal University of Technology Minna, in accordance with the AOAC (2000) standard procedure.

3.9 Data Analysis

All data collected from the two experiments were subjected to a two-Way Analysis of Variance (ANOVA) using SAS statistical package (SAS, 2003) as a 4×4 factorial arrangement in a completely randomized design. Significant means were separated using Duncan multiple range test at $P<0.05$. The following model was use.

$Y_{ijk} = \mu + P_i + E_j + (PE)_{ij} + \mathcal{E}_{ijk}$ $i = 1...4, p;\ j = 1...4, e; k = 1...16, n$

where:

Y_{ijk}=observation k in level i of factor P and level j of factor E

μ = the overall mean

P_i = the effect of level i of factor P

E_j = the effect of level of j of factor E

$(PE)_{ij}$ = the effect of the interaction level i of factor P with level j of factor E

$\mathcal{E}_{ijk}$ = random error with mean 0 and variance o^2

p = number of levels of factor P; e = number of levels of factor E; n = number of observation for each P x E combination.

CHAPTER FOUR

4.0 RESULTS

4.1 Proximate Composition of the Experimental Diets One

The chemical composition of the experimental diets on dry matter basis is shown in table 4.1. The dry matter of the diet ranged from 93.00 to 94.50 % across the 16 treatments. Crude protein ranged from 18 to 26 %, while the crude fibre, ether extract, ash and nitrogen free extract ranged from 2.00 to 4.50 %, 12.50 to 14.50 %, 8.00 to 10.00 % and 35.25 to 45.95 respectively.

4.2 Proximate Composition of the Experimental Diets Two

The chemical composition of the experimental diet on dry matter basis is shown in table 4.2. The dry matter of the diet ranged from 93.50 to 94.50 % across the 16 treatments. Crude protein ranged from 20 to 26 %, while the crude fibre, ether extract, ash and nitrogen free extract ranged from 2.00 to 4.00 %, 12.50 to 14.50 %, 8.50 to 10.00 % and 38.55 to 46.50 respectively.

4.3 Main Effect of Different Dietary Protein and Energy Levels on the Growth Performance of Japanese Quails

The results of the main effect of different dietary protein and energy levels on the growth performance of Japanese quails are presented in Table 4.3. In all the growth performance parameters measured, there were no significant ($p>0.05$) differences observed in the treatment groups.

4.4 Interaction Effect of Different Dietary Protein and Energy Levels on the Growth Performance of Japanese Quails

The interaction results between different dietary protein and energy levels on the growth performance of Japanese quails are presented on Table 4.4. The results showed that there was no ($p>0.05$) interaction between dietary protein and energy levels in all the growth performance parameters measured.

4.5 Main Effect of Different Dietary Protein and Energy Levels on the Nutrient Digestibility of Japanese Quails

The results of the main effect of different dietary protein and energy levels on the nutrient digestibility of Japanese quails are presented on Table 4.5. All the nutrient digestibility results were influenced ($p<0.05$) by dietary protein levels except the ash digestibility. However, only crude protein (CP), ether extract (EE) and nitrogen free extract (NFE) were influenced ($p<0.05$) by dietary energy levels.

Dry matter (DM) results showed that birds on 20, 24 and 26 % CP levels had similar ($p>0.05$) digestibility. Birds on 22 and 26 % CP levels also had similar ($p>0.05$) DM digestibility results. However, birds on 22 % CP level had higher ($p<0.05$) dry matter digestibility than birds on 20 and 24 % CP levels.

Birds on 22 % CP level had higher ($p<0.05$) crude protein digestibility than all other treatments. Birds on 26 % CP had higher ($p<0.05$) crude protein digestibility than birds on 20 and 24 % CP levels which had similar($p>0.05$) crude protein digestibility.

Crude fibre (CF) results showed that birds on 20 % CP level had the lowest CF digestibility, they were significantly ($p<0.05$) lower than those birds on 22, 24 and 26 % CP levels which had similar ($p>0.05$) values.

The ether extract result showed that birds on 20, 22 and 26 % CP levels had similar ($p>0.05$) ether extract digestibility. Birds on 20 and 24 % CP levels had also similar ($p<0.05$) ether extract digestibility. However, birds on 22 and 26 % CP had higher ($p>0.05$) ether extract which had similar digestibly than the birds on 24 % CP level.

Birds on 20 and 24 % CP levels had similar ($p>0.05$) NFE digestibility results. Similarly birds on 20 and 26 % CP levels also had similar ($p>0.05$) NFE digestibility results. However, birds on 24 % CP level had higher ($p<0.05$) NFE digestibility than birds on 20, 22 and 26 % CP levels.

The CP digestibility results showed that birds on 3200 ME / Kcal/kg energy level had higher ($p<0.05$) CP digestibility than all the other treatments. Also birds on 2800 ME / Kcal/kg energy level had high ($p<0.05$) % CP digestibility than birds on 2600 and 3000 ME / Kcal/kg energy levels which had similar ($p>0.05$) values.

The EE digestibility results showed that birds on 2600 ME /Kcal level had higher ($p<0.05$) EE digestibility than all the other treatments which had similar ($p>0.05$) values. Birds on 2600 and 3000 ME /Kcal/kg had similar ($p>0.05$) NFE digestibility, the values where however higher ($p>0.05$) than those birds on 2800 and 3200 ME / Kcal/kg which also had similar ($p<0.05$) NFE digestibility result.

4.6 Interaction Effect of Different Dietary Protein and Energy Levels on the Nutrient Digestibility of Japanese Quails

The interaction results between different dietary protein and energy levels on the nutrient digestibility of Japanese quails are presented on Table 4.6. All the parameter measured were influenced ($p<0.05$) by the interaction between dietary protein and energy levels. However, dry matter digestibility parameters were not ($p>0.05$) affected.

Birds on 22 % CP / 2800 ME / Kcal/kg and 26 % CP / 3200 ME / Kcal/kg had higher ($p<0.05$) CP digestibility results than other treatments except birds on 20 % CP / 2600 ME / Kcal/kg which had similar ($p>0.05$) CP digestibility. Birds on 24 % CP / 3000 ME / Kcal/kg had the least CP digestibility and their value was ($p<0.05$) lower than all the other treatments except birds on 24 % CP / 2600 ME / Kcal/kg which had similar ($P> 0.05$) results.

The crude fibre results showed that birds on 22 % CP / 3000 ME / Kcal/kg and 26 % CP / 2600 ME / Kcal/kg levels had higher ($p<0.05$) crude fibre digestibility than most of the other treatments except those on 22 % CP / 2800 ME / Kcal/kg, 22 % CP / 3200 ME / Kcal/kg, 24 % CP / 2800 ME / Kcal/kg, 24 % CP / 3000 ME / Kcal/kg, 24 % CP / 3200 ME / Kcal, 26 % CP / 2800 ME / Kcal/kg, 26 % CP / 3000 ME / Kcal/kg and 26 % CP / 3200 ME / Kcal/kg had similar ($p>0.05$) CF digestibility. However, birds on 20 % CP / 3000 ME / Kcal/kg level had the least crude fibre digestibility and the result was lower ($p<0.05$) than all other treatments.

Table 4.1 Proximate composition of the experimental diets (Growth phase)

Parameters	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16
DM (%)	93.51	94.05	93.00	94.00	94.00	93.90	94.50	93.90	94.40	94.90	93.90	94.50	94.00	94.50	93.80	93.79
CP (%)	20.00	20.02	20.00	20.03	22.04	22.00	22.00	22.02	24.05	24.00	24.04	24.03	26.02	26.01	25.98	26.03
CF (%)	3.00	4.00	3.05	3.00	2.50	3.00	3. 50	4.50	3.00	2.50	2.50	4.50	4.00	4.00	4.00	3.05
EE (%)	14.00	13.50	13.40	13.00	13.00	12.80	13.00	12.50	13.50	14.00	14.00	14.00	13.50	14.50	14.50	14.00
Ash (%)	9.90	10.00	9.50	8.50	10.00	9.50	9.50	9.00	8.50	9.50	8.50	9.00	10.00	8.00	9.00	9.00
NFE (%)	46.88	46.30	46.50	45.57	46.46	46.60	46.50	45.88	45.35	44.90	44.86	42.97	40.48	41.99	40.32	41.26
ME (Kcal/kg)	2600	2800	3000	3200	2600	2800	3000	3200	2600	2800	3000	3200	2600	2800	3000	3200

Key

DM = Dry matter

CP = Crude protein

CF = Crude fiber

EE = Ether extract

NFE = Nitrogen free extract

ME = Metabolizable energy

Table 4.2 Proximate composition of the experimental diets (Laying phase)

Parameters	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16
DM (%)	93.50	93.58	93.60	93.60	94.00	93.90	94.00	93.70	94.40	93.90	93.60	94.20	94.50	93.50	93.80	93.79
CP (%)	20.00	20.02	20.00	20.03	22.04	22.00	22.00	22.02	24.04	24.00	24.04	24.03	26.02	26.01	25.95	26.03
CF (%)	4.00	3.00	3.50	3.50	3.00	4.00	3.50	4.50	3.50	2.50	3.00	4.00	4.00	3.50	4.00	3.00
EE (%)	13.00	13.10	13.40	13.20	13.00	13.50	13.00	12.50	13.50	14.00	13.80	14.00	13.50	14.50	14.00	14.50
Ash (%)	9.90	9.00	9.50	9.40	10.00	9.50	9.50	8.50	8.00	9.50	8.50	9.00	10.00	9.00	9.00	9.00
NFE (%)	46.60	45.30	46.00	46.67	45.96	44.90	46.00	46.18	45.00	43.90	43.86	43.69	40.98	44.49	40.85	41.26
ME (Kcal/kg)	2600	2800	3000	3200	2600	2800	3000	3200	2600	2800	3000	3200	2600	2800	3000	3200

Key

DM = Dry matter

CP = Crude protein

CF = Crude fiber

EE = Ether extract

NFE = Nitrogen free extract

ME = Metabolizable energy

Table 4.3 Main effect of dietary protein and energy on performance of Japanese Quails

Treatments	Initial Weight (g)	Final Weight (g)	Weight Gain (g)	Daily weight Gain (g/d/bird)	Total feed Intake	Daily feed Intake (g/d/bird)	F.C.R
Effect of protein							
20.00	20.23	84.16	63.94	1.52	892.89	21.26	0.33
22.00	20.27	84.83	64.56	1.53	893.01	21.26	0.32
24.00	20.25	84.63	64.38	1.53	915.44	21.80	0.34
26.00	20.24	84.06	64.82	1.54	903.16	21.50	0.33
SEM	0.02	0.66	0.65	0.02	20.92	0.50	0.06
p. value	0.81	0.81	0.83	0.82	0.85	0.85	0.93
Effect of energy							
2600	20.26	83.91	63.65	1.52	928.44	22.11	0.33
2800	20.24	84.14	63.90	1.53	926.41	22.06	0.34
3000	20.24	84.94	64.70	1.54	883.61	21.04	0.33
3200	20.26	84.53	64.27	1.53	865.95	20.62	0.32
SEM	0.03	0.66	0.65	0.02	20.92	0.50	0.06
p. value	0.86	0.71	0.70	0.68	0.12	0.12	0.34

Table 4.4 Interaction effect of dietary protein and energy on performance of Japanese Quails

Protein (%)	Energy Kcal/kg ME	Initial Weight (g)	Final Weight (g)	Weight Gain (g)	Daily weight Gain (g/d/bird)	Total feed Intake (g)	Daily feed Intake (g)	F.C.R
20.00	2600	20.21	84.35	64.14	1.54	875.90	20.85	0.33
	2800	20.21	83.56	63.35	1.51	935.44	22.27	0.34
	3000	20.25	84.71	64.50	1.54	880.58	20.97	0.33
	3200	20.29	82.80	62.55	1.49	879.63	20.94	0.34
22.00	2600	20.25	85.15	64.86	1.54	982.17	23.38	0.32
	2800	20.21	85.29	65.04	1.55	910.70	21.68	0.32
	3000	20.33	85.25	63.31	1.55	842.45	20.06	0.33
	3200	20.25	83.64	63.31	1.51	836.71	19.92	0.32
24.00	2600	20.25	83.62	63.37	1.51	954.00	22.71	0.33
	2800	20.25	83.89	63.14	1.51	937.74	22.33	0.33
	3000	20.25	85.89	65.64	1.56	883.80	21.04	0.33
	3200	20.25	85.62	65.37	1.50	886.20	21.10	0.33
26.00	2600	20.25	85.28	65.03	1.55	901.70	21.47	0.33
	2800	20.25	84.33	64.04	1.53	921.75	21.95	0.33
	3000	20.25	82.89	62.64	1.49	927.93	22.09	0.34
	3200	20.21	83.74	63.53	1.50	861.25	20.51	0.33
SEM		0.06	1.31	1.30	0.03	41.85	1.00	0.11
p. value		0.98	0.63	0.61	0.62	0.70	0.68	0.64

Table 4.5 Main effect of dietary protein and energy on digestibility of the diet of Japanese Quails

Treatments	Dry matter	Crude protein	Crude fibre	Ether extract	Ash	NFE
Effect of crude protein						
20.00	80.46^{b}	69.72^{c}	34.36^{b}	86.90^{ab}	65.36	89.37^{ab}
22.00	82.10^{a}	78.86^{a}	57.31^{a}	87.77^{a}	70.22	85.44^{c}
24.00	80.78^{b}	66.48^{c}	48.25^{a}	86.75^{b}	68.76	91.07^{a}
26.00	81.21^{ab}	76.44^{b}	59.04^{a}	87.75^{a}	67.28	88.50^{b}
SEM	0.38	0.67	4.37	0.29	1.30	0.74
p. value	0.04	0.04	0.02	0.04	0.09	0.02
Effect of energy						
2600	81.32	68.63^{c}	38.96	88.47^{a}	66.68	91.52^{a}
2800	80.67	75.64^{b}	50.90	86.31^{b}	67.40	85.89^{b}
3000	81.19	67.87^{c}	39.59	87.22^{b}	68.88	90.66^{a}
3200	81.36	79.41^{a}	46.52	87.16^{b}	68.65	86.31^{b}
SEM	0.13	0.67	4.37	0.29	1.30	0.74
p. value	0.55	0.03	1.00	0.001	0.60	0.04

abc means on the same column having different superscript differs significantly ($p<0.05$); SEM = standard error of mean

Table 4.6 Interaction effect of dietary protein and energy on nutrient digestibility diet of Japanese Quails

Protein (%)	Energy Kcal/kg ME	Dry matter	Crude protein	Crude fibre	Ether extract	Ash	NFE
20.00	2600	80.51	72.66^{abc}	25.55^{d}	87.52^{cd}	61.59^{de}	88.97^{abc}
	2800	79.23	68.55^{cde}	36.32^{bcd}	84.37^{f}	66.07^{bcde}	87.17^{cd}
	3000	80.36	65.49^{ef}	19.62^{e}	87.48^{bcd}	66.49^{bcde}	92.31^{abc}
	3200	81.72	72.19^{bcd}	23.20^{d}	88.24^{bcd}	67.31^{abcde}	89.05^{bc}
22.00	2600	82.34	67.71^{de}	37.06^{bcd}	88.54^{abc}	70.42^{abcd}	93.13^{ab}
	2800	82.46	97.63^{a}	64.31^{ab}	89.31^{ab}	68.09^{abcd}	75.53^{f}
	3000	82.96	76.13^{b}	64.43^{a}	86.85^{cde}	74.94^{ab}	89.55^{abc}
	3200	80.63	73.96^{b}	60.46^{abd}	86.37^{de}	67.44^{abcde}	83.55^{de}
24.00	2600	80.40	62.47^{fg}	33.29^{cd}	87.41^{bcd}	58.75^{f}	94.19^{a}
	2800	79.47	68.24^{cde}	45.26^{abc}	83.88^{f}	70.11^{abcd}	87.58^{cd}
	3000	80.46	60.64^{g}	51.77^{abc}	87.12^{cde}	71.70^{abc}	90.73^{abc}
	3200	82.81	74.59^{b}	62.68^{abc}	88.57^{abc}	74.48^{ab}	91.77^{abc}
26.00	2600	82.02	71.67^{bcd}	69.95^{a}	90.41^{a}	75.97^{a}	89.81^{abc}
	2800	81.52	68.12^{cde}	57.73^{abc}	87.70^{bcd}	65.35^{cde}	93.27^{ab}
	3000	81.00	69.05^{cde}	58.77^{abc}	87.45^{bcd}	62.39^{de}	90.07^{abc}
	3200	80.29	96.91^{a}	49.73^{abc}	85.45^{ef}	65.39^{cde}	80.86^{e}
SEM		0.75	1.35	8.68	0.58	2.59	1.48
p. value		0.07	0.04	0.01	0.04	0.003	0.01

abc means on the same column having different superscript differs significantly ($p<0.05$); SEM = standard error of mean

Ether extract result showed birds on 26 % CP / 2600 ME / Kcal/kg level had higher ($p<0.05$) ether extract digestibility than all the other treatments except birds on 22 % CP / 2600 ME / Kcal/kg, 22 % CP / 2800 ME / Kcal/kg and 24 % CP / 3200 ME / Kcal/kg levels which had similar ($p>0.05$) ether extract digestibility. Birds on 20 % CP / 2800 ME / Kcal/kg and 24 % CP / 2800 ME / Kcal/kg levels had the least ether extract digestibility and their results were lower ($p<0.05$) than all the other treatments except birds on 26 % CP / 3200 ME / Kcal/kg level which had similar ($p>0.05$) results.

Birds on 26 % CP / 2600 ME / Kcal/kg level had higher ($p<0.05$) ash digestibility results than other treatments except birds on 20 % CP / 3200 ME / Kcal/kg, 22 % CP / 2600 ME / Kcal/kg, 22 % CP / 2800 ME / Kcal/kg, 22 % CP / 3000 ME / Kcal/kg, 22 % CP / 3200 ME / Kcal/kg, 24 % CP / 2800 ME / Kcal/kg, 24 % CP / 3000 ME / Kcal/kg and 24 % CP / 3200 ME / Kcal/kg had similar ($p>0.05$) ash digestibility. However, birds on 24 % CP / 2600 ME / Kcal/kg had the least ($p<0.05$) ash digestibility.

The NFE results showed that birds on 24 % CP / 2600 ME / Kcal/kg level had higher ($p<0.05$) NFE digestibility than all other treatments except those birds on 20 % CP / 2600 ME / Kcal/kg, 20 % CP / 3000 ME / Kcal/kg, 22 % CP / 2600 ME / Kcal/kg, 22 % CP / 3000 ME / Kcal/kg, 24 % CP / 3000 ME / Kcal/kg, 24 % CP / 3200 ME / Kcal/kg, 26 % CP / 2600 ME / Kcal/kg, 26 % CP / 2800 ME / Kcal/kg and 26 % CP / 3000 ME / Kcal/kg levels had similar ($p>0.05$) NFE digestibility. However, birds on 22 % CP / 2800 ME / Kcal/kg level had lower ($p<0.05$) NFE digestibility than all other treatments.

4.7 Main Effect of Different Dietary Protein and Energy Levels on the Carcass Characteristics of Japanese Quails

The results of the main effect of different dietary protein and energy levels on the carcass characteristics of Japanese quails are presented in Table 4.7. In all the carcass parameters measured, there was no significant ($p>0.05$) differences observed between the treatment groups on the carcass characteristics.

4.8 Interaction Effect of Different Dietary Protein and Energy Levels on the Carcass Characteristics of Japanese Quails

The interaction results between different dietary protein and energy levels on the carcass characteristics of Japanese quails are presented on Table 4.8. The results showed that there was no ($p>0.05$) interaction between dietary protein and energy levels in all the carcass characteristics parameters measured.

4.9 Main Effect of Different Dietary Protein and Energy Levels on Egg Production Parameters of Japanese Quails

The results of the main effect of different dietary protein and energy levels on the egg production parameters of Japanese quails are presented on Table 4.9. In all the egg production parameters (Total egg collected, Egg per day, Average feed intake per egg, Hen day egg production, Hen housed egg production, FCR per egg and FCR per dozen of egg) measured, there were no significant difference.

Table 4.7 Main effect of dietary protein and energy on carcass characteristics of Japanese Quails

Treatment	Live Weight(g)	Slaughter weight(g)	Eviscerated weight(g)	Dressing %	Breast Weight(%)	Back weight(%)	Wing Weight(%)	Drum Stick(%)	Thigh Weight(%)
Protein									
20.00	82.63	73.50	66.25	80.29	34.82	16.83	17.12	17.43	25.15
22.00	80.88	69.38	63.88	79.10	35.00	18.41	18.71	18.11	27.60
24.00	81.25	70.25	64.88	78.83	34.56	18.19	18.16	18.19	25.59
26.00	80.13	68.88	64.13	80.03	34.74	18.62	18.31	18.32	26.77
SEM	1.41	1.59	1.55	1.69	0.61	0.45	0.31	0.46	0.62
p. value	0.66	0.25	0.70	0.96	0.79	0.63	0.57	0.97	0.62
Energy									
2600	81.63	71.00	64.88	79.52	34.79	17.82	17.56	18.19	26.46
2800	82.00	71.25	65.00	79.25	34.78	17.86	18.09	17.85	26.46
3000	79.50	69.13	64.25	80.91	36.05	18.80	18.85	18.05	25.77
3200	81.75	70.38	65.00	79.57	33.51	17.52	17.78	18.12	26.35
SEM	1.41	1.59	1.55	1.69	0.61	0.45	0.31	0.46	0.62
p. value	0.58	0.78	0.93	0.90	0.48	0.74	0.43	0.96	0.87

Table 4.8 Interaction effect of dietary protein and energy on carcass of Japanese Quails

Protein (%)	**Energy Kcal/kg**	Live Weight(g)	S.ter Weight(g)	Eviscerated Weight(g)	Dressing %	Breast Weight(%)	Back Weight(%)	Wing Weight(%)	Drum Stick(%)	Thigh Weight(%)
20.00	2600	83.00	71.50	66.00	78.53	36.86	17.21	16.14	17.35	26.56
	2800	85.00	73.50	66.50	79.96	33.29	16.71	16.57	17.76	26.36
	3000	82.00	72.00	66.00	80.74	35.61	17.20	17.24	17.24	26.56
	3200	79.50	72.00	65.00	81.95	34.31	16.57	18.94	17.77	26.97
22.00	2600	82.00	71.50	66.00	80.49	34.02	17.24	18.36	17.24	26.56
	2800	82.50	71.00	62.50	75.82	38.42	19.25	19.18	19.25	28.05
	3000	75.00	64.50	61.50	82.10	38.36	20.41	21.14	19.54	28.50
	3200	84.00	74.50	68.50	79.01	31.23	16.70	15.61	15.61	25.59
24.00	2600	82.00	70.50	65.50	79.88	35.86	17.47	16.32	17.51	26.76
	2800	79.50	69.50	63.00	79.29	35.35	18.87	20.21	19.00	27.83
	3000	80.50	70.50	65.50	81.33	33.80	18.67	18.67	17.47	26.76
	3200	83.00	70.50	65.50	78.83	32.96	17.77	17.54	18.82	26.76
26.00	2600	78.50	66.50	62.00	79.19	35.19	19.48	19.48	20.84	28.27
	2800	81.00	71.00	66.50	81.96	33.11	17.17	16.98	15.94	26.36
	3000	80.50	69.50	64.00	79.48	36.61	19.05	18.45	17.16	27.39
	3200	80.50	68.50	64.00	79.49	34.14	18.30	18.36	19.55	27.39
SEM		2.83	3.17	3.10	3.37	1.23	0.91	0.63	0.91	1.23
p. value		0.59	0.89	0.93	0.96	0.54	1.00	0.19	0.66	0.95

Table 4.9 Main effect of dietary protein and energy on egg performance of Japanese Quails

Treatment	Egg Total	Egg Per Day	AFI Per Egg	HDEP (%)	HHEP (%)	FCR Per Egg	FCR Per Dozens of egg
Protein							
20.00	73.88	1.76	28.40	70.00	70.00	0.04	0.00
22.00	77.36	1.84	27.89	73.00	73.00	0.04	0.00
24.00	78.88	1.88	28.26	75.00	75.00	0.04	0.00
26.00	78.25	1.86	27.50	74.00	74.00	0.04	0.00
SEM	1.30	0.03	0.24	0.01	0.01	0.00	0.00
p. value	0.06	0.12	0.07	0.06	0.15	0.09	0.13
Energy							
2600	77.00	1.83	28.42	73.00	73.00	0.04	0.00
2800	75.50	1.80	27.89	71.00	71.00	0.04	0.00
3000	79.88	1.90	28.26	75.00	75.00	0.04	0.00
3200	76.00	1.81	27.87	72.00	72.00	0.04	0.00
SEM	1.30	0.03	0.24	0.01	0.01	0.00	0.00
p. value	0.12	0.13	0.09	0.12	0.12	0.54	0.18

ab means on the same column having different superscript differs significantly ($p<0.05$); SEM = standard error of mean, HDEP = Hen day egg production, HHEP = Hen housed egg production, FCR = Feed conversion ratio, AFI = Average feed intake.

($p>0.05$) by dietary protein levels. However, only average feed intake (AFI) per egg were influenced ($p<0.05$) by dietary energy levels.

Birds on 2600 and 3000 ME / Kcal/kg levels energy had similar ($p>0.05$) average feed intake per egg. Birds on 2800 and 3000 ME / Kcal /kg had similar ($p>0.05$) average feed intake per egg results. However, birds on 2600 ME / Kcal/kg had higher ($p<0.05$) average feed intake per egg than those on 2800 and 3200 ME / Kcal treatments.

4.10 Interaction Effect of Different Dietary Protein and Energy Levels on Egg Production Parameters of Japanese Quails

The interaction results between different dietary protein and energy levels on the egg production parameters of Japanese quails are presented on Table 4.10. In all the dietary protein and energy levels had no ($p>0.05$) interaction on all the egg production parameters measured.

4.11 Main Effect of Different Dietary Protein and Energy Levels on the External Egg Parameters of Japanese Quails

The main effect of different dietary protein and energy levels on the external egg parameters of Japanese quails are presented in Table 4.11. The results showed that the dietary crude protein and energy levels treatments on egg length, egg width and egg shape index were influenced ($p<0.05$). However, the treatments had no significant ($p>0.05$) effect on egg weight, shell weight, shell thickness and egg mass.

Egg length result showed that birds on 20 and 22 % CP levels had similar ($p>0.05$) values, their length was however longer ($p<0.05$) than birds on 24 and 26 % CP levels which had similar ($p>0.05$) egg length.

Birds on 20 and 22 % CP levels had higher similar width, than which was wider ($p<0.05$) than those on other treatments. Birds on 24 % CP level had wider ($p<0.05$) egg width than birds on 26 % CP level had the least egg width.

Egg shape index result showed that birds on 22 and 24 % CP levels had similar ($p<0.05$) egg shape index the values were, however, higher than those birds on 20 and 26 % CP levels which had similar ($p>0.05$) egg shape index.

The egg length results showed that birds on 2600 ME /Kcal/kg energy level had longer ($p<0.05$) egg length then all other treatments. Birds on 2800 and 3000 ME /Kcal/kg levels had similar ($p>0.05$) egg length result. However, birds on 3200 ME /Kcal/kg had the least ($p<0.05$) egg length values which is significantly ($p<0.05$) shorter than all other treatments.

Birds on energy level of 3000 ME /Kcal/kg had the lowest ($p<0.05$) egg width result than those birds on 2600, 2800 and 3200 ME /Kcal/kg levels which had similar ($p>0.05$) egg width values.

Egg shape index result showed that birds on 2800 and 3200 ME /Kcal levels had similar ($p>0.05$) values, there values were, however, higher ($p<0.05$) than those birds on 2800 and 3000 ME /Kcal levels which had similar ($p>0.05$) egg shape index results

Table 4.10 Interaction effect of dietary protein and energy on egg performance of Japanese Quails

Protein (%)	Energy Kcal/kg ME	Egg Total	Egg Per Day	AFI Per Egg	HDEP (%)	HHEP (%)	FCR Per Egg	FCR Per Dozens of egg
20.00	2600	70.50	1.68	28.89	67.00	67.00	0.05	0.00
	2800	73.50	1.65	28.94	69.00	69.00	0.04	0.00
	3000	74.50	1.77	28.32	70.00	70.00	0.04	0.00
	3200	77.00	1.83	27.44	73.00	73.00	0.04	0.00
22.00	2600	77.50	1.85	28.60	73.00	73.00	0.04	0.00
	2800	75.00	1.79	27.56	71.00	71.00	0.04	0.00
	3000	80.00	1.90	28.11	76.00	76.00	0.04	0.00
	3200	77.00	1.83	27.29	73.00	73.00	0.04	0.00
24.00	2600	82.00	1.95	29.08	77.00	77.00	0.04	0.00
	2800	73.00	1.75	27.96	69.00	69.00	0.04	0.00
	3000	83.00	1.98	28.97	78.00	78.00	0.04	0.00
	3200	77.00	1.83	27.03	73.00	73.00	0.04	0.00
26.00	2600	78.00	1.86	28.46	74.00	74.00	0.04	0.00
	2800	80.00	1.90	26.72	76.00	76.00	0.04	0.00
	3000	82.00	1.95	27.64	77.00	77.00	0.04	0.00
	3200	73.00	1.74	27.17	69.00	69.00	0.04	0.00
SEM		2.60	0.06	0.48	0.02	0.02	0.00	0.00
p. value		0.22	0.22	0.57	0.22	0.22	0.49	0.26

abc means on the same column having different superscript differs significantly ($p<0.05$); SEM = standard error of mean, HDEP = Hen day egg production, HHEP = Hen housed egg production, FCR = Feed conversion ratio, AFI = Average feed intake.

4.12 Interaction Effect of Different Dietary Protein and Energy Levels on the External Egg Parameters of Japanese Quails

The interaction results between different dietary protein and energy levels on the external egg parameters of Japanese quails are presented on Table 4.12. Dietary protein and energy interaction had effect ($p<0.05$) on egg length, egg width and egg shape index. However, egg weight, shell weight, shell thickness and egg mass were not ($p>0.05$) affected by dietary protein and energy interaction.

Egg length result showed that, birds on 26 % CP / 2600 ME Kcal/kg level had higher ($p<0.05$) egg length results than all other treatments except for birds on 20 % CP / 2600 ME /Kcal.kg level had similar ($p>0.05$) egg length. Birds on 26 % CP / 3200 ME/Kcal/kg level energy had the lowest ($p<0.05$) egg length and their result was similar to those birds on 20 % CP / 3000 ME/Kcal and 24 % CP / 2800 ME/Kcal/kg levels which had similar ($p>0.05$) egg length results.

The egg width result showed that birds on 20 % CP / 2600 ME /Kcal/kg, 20% CP / 2800 ME /Kcal/kg, 22 % CP / 2800 ME/Kcal/kg and 22% CP / 3200 ME /Kcal/kg levels had wider ($p>0.05$) egg width results than all other treatments except birds on 20 % CP / 3000 ME/Kcal/kg, 22 % CP / 3000 ME/Kcal/kg, 24 % CP / 2600 ME/Kcal/kg, 24 % CP / 2800 ME/Kcal/kg, 26 % CP / 2600 ME/Kcal/kg and 26 % CP / 3200 ME/Kcal levels had similar ($p>0.05$) egg width results. Birds on 26 % CP / 3000 ME/Kcal/kg level had the lowest ($p<0.05$) egg width, their values were, however, similar ($p>0.05$) to those on 22 % CP / 2600 ME/Kcal/kg, 24 % CP / 3000 ME/Kcal/kg and 24 % CP / 3200 ME/Kcal/kg.

Egg shape index result showed that birds on 24 % CP / 2800 ME/Kcal/kg and 26 % CP / 3200 ME/Kcal levels had higher ($p>0.05$) egg shape index results. Birds on 24 % CP / 3200 ME/Kcal/kg and 26 % CP / 2800 ME/Kcal/kg levels had the lowest ($p>0.05$) egg shape index than all other treatments except birds on 22 % CP / 2600 ME/Kcal/kg and 26 % CP / 2800 ME/Kcal/kg which had similar ($p>0.05$) results.

4.13 Main Effect of Different Dietary Protein and Energy Levels on Internal Egg Parameters of Japanese Quails

The results of the main effect of dietary protein and energy levels on the internal egg parameters of Japanese quails is presented in table 4.13. The result showed that all the dietary crude protein and energy levels treatments were influenced significantly ($P<0.05$) by dietary protein and energy levels. However, the treatments had no effect ($p>0.05$) on yolk and albumen weight and Haugh unit.

Yolk weight result showed that birds on 24 % CP level had higher ($P<0.05$) yolk weight than all other treatments. Birds on 22 and 26 % CP levels had similar ($P>0.05$) yolk weight results.

However, birds on 20 % CP level had least yolk weight which is significantly ($p<0.05$) lower than all other treatments.

Birds on 26 % CP level had higher ($p<0.05$) albumen weight than all other treatments. Birds on 24 % CP level had higher ($p<0.05$) albumen weight result than 20 and 22 % CP levels. However, birds on 20 % CP level had lowest ($p<0.05$) albumen weight results.

Table 4.11 Main effect of dietary protein and energy on external egg characteristics of Japanese Quails

Treatment	Egg weight (g)	Egg length (cm)	Egg width (cm)	Egg shape Index	Shell Weight (g)	Shell thickness (mm)	Egg mass
20.00	9.31	2.67^{a}	2.17^{a}	0.81^{b}	1.04	0.15	16.37
22.00	9.40	2.67^{a}	2.18^{a}	0.82^{a}	1.04	0.15	17.31
24.00	9.42	2.64^{b}	2.16^{b}	0.82^{a}	1.04	0.15	17.71
26.00	9.60	2.63^{b}	2.14^{c}	0.81^{b}	1.04	0.15	17.88
SEM	0.21	0.00	0.00	0.00	0.06	0.00	2.00
p. value	0.78	0.02	0.04	0.02	0.15	0.67	0.15
Energy							
2600	9.69	2.70^{a}	2.18^{a}	0.81^{b}	1.04	0.15	17.79
2800	9.50	2.65^{b}	2.18^{a}	0.82^{a}	1.04	0.15	17.08
3000	9.51	2.64^{b}	2.13^{b}	0.81^{b}	1.04	0.15	18.09
3200	9.52	2.63^{c}	2.16^{a}	0.82^{a}	1.04	0.15	16.33
SEM	0.21	0.00	0.00	0.00	0.06	0.00	2.71
p. value	0.16	0.01	0.01	0.03	0.31	0.96	0.08

ab means on the same column having different superscript differs significantly ($p<0.05$); SEM = standard error of mean.

Table 4.12 Interaction effect of dietary protein and energy on external egg characteristics of Japanese Quails

Protein (%)	Energy Kcal/kg ME	Egg weight (g)	Egg length (cm)	Egg width (cm)	Egg shape Index	Shell weight (g)	Shell thickness (mm)	Egg mass
20.00	2600	9.08	2.73^{ab}	2.20^{a}	0.81^{e}	1.00	0.15	15.25
	2800	9.67	2.69^{bc}	2.19^{a}	0.82^{cde}	1.00	0.15	16.94
	3000	9.81	2.65^{cd}	2.16^{abc}	0.82^{cde}	1.00	0.15	17.39
	3200	8.67	2.61^{cde}	2.14^{bc}	0.82^{cd}	1.17	0.15	15.91
22.00	2600	9.67	2.65^{cd}	2.13^{cd}	0.80^{efg}	1.00	0.15	17.84
	2800	9.67	2.72^{b}	2.20^{a}	0.81^{de}	1.00	0.15	17.24
	3000	8.92	2.64^{cd}	2.17^{abc}	0.82^{cd}	1.17	0.15	16.98
	3200	9.33	2.67^{bcd}	2.22^{a}	0.83^{b}	1.17	0.15	17.16
24.00	2600	10.00	2.66^{bcd}	2.19^{ab}	0.82^{bc}	1.00	0.15	19.52
	2800	9.17	2.56^{de}	2.17^{abcd}	0.85^{a}	1.00	0.15	16.02
	3000	9.58	2.64^{cd}	2.13^{cd}	0.81^{e}	1.17	0.15	18.94
	3200	8.92	2.69^{bc}	2.13^{cd}	0.79^{g}	1.00	0.15	16.35
26.00	2600	10.00	2.74^{a}	2.18^{abc}	0.80^{efg}	1.17	0.15	18.51
	2800	9.50	2.63^{cd}	2.13^{c}	0.81^{de}	1.17	0.15	18.10
	3000	9.75	2.64^{cd}	2.08^{d}	0.79^{g}	1.17	0.15	19.03
	3200	9.16	2.53^{e}	2.16^{abc}	0.85^{a}	1.33	0.15	15.89
SEM		0.41	0.01	0.01	0.00	0.11	0.00	0.21
p. value		0.58	0.01	0.01	< 0001	0.92	1.00	0.29

abc means on the same column having different superscript differs significantly (p<0.05); SEM = standard error of mean.

The yolk height result showed that birds on 20 and 22 % CP level had similar (P>0.05) yolk height result. Similarly, birds on 20 and 224 % CP levels had similar (p>0.05) yolk height results. However, birds on 22 % CP level had higher (P<0.05) yolk height than all other treatments.

Albumen height result showed that birds on 26 % CP level had higher albumen height than all other treatments. Birds on 20 % CP level had higher (P<0.05) albumen height than birds on 22 and 24 % CP levels which had similar (P>0.05) albumen height.

The yolk diameter result showed that birds on 20, 24 and 26 % CP levels had similar (P>0.05) yolk diameter. Birds on 20 and 22 % CP levels which also had similar (P>0.05) yolk diameter results. However, birds on 22 % CP level had higher (P>0.05) yolk diameter results than all other treatments.

Yolk index result showed that birds on 22 % CP level had higher yolk index than all other treatments. Birds on 20% CP level had higher (P<0.05) yolk index than birds on 24 and 26 % CP levels. However, birds on 26 % CP level had lower (p<0.05) yolk index than all other treatments.

Yolk weight result showed that birds on 2800 ME / Kcal/kg level had higher (P<0.05) yolk weight than all other treatments. Birds on 2600 and 3200 ME / Kcal/kg levels had similar (P>0.05) yolk weight result. Birds on 3000 ME / Kcal/kg and 3200 ME / Kcal/kg levels had similar (P>0.05) yolk weight. However, birds on 3000 ME / Kcal/kg level had lower (p<0.05) yolk weight results.

The albumen weight result showed that birds on 2600, 3000 and 3200 ME/Kcal/kg levels had similar (P>0.05) albumen weight results. However, birds on 2800 ME / Kcal/kg had higher (P<0.05) albumen weight then birds on all other treatments.

Birds on 2800 ME/Kcal/kg level had higher yolk height than all other treatments. Birds on 2600 ME/Kcal level had higher (P<0.05) yolk height than birds on 3000 and 3200 ME/Kcal/kg levels. However, birds on 3200 ME/Kcal/kg level had lower (P<0.05) yolk height results than all other treatments.

The albumen height result showed that birds on 2600 ME/Kcal/kg level had the lowest albumen height their result were significantly (P<0.05) lower than those birds on 2800, 3000 and 3200 ME/Kcal/kg which had similar (P>0.05) values.

Yolk diameter result showed that birds on 2600 and 3200 ME/Kcal/kg levels had similar (P>0.05) yolk diameter the values which, however, are higher (p<0.05) than those birds on 2800 and 3000 ME/Kcal/kg levels. Birds on 2800 ME/Kcal/kg level had lowest (p.<0.05) yolk diameter results.

The yolk index result showed that birds on 2800 ME/Kcal/kg level had higher yolk index than all other treatments. Birds on 2600 ME/Kcal/kg level had higher (P<0.05) yolk index than birds on 3000 and 3200 ME/Kcal/kg levels. However, birds on 3000 ME/Kcal/kg had lower (p<0.05) yolk diameter results.

4.14 Interaction Effect of Different Dietary Protein and Energy Levels on the Internal Egg Parameters of Japanese Quails

The interaction results between different dietary protein and energy levels on the internal egg parameters of Japanese quails are presented on Table 4.14. The result showed that dietary protein and energy interaction had effect (p<0.05) on Yolk weight, Albumen weight, Yolk height, Albumen weight, Yolk diameter and Yolk index. However, yolk and albumen weight and Haugh unit were not (p>0.05) affected by dietary protein and energy interaction.

Yolk weight result showed that birds on 22 % CP / 2800 ME/Kcal/kg level had higher ($p < 0.05$) than all other treatments except birds on 22 % CP / 2600 ME/Kcal/kg, 24 % CP / 2800 ME/Kcal/kg and 26 % CP / 3200 ME/Kcal levels had similar ($p > 0.05$) yolk weight results. However, birds on 20 % CP / 2600 ME/Kcal/kg and 20 % CP / 3200 ME/Kcal/kg levels had lowest ($p < 0.05$) yolk weight results than all other treatments.

The albumen weight result showed that birds on 22 % CP / 2600 ME/Kcal/kg level had higher ($p < 0.05$) albumen weight than all other treatments. Birds on 20 % CP / 2600 ME/Kcal/kg level had least albumen weight and their result were lower ($p < 0.05$) than all other treatments except birds on 22 % CP / 3000 ME/Kcal/kg level which had similar ($p > 0.05$) albumen weight results.

Yolk height result shows that birds on 22 % CP / 2800 ME/Kcal/kg level had higher ($p < 0.05$) yolk height than all other treatments. Birds on 26 % CP / 3000 ME/Kcal/kg level had least yolk height and their result were lower ($p < 0.05$) than all other treatments except birds on 22 % CP / 3200 ME/Kcal level which had similar ($p > 0.05$) yolk height results.

Birds on 20 % CP / 2800 ME/Kcal/kg and 26 % CP / 3000 ME/Kcal/kg levels had higher ($p < 0.05$) albumen height results than all other treatments. Birds on 20 % CP / 3000 ME/Kcal/kg level had lower ($p < 0.05$) albumen height results than all other treatments.

Yolk diameter result showed that birds on 22 % CP / 2800 ME/Kcal/kg level had higher ($p < 0.05$) yolk diameter than all other treatment except birds on 24 % CP / 2800 ME/Kcal/kg and 26 % CP / 2600 ME/Kcal/kg had similar ($p > 0.05$) yolk diameter results. Birds on 26 % CP / 3000 ME/Kcal/kg level had lower ($p < 0.05$) yolk diameter than other treatment except birds on 26 % CP / 2800 ME/Kcal/kg level which had similar ($p > 0.05$) results.

The yolk index results showed that birds on 22 % CP / 2800 ME/Kcal/kg level had higher ($p<0.05$) yolk index than all other treatments. Birds on 22 % CP / 3200 ME/Kcal/kg and 26 % CP / 3000 ME/Kcal levels had lowest ($p<0.05$) yolk index except birds on 24 % CP / 2800 ME/Kcal and 26 % CP / 3200 ME/Kcal/kg levels which had similar ($p>0.05$) yolk index results.

Table 4.13 Main effect of dietary protein and energy on internal egg characteristics of Japanese Quails

Treatment	Yolk and albumen weight (g)	Yolk weight (g)	Albumen weight (g)	Yolk height (cm)	Albumen height (cm)	Yolk diameter (cm)	Yolk Index	Haugh Unit
Protein								
20.00	8.33	2.52^{c}	4.70^{d}	0.70^{ab}	0.79^{b}	1.77^{ab}	0.39^{b}	65.11
22.00	8.08	2.73^{b}	4.76^{c}	0.70^{a}	0.78^{c}	1.77^{a}	0.40^{a}	64.89
24.00	8.04	2.78^{a}	4.78^{b}	0.69^{b}	0.78^{c}	1.77^{b}	0.39^{c}	64.87
26.00	8.01	2.73^{b}	4.85^{a}	0.68^{c}	0.79^{a}	1.77^{b}	0.38^{d}	64.69
SEM	0.15	0.01	0.00	0.00	0.00	0.00	0.00	0.31
p. value	0.44	0.01	0.01	0.02	0.03	0.01	0.01	0.81
Energy								
2600	8.18	2.69^{b}	4.77^{b}	0.70^{b}	0.78^{b}	1.78^{a}	0.39^{b}	64.57
2800	8.26	2.71^{a}	4.80^{a}	0.70^{a}	0.79^{a}	1.77^{c}	0.40^{a}	64.79
3000	8.11	2.67^{c}	4.77^{b}	0.68^{c}	0.79^{a}	1.77^{b}	0.39^{c}	64.77
3200	7.91	2.68^{bc}	4.76^{b}	0.68^{d}	0.79^{a}	1.77^{a}	0.38^{d}	65.53
SEM	0.15	0.01	0.00	0.00	0.00	0.00	0.00	0.31
p. value	0.42	0.01	0.01	0.02	0.04	0.02	0.02	0.13

abc means on the same column having different superscript differs significantly ($p<0.05$); SEM = standard error of mean

Table 4.14 Interaction effect of dietary protein and energy on internal egg characteristics of Japanese Quails

Protein (%)	Energy Kcal/kg ME	Yolk and albumen weight (g)	Yolk weight (g)	Albumen weight (g)	Yolk height (cm)	Albumen height (cm)	Yolk diameter (cm)	Yolk Index	Haugh Unit
20.00	2600	8.33	2.42^{f}	4.58^{e}	0.68^{de}	0.78^{cde}	1.78^{bc}	0.38^{de}	65.39
	2800	8.67	2.58^{e}	4.70^{d}	0.71^{b}	0.81^{a}	1.77^{d}	0.40^{b}	64.80
	3000	8.30	2.62^{de}	4.83^{bc}	0.69^{cd}	0.80^{b}	1.78^{b}	0.39^{c}	64.49
	3200	8.00	2.45^{f}	4.69^{d}	0.69^{cd}	0.76^{e}	1.78^{bc}	0.39^{c}	65.77
22.00	2600	8.30	2.82^{ab}	4.98^{a}	0.71^{b}	0.78^{de}	1.77^{c}	0.40^{b}	64.45
	2800	8.09	2.85^{a}	4.81^{b}	0.74^{a}	0.77^{de}	1.79^{a}	0.42^{a}	64.40
	3000	8.03	2.60^{de}	4.65^{de}	0.69^{d}	0.78^{cd}	1.78^{b}	0.39^{bc}	65.65
	3200	7.92	2.65^{d}	4.71^{d}	0.66^{e}	0.79^{bcd}	1.78^{bcd}	0.37^{e}	65.06
24.00	2600	8.00	2.75^{c}	4.66^{d}	0.71^{b}	0.78^{d}	1.78^{bc}	0.40^{b}	63.97
	2800	8.28	2.82^{ab}	4.82^{bc}	0.67^{de}	0.77^{de}	1.78^{ab}	0.38^{de}	65.13
	3000	7.79	2.75^{c}	4.81^{c}	0.69^{cd}	0.78^{de}	1.77^{cd}	0.39^{cd}	64.64
	3200	8.09	2.81^{bc}	4.82^{bc}	0.68^{de}	0.79^{bc}	1.77^{cd}	0.38^{de}	65.74
26.00	2600	8.07	2.77^{bcd}	4.86^{bc}	0.69^{cd}	0.79^{bcd}	1.78^{ab}	0.39^{cd}	65.06
	2800	8.00	2.58^{e}	4.85^{bc}	0.69^{cd}	0.79^{bc}	1.76^{e}	0.39^{cd}	64.85
	3000	8.33	2.73^{c}	4.87^{b}	0.66^{e}	0.77^{de}	1.76^{de}	0.37^{e}	64.31
	3200	7.63	2.82^{ab}	4.83^{bc}	0.67^{de}	0.81^{a}	1.78^{b}	0.38^{de}	65.55
SEM		0.30	0.01	0.01	0.00	0.00	0.00	0.00	0.61
p.value		0.84	0.01	0.03	0.01	0.01	0.01	0.02	0.66

abcde means on the same column having different superscript differs significantly ($p<0.05$); SEM = standard error of mean.

CHAPTER FIVE

5.0 DISCUSSION

The nutrient values obtained from the proximate analysis of the basal diets are acceptable for feeding growing and laying quails and are within the ranges recommended by NRC (1994).

The performance results indicated varying dietary protein and energy had no effect on the performance of Japanese quails neither was their interaction. This might imply that either the levels of 20 - 26 % crude protein (CP) and 2600 - 3200 ME Kcal used in this study were adequate for these birds or the optimum level required by the birds are outside the range of dietary crude protein and energy used in this study. Similar result was reported by Runjun and Sethi (2014), the authors did not observe any effect of varying dietary energy and protein on the final body weight and weight gain of Japanese quails when the quails were fed various dietary levels of protein and energy interaction on growth performance of white plumage japanese quails. In another study, Gheisari *et al.* (2011) and Babatunde *et al.* (2016) also reported that varying dietary protein of 20 % CP and energy 3000 ME Kcal did not affect body weight at day 49 of rearing, daily gain and FCR when the Japanese quail were fed Crude protein (20, 22, 24 and 26%) and energy (3000, 3100 and 3200 kcal) during rearing period.

Birds fed 22 % CP had better dry matter and crude protein digestibility than the control which were given 20 % CP. It might mean that 22 % CP was more adequate for the digestibility of these birds. The present findings are also in line with the results obtained by Sherif (2009), who evaluated the growth performance of broiler chicks fed isocaloric diets containing 18 and 20 % crude protein in absence or presence of enzyme preparations and found that chicks fed the 20 % CP diets achieved better nitrogen retention and CP digestibility as compared to those fed the 18

% CP diets. Similar result was reported by Mosaad and Iben (2009) when fed Japanese quails diets containing three protein levels (21, 24 and 27 % CP) during the growing period, they found that nitrogen retention was significantly higher in quail fed on the high protein diet compared with those fed on the low protein diets. However, Omidiwura *et al*. (2016) did not find any effect of CP levels on the digestibility of DM (dry matter) and CP.

The better digestibility were observed at higher dosage of CF (CP levels of 22, 24 and 26 %) might implies that CF digestibility is better at high CP diets, this support the findings of Babatunde *et al.* (2016) who observed that crud fibre digestibility were best in medium to high protein diet. Similarly, the findings of Dowarah and Sathi (2004) reported that the highest CF digestibility was observed 25 % CP supplemented diet.

The lower EE digestibility observed at CP level of 24 % CP is not well understood. However, the EE digestibility observed in this study is in line with those reported by Runjun and Sathi (2014) that reported lowest EE was at high protein when varying dietary levels of protein and energy and the interaction on growth performance of white plumage Japanese quails were studied.

Birds fed 24 % CP had better NFE (nitrogen free extract) digestibility than other levels except 20 % CP. This could be that birds on 24 % CP diets were able to digest the feed more adequately. this result is in agreement with Babatunde *et al. (*2016) who fed quails with different energy and protein at medium protein to high energy combination and observed birds on 24 % CP had higher NFE digestibility.

Highest CP digestibility observed at 3200 ME kcal/kg could mean as dietary energy increase, CP digestibility increases than the other levels. This report is not in accordance with Shrivastav *et al*. (1999) who recommended 2800 kcal ME / kg for the quail up to 5 weeks of age in dry tropical climate. The variation could be due to the time of the season the studies was carried out. Studies have shown that birds eat to meet their energy requirements. Mosaad and Iben (2009).

Birds fed 2600 ME / kcal/kg energy level had better ether extract and nitrogen free extract digestibility than those on higher levels, this implies that this energy level is more adequate for ether extract and nitrogen free extract digestibility. The 88.47 % result obtained here is within the 79.18 – 89.90 reported by Malik *et al*. (2010).

Birds fed 22 % CP, and energy level of 2800 kcal/kg and 26 %, 32000 kcal/kg had better CP digestibility. The physiological reason for this is not well understood, thus, it might require further study. However, it implies that the optimum digestible of CP is a combination of two or factors as observed in this study. Similar results were observed in CF digestibility were 22 % CP, 2800kcal/ME and 26 % CP, 3200kcal/ME gave better digestibility. Alabi *et al.* (2015) reported that different parameter were optimized at different ratio of lysine and energy. This is also in agreement with the report of Omidiwura *et al*. (2016), and Reda *et al*. (2015). who worked on the interaction effect of dietary protein and energy on nutrient digestibility indicated that birds fed protein level 26 % CP and 2600 ME kcal/kg had better crude fibre, ether extract and ash contents than most of the other levels. This might be an indication that these protein and energy levels were most adequate for these birds. This supports the findings of Runjun and Sethi (2014) who reported that the highest crude fibre and ash content digestibility was achieved at 25% CP supplemented diet in white and colour plumage Japanese quail. Furthermore, Jahanian and Edriss (2015) reported that 25 % CP were adequate for these nutrients digestibility, however, higher level of 3000 ME kcal was recommended for this nutrients digestibility by the same authors. The authors also reported that crude fiber digestibility was not affected by the different dietary levels of energy and protein combinations which does not agrees with the report of this study. The results of this study also disagreed with the Babatunde *et al.* (2016) who reported that there was not interaction between the dietary crude protein and energy levels in the nutrients digestibility of Japanese Quail (*Coturnix coturnix japonica*) during rearing period. The variation could be due to the geographical location.

Birds fed 24% CP and energy level of 2600kcal/kg had better nitrogen free extract digestibility than most of the other levels. The 24 % CP is similar to NRC (1994) recommendation and 2600 Kcal is similar to the 2650 Kcal recommended by Prabakaran (2003) for adult quail older than 6 weeks.

There was no effect on both the main and interaction of dietary protein and energy levels on carcass characteristics and egg production parameters. This might be an indication the requirements for these parameters are within the dietary protein and energy used in the study.

Lower protein and energy levels favored egg length and width. The length and weight of an egg is a function of area of the egg and the content of the egg. This might imply that lower dietary protein (20 – 22 %) and energy (2600-2800 kcal) improves the egg quality. This is similar to what was observed by Agboola *et al*. (2016) when they worked on determination of Crude Protein and Metabolizable Energy of Japanese Quail (*Coturnix coturnix japonica*) during Laying Period. Their results showed that performance characteristics were improved at low protein and energy levels. Pires Jr (1981) reported that bird on 22 % CP had longer egg length, egg width and egg shape index. The 22.42 % CP reported for optimal egg length and width by Pinto *et al*. (1998) aligned with this current study. Singh and Narayan (2002) also recommended 22 % protein for external egg qualities. However, a higher level of 24 % was reported by Vilar *et al*. (1991). On the contrary, Murakami *et al*. (1993b) reported that egg length and egg width of laying quails were optimized at a CP of 18 %. Gunawardana *et al.* (2008) also recorded significant effect on egg length in low energy and low protein levels in the diet which was in accordance with our study. On a contrary Sung-Taek *et al.* (2012) reported no significant difference in egg length due to different levels of energy and lysine supplementation in the diet which was not accordance with our study. Birds fed 2600 ME K/cal diets had longer egg. Similarly, there was significant effect in egg length due to feeding of different levels of energy and protein. The egg shape index which is a ratio of length to width of the egg followed the result of the length and weight. Lower protein level improved the egg shape index, the reason for this is not well known..

Mizumoto *et al*. (2008) reported that nutrient and breeding system have major effect on the egg quality. The yolk and albumen formation and other internal egg qualities are function of the dietary protein content of the diet. Eduardo *et al*. (2017) reported that birds have limited dietary protein storage, thus, their presence in feed play a great role in the internal egg quality. in the present study, yolk weight, albumen weight yolk height and albumen height yolk diameter and yolk index were influenced by dietary protein and energy level. This report is in line with Novak *et al.* (2010) who reported significant effect of protein levels on yolk percentage. This could be because birds have limited ability to store protein as reported by Eduard *et al*. (2017). Low protein level (22 %) and energy (2800 kcal) gave better yolk height, diameter and index. Unlike the results obtained from this study, Yusuf *et al*. (2016) reported that as the dietary protein and energy increase the albumen and yolk weight increased were hens fed varying dietary energy and protein. In another study, Novak *et al*. (2006) found that the dry and wet albumen decreased with feeding low CP diet. However, Muhammad *et al.* (2016) did not observed any effect of varying dietary energy and protein on the internal egg quality when they worked on dietary supplement of energy and protein on production performance of indigenous crossbreed chickens. The variations observed by different author might be because the authors work on other breeds of birds and not quails. there are limited study on the effect of dietary protein and energy on the internal egg quality.

Yolk weight, albumen weight, yolk height, albumen height, yolk diameter and yolk index were optimized at diet containing 2800 ME K/cal/kg. It might imply that the 2800 ME K/cal/kg is most adequate for these parameters. Alabi *et al.* (2015) reported that different egg parameters were optimized at different dietary energy levels. This study is in line with those of Runjun and Sethi (2014) who observed significant differences in yolk weight in white and color plumage Japanese quail fed 2800 ME K/cal/kg diet. Albumen weight, yolk height and albumen height were best in 2800 ME K/cal fed diet. This agrees with the findings of Runjun and Sethi (2014) who observed that highest internal egg qualities were achieved at 2800 ME K/cal/kg supplemented diet. Contrary to the above findings Tarasewicz *et al.* (2006) and Abdel-Azeem (2011) reported no significant effect on albumen weight and height with effect of feeding different levels of energy, lysine and protein. Similar to what was observed at the main effect lower protein levels of 20 and 22 % and energy levels of 2600 and 2800 ME kcal/kg had better interaction effect on most of the internal egg characteristics. This further buttressed the main effect results of both dietary protein and energy treatments observed earlier. It could also mean that higher dietary protein and energy levels in the diets of quails is not needed if the internal egg parameters are of interest.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The following conclusions are arrived from the results of this study

i. Dietary protein had no effect (P>0.05) on all the growth performance parameters measured. Similarly different dietary energy did not (P>0.05) influenced the growth performance parameters. However birds on lower CP (22 % CP level) had better (P<0.05) dry matter, crude protein, crude fibre and ether extract than most of the other treatments. The birds on low energy of 2600 kcal/kg had better ether extract and NFE digestibility.

ii. The egg production parameters measured were not (P>0.05) influenced by different dietary protein levels. The egg production parameters measured were also not (P>0.05) affected by different energy levels. However, the external and internal characteristics were influenced (P<0.05). Birds on 22 % CP on the average had longer egg length (2.67 cm), egg width (2.18 cm) and egg shape index (0.82). On the internal parameters, birds on 22 % CP had longer yolk height (0.70 cm), yolk diameter (1.77 cm) and yolk index (0.40 cm). Similarly, the external and internal characteristics were influenced (P<0.05) by dietary energy intake. Birds on low 'energy (2600 ME kcal/kg) had better external characteristics (egg length (2.70 cm), egg width (2.18 cm) and egg shape index (0.82). However, on the internal parameters, birds on 2800 ME kcal/kg had better yolk weight (2.21g), albumen weight (4.80 g), yolk height (0.70 cm), albumen height (0.79 cm) and yolk index (0.40).

iii. The interaction results showed that different dietary protein and energy treatments had no effect (P>0.05) on all the growth and egg production performance parameters measured. However birds on high CP (26 % CP level) and low energy of (2600 ME kcal/kg) had better crude fibre (69.95 %), ether extract (90.41) and ash (75.97) than most of the interaction digestibility results. On the external egg interaction results, birds on low dietary energy (2600 and 2800 ME kcal/kg) and medium CP levels (22 and 24 %) had better egg length, egg width and egg shape index. Similarly, birds on low protein - low energy (22 % CP - 2800 ME kcal/kg) had better internal egg {yolk weight (2.85 g), yolk height (0.74 cm), yolk diameter (1.79 cm) and yolk index (0.42)} interaction results.

6.2 Recommendation

i. For improved nutrient digestibility low protein (22 % CP) with low energy (2600 ME kcal/kg) is recommended. This is because they gave better dry matter, crude protein, crude fibre and ether extract digestibility. The same recommendation (22 % CP and 2600 ME kcal/kg) is given for carcass characteristics and egg production since there were no significant difference when compared with others inclusion levels.

ii. For the both external and internal egg characteristics a range of 20 - 22 % CP and 2600 - 2800 kcal energy is recommended as they gave better external and internal egg results.

iii. Further study on lower levels of both protein and energy is recommended, since there were no significant difference of the ranges of protein and energy used on the growth and egg production parameters measured in this study.

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