NUTRITIVE VALUE OF AFRICAN LOCUST BEAN (*Parkia biglobosa*) PULP IN EGG -TYPE CHICKEN DIET

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DECLARATION

I declare that the work in this Dissertation entitled **Nutritive Value of African Locust Bean (*Parkia biglobosa*) Pulp In Egg-Type Chicken Diet** has been carried out by me in the Department of Animal Science, Ahmadu Bello University, Zaria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree at this or any other Institution.

Moji Afolayan	Signature	Date

CERTIFICATION

This Thesis entitled "NUTRITIVE VALUE OF AFRICAN LOCUST BEAN (*Parkia biglobosa*) PULP IN EGG-TYPE CHICKEN DIET" by Moji AFOLAYAN meets the regulations governing the award of the degree of Doctor of Philosophy in Animal Science, Ahmadu Bello University Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

I dedicate this work to the ALMIGHTY GOD,

Who had filled my mouth with songs of testimonies,

Unto Him be all Glory and Praises.

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To God be all glory, praises and honour for He keeps covenant and mercies, He has never let me down therefore all my trophies will I lay at His feet.

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ABSTRACT

Five studies were conducted to determine the proximate composition and anti - nutritional factors in locust bean pulp (LBP), metabolizable energy value and the performance of the egg type chickens fed graded dietary levels of locust bean pulp (LBP).The proximate analysis showed that LBP has low crude protein content of 3.19%, 6.03% crude fibre, 1.84% ether extract, 6.86% ash, 88.45% dry matter, 66.39% nitrogen free extract (NFE) and 542.40mg/100g Vitamin C. It also contained 0.32mg/100g tannin, 0.93mg/100g oxalate, 1.67mg/100g phytate, 0.34mg/100g saponin, 0.08mg/100g cyanide, 0.41mg/100g trypsin inhibitor, 19.72% alkaloid and 40.20% flavonoid. Experiment one was conducted to determine the metabolizable energy level of the LBP. Fifteen cocks were randomly allotted to three treatments. The first treatments were fed control layer diet, the second treatments were fed diet containing 80% of the control diet and 20% of the LBP while the third treatment were fasted throughout the period of the study. Results showed that the apparent metabolizable energy (AME) for the LBP was 2344 kcal ME/kg diet. Experiment two was conducted with 375 pullet chicks (0-8weeks) allotted to five dietary treatments (0, 7.5, 15.0, 22.5 and 30.0% LBP) with three replicates per treatment in a completely randomized design. Birds fed 22.5% LBP diet had a significantly higher weight gain than those fed 30% LBP diet but similar to those fed 0.0, 7.5, 15.0 % and all the cost parameters (feed cost per bird, feed cost / kg gain and total cost /bird) for the birds fed LBP diets were not better than that of the control diet. In experiment three, 330 growing pullets (9-20weeks) were randomly allocated to five dietary treatments as explained for the chicks phase. Final weight and weight gain for the birds on LBP diets were similar. Both the feed intake (g)/bird and water intake (ml/bird) increased significantly ($P<0.05$) as the level of LBP increased in the diets, the marginal profit increased and there were no mortality recorded during the growing period. Experiment four was conducted to determine the residual effect of graded dietary levels of LBP fed during the growing phase on subsequent laying performance of the birds (20 - 42 weeks). The same sets of birds used during the grower phase were used without randomization. The carry over effect of LBP fed during the grower phase was observed on the feed and water intake as both parameters increased with the levels of LBP in grower diets. However, feed efficiency was significantly ($p<0.05$) better for the hens fed on 0 and 7.5% levels of LBP than those on other diets. In experiment five, two hundred and seventy (270) hens (42 – 53 weeks) were randomly assigned into five treatments with 18 birds per replicate and were fed diets containing LBP at 0, 7.5, 15, 22.5 and 30%. Feed cost per crate of egg increased with increase in the level of LBP across treatments, which consequently reduced the income above feed cost. There were no significant ($P>0.05$) differences in the shell thickness, shell index, shell percentage and Haugh unit across dietary levels. LBP had a significant ($P<0.05$) positive effect on the yolk colour. The colour varied from 1 – 4.5 on the Roche Yolk Colour Fan (RYCF) score. There were no significant ($P>0.05$) differences observed for most of the haematological and serum parameters except for the TWBCmm^3 which was significantly ($P<0.05$) higher for the 30% (19.09 mm^3) but the value was comparable to the 7.5% LBP diet. Digestibility of crude fibre decreased significantly as the level of LBP increased in the diet up to 22.5% level. From this study, it was concluded that LBP contains nutrients which can improve the performance of birds and can serve as alternative source of energy in the diet of egg type chickens when maize is expensive however, the optimum level recommended for better growth in chicks was 22.5% and can be fed up to 30% for growers and 7.5% in layers ration.

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CHAPTER ONE

1.0 INTRODUCTION

Much work has been done on the use of alternative energy sources to replace the conventional sources of energy in poultry diets. In terms of total cost, energy is the main factor influencing diet cost (Afolayan *et al.,* 2009a). The high cost of maize and other conventional feed resources in Nigeria had led to high cost of poultry feed which in turn has prompted the need to explore the use of unconventional feed resources as alternative or replacement for the conventional feed ingredients (Vantsawa, 2001; Agbede *et al.,* 2002). Maize which is a common feedstuff of choice as a source of energy is expensive, thereby increasing the cost of production (Bawa *et al.,* 2003; Abeke, 2005; Diarra *et al*., 2008; Ogundipe *et al.,* 2008; Ijaiya *et al.,* 2012). Its proportion in monogastrics animal diets ranges from 50 to 70%. Energy is required for all processes of life and without energy, growth will not be possible, laying birds cannot produce eggs, feed cannot be digested, waste products cannot be eliminated and amino acid cannot be converted to muscle (Afolayan *et al.,* 2009a). Energy is a vital feed nutrient and the fuel that keeps the body functioning (Summer, 2000). Generally, poultry farmers are interested in the total cost of production and the final returns after sales, therefore there is the need to intensify research into alternative energy sources in order to cut down the cost of poultry feed production (Dafwang *et al*., 2001; Sekoni *et al*., 2008; Diarra *et al*., 2008; Afolayan *et al.,* 2009b). Over the years several alternatives have been recommended for use. However, the potentials of LBP (a waste product from locust bean) has not been fully exploited.

Locust bean pulp is obtained from the locust bean seed (Parkia biglobosa). It belongs to the family Leguminoceae, sub - family Mimosoidae and genus Parkia. Although, the yellow fruit pulp does not attract much attention like the locust beans, it is a potential source of energy because of the high carbohydrate content. There is also lots of research on the significant use of the pulp in feed formulations. According to Owoyele *et al.* (1989) and Akoma *et al.* (2001), the yellow – pulp has been reported to be edible and non- toxic. Adewusi *et al.* (1995) also reported that it could be a good replacement for the scarce cereal grains as a source of energy in feed formulation. It is also readily available when maize is expensive. According to Kwari and Igwebuike (2002) and Bot *et al.* (2012), locust bean pulp (LBP) can replace some portion of maize in broiler diets. Gernah *et al.* (2005) reported that LBP is very rich in vitamin C (ascorbic acid).

According to Muller (1988), the yellow colour of the pulp indicates the presence of phyto – nutrients possibly carotenoids which are important precursors of retinol (Vitamin A). Lin *et al.* (2002) reported that vitamin A improves the laying performance and immune function of laying hens under heat stress conditions. Muller (1988) and Gernah *et al.* (2005) reported that locust bean-pulp has high value of ascorbic acid (vitamin C) which has beneficial effects on birds during stressful conditions, it also increase egg production and egg weight in cold-stressed hens. Bello *et al.* (2008) reported that the concentration of calcium in LBP is very high (11650mg/kg). Therefore if it is incorporated into the laying hen diets it may be a potential source of calcium which is very essential in the formation of egg-shell and bone. In addition, the yellow color may aid the egg- yolk coloration. Although researches have been done on the use of LBP in broiler diets, not much work has been done on its inclusion in the diets of layers.

This work is important because conventional feedstuffs are expensive and there exist a perpetual competition between man and animals for conventional feeds compared to the non conventional feedstuffs which are readily available, less competitive and cheap as earlier stated. Locust bean pulp is readily available especially when maize is scarce. Kwari and Igwebuike (2002) and Bot *et al.* (2012) had reported that the locust bean pulp could support growth performance of broiler chickens. Sotolu and Byanyiko (2010) also reported that the LBP contained nutrients that are capable of supporting fish growth and performance. Nevertheless, there was limited scientific information on the inclusion of locust bean pulp in the diets of egg type chickens. Hence, the study on inclusion of LBP in the diets of egg type pullets is considered necessary.

1.1 Objectives of the Study

The objectives of this research were:

i. To determine the proximate composition and anti-nutritional factors in LBP

ii. To determine the metabolizable energy value of LBP.

iii. To evaluate the growth performance of egg type chicks and pullets fed graded dietary levels of LBP.

iv. To evaluate the effect of LBP diet fed to growers on the subsequent egg laying performance of pullets.

v. To assess the effect of feeding diets containing LBP on the performance of laying hens

vi. To evaluate the effect of LBP diets on the nutrient digestibility, egg quality traits, hematological and serum chemistry of laying hens.

1.2 Research Hypotheses

Null Hypotheses:

i. Locust bean pulp contains anti-nutritional factors, therefore it is not safe in poultry diets.

ii. Inclusion of locust bean pulp in the diets of egg type chickens has no significant effect on growth and egg production

iii. The yellow colour of the locust bean pulp has no significant effect on yolk colouration.

iv. Inclusion of locust bean pulp in the diets of egg type chickens has no significant effect on nutrient digestibility and blood parameters.

Alternative Hypotheses:

i. Locust bean pulp contained moderate levels of anti-nutritional factors, therefore it is safe in poultry diets.

ii. Inclusion of locust bean pulp in the diets of egg type chickens will have a significant effect on growth and egg production

iii. The yellow colour of the locust bean pulp has a significant effect on yolk colouration.

iv. Inclusion of locust bean pulp in the diets of egg type chickens will have a significant effect on nutrient digestibility and blood parameters.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Status of Poultry Production in Nigeria

Poultry production is an aspect of animal husbandry concerned with the rearing of domestic birds such as chickens, turkeys, guinea fowls, ducks, geese, quails, pigeons, ostriches and other species for provision of eggs, meat and other products (Oluyemi and Roberts, 2000). Poultry production seems to be one of the fastest means of increasing animal protein supply for human diets in form of meat and eggs. Poultry keeping is one of the most popular enterprises adopted by both small and medium scale farmers in Nigeria. The poultry industry is not diversified in the tropics as in the temperate regions (Oluyemi and Roberts, 2000; Fafiolu *et al.*, 2004; Basil, 2011). Contrary to this was the report of Amos (2006) who indicated that the poultry industry has become a diverse industry with a variety of business interests such as egg production, broiler production, hatchery and poultry equipment business.

However, poultry production in Nigeria has undergone various changes in terms of stock management, genotype and technological advancement. Before 1930, most chickens were produced as a backyard enterprise just to provide "pin" money for the housewife (Basil, 2011). Farm inputs were distributed to the farmers, feed mill and some research institutes were also established. Then came the sudden rise in the cost of feed, day old chicks, drugs and other farm inputs between 1990s and 2000, after which there was a general ban on importation of poultry products in 2003 which led to the resuscitation of the poultry industry in Nigeria. Dafwang (2006) also indicated that the outbreak of the avian influenza in 2006 brought a kind of set back which resulted in a total net worth loss in investment of about 30billion naira in Nigeria. The estimated chicken population in Nigeria was about 150 million in 2006 before the bird flu episode, but the population was brought down to 103 million in 2010 as a result of the disease outbreak (Basil, 2011).

2.2 Cost and Returns of Table Egg Production

Between 1998 – 2008, Nigeria was the leading egg producing country (419,000 – 552,800 tonnes) in the whole of Africa, while South Africa was the leading poultry meat producer (665,000 – 974,150 tonnes) according to FAO statistics (Gineke, 2010). Ojo (2003) reported that egg production was very profitable and has a mean value of ₦2,158,162.53, which was further confirmed by a net return of ₦1498.88 per bird. However, Evbuomwan (2006) analyzed cost and returns to commercial table egg production in Lagos state and indicated an improvement in gross profit margin despite increase in prices of all inputs. This confirmed that increases in production cost were all transferred to the consumers. Similarly, Ekunwe and Soniregun (2007) also reported that for every ₦1 invested, the farmers get ₦ 12.5. In the same vein, the findings of Ibrahim *et al.* (2009) revealed that average net farm income of ₦85,558.30 with a return on capital invested of about 40%, established the fact that poultry egg production business was highly profitable. In another report, Ala and Boniface (2009) affirmed that farmers made an average net farm income of about ₦194, 698.39 per production season from table egg production enterprises in Sokoto state. According to Tijani *et al.* (2012) analysis of the costs and returns associated with table egg production showed that feed costs and hired labour accounts for 80.65 and 5.25% of the total costs.

2.3 Feed and its Role in the Supply of Animal Products

There is inadequate supply of animal protein due to high cost of conventional sources of feed. According to the report by FAO (2003), the number of under - nourished people is on the increase all over the world due to sub – optimal protein consumption which is more prevalent in the developing countries. The demand for animal product is high, for example in Nigeria, the average daily protein intake per adult is below 35g per day recommended by the World Health Organization (ILCA, 1992). An average Nigerian consumes less than 10g of protein per person per day out of which only about 3.2g is animal protein in form of milk, meat and eggs (Dafwang, 2006) thus Nigerians are not able to meet their daily intake of animal protein requirement. The biggest challenge facing the animal scientists is how to produce animal products in sufficient quantities to balance the demand and supply without compromising on quality and affordability (Ezekwe and Odoh, 2004; Dafwang, 2006). Poultry meat and eggs offer considerable potential for meeting human needs for dietary animal supply (Folorunsho and Onibi, 2005; Adepoju, 2008). Adequate quantity and quality feeds need to be provided to meet the requirement of various classes of livestock so as to improve the productivity of the animals, thus facilitating animal protein supply to the Nigerian populace. According to Orheruata and Otoikhian (2007) animals should be given good quality feed to enable optimal productivity. The two major concerns of poultry farmers are thus the total cost of production and the final returns after sales.

Feed is the largest single cost factor in the production of meat and egg with cost of energy being the major consideration because birds eat to satisfy their energy requirements. In Nigeria, feed cost accounts for about 70% of the total cost of producing broilers and egg (Oluyemi and Roberts, 2000; Adebayo *et al*., 2002; Kehinde *et al.,* 2006). Feed also play a significant role in the performance of chickens, many commercial poultry farms collapsed when there was a sudden increases in the cost of poultry feeds (Ogundipe, 2002; Onimisi, 2004; Sekoni *et al.,* 2008). High cost of poultry feed results in general increase in the cost of production. Hence, in order to increase profitability and survivability of the poultry industry, there is the need to incorporate feed ingredients that will be efficient in supporting meat and egg production and on the long- run help reduce the cost of production (Dafwang *et al.,* 2001; Adebayo *et al.,* 2002). However, the quality of feed should be ensured before feed cost is considered. Therefore, low feed cost should not be a reason to compromise on feed quality (Ogundipe *et al*. 2003). Adesehinwa *et al*. (2001) had earlier reported that feed cost is predominant among other factors influencing livestock production and that the solution to reduction in feed costs is not only to obtain cheaper feeds but to provide such feed that can be efficiently converted to products so that farmers will make profit.

2.4. Conventional Energy Sources Used in Livestock Feeding

Dafwang (2006) defined conventional feedstuffs as the naturally occurring feed ingredients whose quality parameters have been recognized and standardized by the animal feed industry. Most conventional feedstuff are very expensive and they constitute about 45-60% of poultry diets though they are of high nutritional value, their increasing cost has led to increase in the cost of finished feeds and poultry products making them out of reach of most farmers (Abouelezz *et al.,* 2012). There is the need to intensify research into the inclusion of the nonconventional feed resources which are not useful for human nutrition (Agbede *et al.,* 2002). Some examples of conventional feedstuffs are: maize and sorghum. Conventional source of energy provide bulk of the energy and other essential nutrients for commercial poultry production (Adesehinwa *et al*., 2001). The energy content of cereal grains is assumed to be relatively constant, but the availability of the energy varies widely between both grain and animal species (Hughes and Zviedrans, 1999). Wyatt *et al.* (1999) reported that the apparent

Metabolizable energy (AME) for broiler chickens ranges from 10.4 - 15 9 MJ/kg in wheat based diet, compared to a range of 13.3 - 17.0 MJ/kg for pig.

2.4.1 Maize as a conventional feedstuff

Maize is the principal source of carbohydrate and energy in conventional feeds for poultry because of its availability and nutrient quality. Maize constitute about 50-70% of the total ingredient used in poultry feeds (Bamgbose *et al*., 2008; Abouelezz *et al*., 2012). It is expensive and there is a continuous competition between livestock and human as feed or food. Vantsawa (2001) and Agbede *et al.* (2002) indicated that the high cost of maize had led to the high cost of conventional feed. Maize has traditionally been the preferred grains for monogastric animals, with its dietary energy value being one of the highest of the feed grains. According to NRC (1998), maize was the main animal feed ingredients due to its worldwide distribution because of its low fibre content. Maize is grown across a wide range of agro-ecological zones in Nigeria, though it is grown more in the northern part of Nigeria and it is mainly grown for human consumption. Larger percentage of the maize produced is now used in breweries and confectioneries (Adesehinwa *et al.,* 2001). High cost of fertilizer and poor soil fertility are major challenges affecting its cultivation and productivity. Hence, there is inadequate amount of maize available for compounding poultry feed. The shortage of maize had been a major bottleneck to efficient poultry production. RMRDC, (2004) reported the nutritional content of maize as: 80% carbohydrates, 10% crude protein, 3.5% crude fibre and 2% minerals, whereas Ekenta *et al.* (2012) reported the protein content of maize as 8.5%.

2.4.2 Sorghum as a conventional feedstuff

Sorghum grain provides a significant alternative to corn and wheat cereals used in animal diets, it is an important feed ingredient in many parts of the world, (Robertson and Perez 2006). The value of feeding sorghum to poultry has been reported to pose a negative result on the performance of birds as a result of an anti nutritional factor (tannin) condensed within the grain testa and pericarp (Hassan and Sultan, 2012). High level of tannins was reported to have negative effects on the metabolizable energy and protein utilization. The tannin content is closely related to darkness of seed colour. Sorghum contains 0.56% tannin and there is a decrease in the digestibility of sorghum crude protein as the tannin content increased, Tannin levels between 1.5% and 3% causes depression in growth rate and decrease in egg production The metabolizable energy value of non tannin sorghum is usually about 5 – 7% lower than that of maize but its protein content is higher (NRC, 1984).

2.5 Utilization of Non Conventional Feedstuffs in Monogastrics Nutrition

Non conventional feedstuffs are feed ingredients that are not usually common in the markets and are not the traditional ingredients used for feeding poultry (Madu *et al.,* 2003). The high cost of the conventional feedstuff has resulted in exploration of possible alternatives which are readily available, cheap with comparable nutritive values to the conventional ingredients (Bamgbose *et al.,* 2007). Non conventional feedstuff are credited to being non competitive in terms of human consumption and cheap to purchase. They usually include by-products or waste products from agriculture, on - farm feeds and processing industries and also serve as a form of waste management in enhancing good sanitation.

Non conventional feedstuff from plant sources includes: palm kernel cake, maize offal, rice offal, wheat offal, ginger waste meal, brewers dried grains etc. Wastes from animal sources and processing of food for human consumption which include: animal dung, visceral, feathers, fish, bone and blood (Fasakin *et al*., 2000; Omitoyin and Faturoti, 2000). All these can be recycled to improve their nutritive values if they can be converted economically into useful products.

However, the utilization of non-conventional feedstuffs of plant origin has been limited as a result of the presence of anti-nutritional factors such as : alkaloids, glycosides, oxalic acids, phytates, protease inhibitors, haematoglutinin, saponin, momosine, cyanoglycosides, linamarin to mention a few despite their nutritive values and low cost implications (Sogbesan *et al*., 2006). These anti- nutritional factors negate growth and other physiological activities at higher inclusion levels (Oresegun and Alegbeleye, 2001).

2.5.1 Palm kernel cake (PKC)

The use of PKC in poultry diet dates back to 1940 and it is not consumed as food by human beings. Ezieshi (2006), Sekoni *et al.* (2008) and Ugwuene (2011) reported that palm kernel cake could serve as replacement for maize in poultry diets with a range of crude protein level of 19 to 21%, and ME value ranging between 2600-2700kcal/kg. The PKC is dry and gritty. Sekoni *et al.* (2008) reported that optimal inclusion level of PKC in chick diets was 20%. Osei and Amo (1987) fed graded levels of palm kernel cake diets containing 0, 5, 7.5, 10, 12.5, and 15% of palm kernel cake (PKC) to broiler chickens. They reported that palm kernel cake had no significant effect on feed consumption and body weight ($P <0. 05$) up to 8 weeks of age. They also concluded that the use of PKC considerably reduced feed costs, but profit over production costs nevertheless favoured the control diet containing no PKC. Onwudike (1986) reported that broiler starters were able to utilize up to 28% of palm kernel meal without any significant effect on performance. Above this level rate of gain and feed conversion value significantly ($P < 0.05$) declined. The finishing birds were able to utilize up to 35% palm kernel meal without any significant effect on performance. Sekoni *et al.* (2008) and Esuga *et al.* (2008) reported that inclusion of enzyme (maxigrain) resulted in significant nutrients (protein, fat, Nitrogen free extract) retention in broiler chickens.

2.5.2 Maize offal

Maize offal is a by - product obtained from the milling of maize. Generally, grain by- products were lower in energy and higher in crude protein than the original grains. Therefore, increasing the inclusion level of maize offal in broiler diets dilutes the energy content of the rations resulting in lower energy concentration. Vantsawa (2001) reported that the higher crude fibre obtained in grains by - products were due to higher concentration of testa and the fibrous parts of the grain. The bulky nature of the maize offal is due to its high fibrous content. The nutrient contents of maize offal are shown in (Table 2.1). According to Fadugba (1989), maize offal is as good as maize for chicks, grower and layers. Maize offal can replace maize up to 24% in the diet of pig weaners, 15 % in the diet of growers and 75% in the diet of finisher (Adesehinwa *et al*., 2001).

2.5.3 Ginger meal

Herawati (2010) reported that inclusion of ginger in broiler ration resulted in higher feed intake and feed conversion ratio.. Zhang *et al.* (2009) and Zhao *et al*. (2011) also reported that ginger meal increases the secretion of gastrointestinal enzymes such as lipase, disaccharides and maltase due to the digestive enzymes found in ginger. Supplementation of ginger in poultry diet had been reported to improve growth, egg production and egg quality (Akbarian *et al.,* 2011). Ginger waste meal is high in NFE which is indicative of high energy content. Chemically it contained 2% crude protein,

Table 2.1 Proximate composition of maize offal

Nutrient	% Dafwang (2006)	% Vantsawa (2007)
Dry matter	92.32	89.5
Crude Protein	11.98	10.6
Ether extract	9.24	4.6
Crude Fibre	15.78	3.5
NFE	57.96	77
Total ash	5.04	4.1

6.9% crude fibre, 2.2% ether extract, 8.7% ash and 80% NFE. Onimisi (2004) reported an optimum level of inclusion 10 and 20% in broiler starter and finisher diet respectively. He also reported that inclusion of ginger meal beyond 10% in broiler starter diet had depressive effect on the feed efficiency. Ademola *et al*. (2009) also reported a significant decrease in the live weight of poultry when ginger was included in the diet. The authors also reported that inclusion of 2% ginger in the diet of broiler starter resulted in significant decrease in weight gain. Similarly, Daudu *et al.* (2012) reported a significant reduction in final weight, weight gain and efficiency of feed utilization in broiler finisher fed ginger by – product meal. Omage *et al*. (2007) reported no adverse effect of ginger meal on rabbits and no significant (P>0.05) differences in weight gain and feed conversion ratio with a significant increase in feed intake of rabbits fed ginger meal diets.

2.5.4 Brewers dried grains (BDG)

This is the primary by- product of corn fermentation to yield ethanol and it is readily available for the poultry producer. BDG contains all the nutrients from grain in a concentrated form (Babcock *et al.,* 2008). The True metabolizable energy (TMEn) ranges between 2380 – 3190kcal/kg and crude protein of 27% (Lumpkins *et al.,* 2005; Leeson and Summers, 2005). According to Lumpkins *et al.* (2005) feeding BDG to poultry resulted in improved overall performance. Ademosun (1983) reported no significant (P>0.05) difference in the growth performance of broiler finisher fed 10% BDG and those on the control diet. Babatunde (1975) had earlier reported that BDG was high in fibre but low in metabolizable energy. Nelson (1984) reported that feeding BDG beyond 25% in broiler starter diet had a depressive effect on weight gain and feed efficiency.

2.5.5 Cassava peel meal

Cassava peel meal is the residue containing little cassava pulp and the skin. It accounts for between 10 – 13 % of tuber by weight and contains about 5% crude protein and reasonable amount of minerals (Tewe and Kasali, 1986). Sekoni (1997) reported that cassava peel meal can be incorporated into layer diet up to 20% without adverse effect on the total number of eggs, percentage hen – day egg production and feed per dozen eggs. Average feed intake and egg weight were not significantly affected by graded levels of cassava peel meal. Aduku *et al.* (1991) reported that cassava peel meal can be fed up to 15% level in broiler rations and that the bulky nature of the cassava peel meal reduced feed consumption. Sogunle *et al.* (2007) fed cassava peel meal diet supplemented with cashew nut meal to growing pullets and reported no significant difference in final body weight and weight gain across the dietary treatments. Oladunjoye *et al.* (2008) reported that lye treated cassava peel meal diets fed to laying hens was able to sustain growth and egg production and the diets has no significant effects on weight gain, feed intake and egg weight.

2.5.6 Rice offal

Rice offal is a mixture of all the by- products obtained in the milling of rice, containing about 60% hull, 35% bran and 5% polishing. Rice offal is one of the most promising agro industrial by- products used in poultry feeds, it is readily available in all rice growing areas. Dafwang (2006) reported the nutritive value of rice offal as follows: crude protein 6%,crude fibre 40% ,ash 20%, metabolisable energy 1300ME kcal/kg, He concluded that rice offal could be used in broiler diets up to 15% level of inclusion without adverse effects on growth. Maikano (2005) in a comparative study on nutrient composition of rice offal reported the proximate composition of rice offal obtained from

Zaria city as 94.42% dry matter, 5.09 % crude protein, 30.39% crude fibre, 3.4% ether extract, 16.67% ash and 46.10% nitrogen free extract, Duru *et al*. (2008) reported that rice offal could be fed to broiler starter up to 20% level of inclusion. Apata and Ojo (2000), Toibipont and Kermanshashi (2004), Iyayi and Davis (2005), and Duru (2010) reported that enzyme enhance better nutrient digestibility of rice offal diets.

2.5.7 Mango seed kernel

According to Diarra *et al.* (2008) the proximate analysis revealed that mango kernel contained 8.75% crude protein, 3.01% ether extract, 3.24 % ash and 70.18 % nitrogen free extract. The presence of anti-nutrients especially tannins had been reported to lower the inclusion level and also affect the performance of chicks negatively (Teguia and Beynen, 2005; Diarra *et al*., 2008). Joseph and Abolaji (1996) reported the optimum inclusion level of 20% of cooked mango kernel in broiler ration and that the presence of anti-nutritional factor such as tannins had a significant effect on the feed efficiency. Mango seed kernel is a good source of soluble carbohydrates and the flour obtained from the kernel is indicated to be equal to rice in food value (Diarra *et al*., 2011). Fowomola (2010) and Ashoush and Gadallah (2011), have also indicated that mango seed is very high in carbohydrate and oil and that it could be used as a source of functional food ingredients. Abdullahi (2012) gave a report that broiler chickens performed better at 20% inclusion rate of local variety of mango seed kernel.

2.5.8 Wheat offal

This is a by-product obtained from wheat processing. Cavins *et al*. (1969) reported that wheat offal is highly palatable, bulky and has a laxative effect. Osuji (1982) reported that the amino acid balance was superior to that of corn or whole wheat but inferior to that of most ingredients that supply protein, it is low in calcium but high in phosphorus. Nelson (1984) also reported that 50% replacement of maize by wheat offal in poultry diets had no adverse effect on weight gain, feed consumption and feed to gain ratio. According to Bala (1986), wheat milling by-products were low in metabolizable energy and high in fibre and that replacement of 75% of the maize components in the ration with wheat offal significantly ($P<0.05$) increased feed intake and weight gain of pullets between two and eight weeks of age.

2.6 The Locust Bean Pulp as a Non Conventional Feedstuff

2.6.1 The origin and geographical distribution of African locust bean tree

The locust bean tree was discovered by Mungo Park - an African explorer in the mid- 1800's, hence the name "Parkia" originated from Mungo Park's name. Sina and Traore (2002), NRC (2006), Sacande and Clethero, (2007), Orwa *et al.* (2009) the African locust bean tree is also known as monkey cutlass tree which is a perennial leguminous trees which belongs to the family Leguminosae/Mimosaceae, Sub- family Mimosoidae and Genius Parkia. The Synonyms are as follow: *Parkia clappertiniana, Parkia africana, Parkia oliveri, Parkia filicoidea, Parkia biglobosa* and *Parkia intermedia.* The most common species in Nigeria are *Parkia biglobosa* and *Parkia filicoidea* (Fetuga *et al.,* 1974)

The Locust bean tree is being cultivated over a wide area within the African Sub-region. It occurs in large numbers in a belt from the Atlantic coast in Senegal to Sudan and Northern Uganda. The belt is widest in West Africa (800km) and narrows to the east (Alabi *et al.,* 2005; Akande *et al.,* 2010). Native species are found in: Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Cote d'Ivoire, Democratic

Republic of Congo, Gambia, Ghana, Guinea, Guinea-Bissau, Mali, Niger, Nigeria, Sao Tome et Principe, Senegal, Sierra Leone, Sudan, Togo and Uganda (Orwa *et al.,* 2009).

2.6.2 Botanical description of locust bean tree

According to Orwa *et al.,* (2009), large quantities of nectar and pollen are produced and pollination is by bats. Trees gave rise to the first fruit between 5-10 years of age and vary in precocity. Each fruit starts to ripen just before the first rain and continue over most of the season, each hermaphrodite flower is potentially capable of producing a single pod and 20 pods may develop per head. The seeds are usually dispersed by animals and birds eating fruits or seeds (Sacande and Clethero, 2007). The tree is about 10-15 m in height, sometimes reaching 20 m. with thick grey bark which is scaly. The dark green leaves are alternate, bi-pinnate and 20-40 cm in length, with 8-30 pairs of alternate pinnae, and 14-65 pairs of leaflets per pinnae (Sacande and Clethero, 2007 ; Orwa *et al.,* 2009).

2.6.3 Flowering and fruiting habit of locust bean tree

Flowering occurs during the dry season in the Sahel region from December to April, which also coincides with loss of leaves. New foliage develops after this peak flowering period. The period lasts between 3 – 8 weeks depending on the region. Mature fruits develop between April- May, However, two periods of flowering and fruiting per year may occur (ICRAF, 2002; NRC, 2006). According to Sacande and Clethero (2007) flowering occurs during the second half of the dry season, usually before the leaves flush. This is usually from December to May in West Africa, Pollination is preliminarily by bats, but also by various insects including honey bees. The fruits ripen over the rainy season, approximately 3 months after flowering. Fruit production starts after 8 to 15 years of plant growth, and will reach its maximum production after 30 years. Each tree can produce up to 100 kg of fruits per year. On the average, 5 kg of fruits are required to obtain 1 kg of seeds. (NRC, 2006).

2.6.3.1 The flower

The inflorescence is a pendant raceme of glomerules, set at the end of a branch, up to 30-50 cm long peduncle, in pink, orange or red balls like badmitton ball (figure 2.1). They are 4-5 cm in diameter, and composed of 1500-2000 flowers. The tree is thought to be able to grow as old as 250 years (NRC, 2006; Sacande and Clethero, 2007 and Orwa *et al.,* 2009)

2.6.3.2 The fruit and the pulp

The fruit (figure, 2.2) is a slightly curved, indehiscent pod of 30-40 cm long and 2-3 cm wide. They are leathery, hang in clusters by the club-shaped fruit base, and are dry and brown in colour when ripe. Each pod contains up to 20 seeds, which are embedded in a sweet, yellow, floury pulp (Salim *et al*., 2002; Sacande and Clethero 2007; Olorunmaiye *et al*., 2011). About 201,000 ton of the locust bean fruits is being produced in Northern Nigeria annually (Sina and Traore, 2002).

The pulp is high in energy value and it contains up to 60% sucrose which is rich in vitamin C. It can be eaten raw or made into a refreshing drink or used as a sweetener and for storage, it is pressed into a cake (Orwa *et al*., 2009). The pulp could also be a source of oil for soap and paint industries but the physicochemical properties of these oils must be ascertained. Those with low ether extract content are comparable to that of cereals like maize; 4.6 g/100 g and millet 4.0 g/100 g (Obioha, 1992; Bello *et al.,* 2008).

2.6.3.3 The seed

The seeds (figure 2.3) are brown-blackish in colour. Each seed has a 0.5-1 cm

Figure 2.1 Flowers of the African locust bean tree

Photo by: Sacande M.

Figure 2.2 Fruit of the African locust bean tree

Figure 2.3 African locust bean seed

long panicle, it is globular-ovoid and slightly compressed laterally. The testa is hard, smooth and glossy. Seed size varies within the pod (NRC, 2006; Sacande and Clethero, 2007; Olorunmaiye, *et al*., 2011).

2.6.4 Nutritional and proximate compositions of locust bean pulp

2.6.4.1 Carbohydrates

The LBP is higher in carbohydrate and is made up of about 19% reducing sugars, 9% non – reducing sugars and about 36% of other complex carbohydrate (Oyenuga, 1968; Fetuga *et al*., 1974; Adewusi *et al.,* 1995 and Uwaegbute, 1996). Bello *et al.* (2008) indicated that the LBP contained 4.27mg/g sugar and 151.88mg/g starch. Aduku (2004) indicated that the metabolizable energy content of the LBP was 2420kcal/kg. Gernah *et al.* (2007), Bello *et al.* *(*2008) and Bot *et al*. (2013) indicated that the carbohydrates contents of the LBP ranges between 67.30% and 68.75% which is higher than 47.63% reported by Musa *et al.* (2005), Omojola *et al.* (2011) and Edigwe *et al.* (2012). LBP contained five simple sugars which are raffinose 0.43mg/100g, sucrose0.48mg/100g, glucose 0.25mg/100g, galactose 0.10mg/100g and fructose 0.20mg/100g (Gernah *et al.,* 2007; Bello *et al.,* 2008). The sweet taste of the LBP is an indication of the presence of natural sugars and thus a potential source of energy that is readily digested and absorbed more than complex carbohydrates (Bello *et al.,* 2008; Bot *et al*., 2013).

2.6.4.2 Crude fibre content

The crude fiber concentration in LBP was given by Gernah *et al.* (2007) as 11.75% whereas, Aduku (2004) reported that the LBP was high in crude fibre content of 11%. Alabi *et al.* (2005) indicated a value of 30.65 mg/100g. Sotolu and Byanyiko (2010) reported the value to be 17.80% and that the locust bean seeds contained 18%

crude fiber. Furthermore, Bot *et al*. (2013) reported that the LBP contained 12.49% of crude fibre.

2.6.4.3 Crude protein

Nordeide *et al*. (1996) reported that LBP contained 3.3% of crude protein. Similarly, Aduku (2004) reported that LBP contained 3.5% of crude protein. Hassan and Umar (2005) also reported that the crude protein content in LBP was 4.81%. Sotolu and Byanyiko (2010) reported a higher value of 9.51% and Edigwe *et al.* (2012) also reported 9.61% while Bot *et al.* (2013) gave a value of 11.52%. The LBP is low in crude protein when compared with the seeds, Fetuga e*t al.* (1974) and Adegbulu (2004) indicated the protein value of the locust bean seeds as 30.06% which is closer to 30.30% given by Aduku (2004) and 30.36% given by Damang (2007). Muazu (2012).reported a value of 24.31% for the locust bean seeds all which are relatively higher than that of the LBP

2.6.4.4 Fat

The fat content of the LBP is low, it ranges between 1.80 to 2.96% (Alabi *et al.,* 2005 and Gernah *et al.,* 2007). Mediterranean locust bean fruit pulp has 0.50% fat as reported by (Stein 1982). According to Oke *et al.* (1995) the low fat content is comparable with that of cowpea 2.05%, while pigeon pea has 1.85% (Amaefule and Obioha, 2001). Bot *et al*. (2013) also reported that LBP contained 3.09% fat. Alabi *et al.* (2005) reported that the fruit pulp can be stored for a long period at the right temperature and moisture without spoilage by rancidity. Olujobi (2012) in a comparative evaluation of nutritional composition of African locust bean (*Parkia* *biglobosa*) fruits from two locations reported that crude fat is significantly higher (8.71%) in LBP from derived savannah than LBP from rainforest zone ($P < 0.01$).

2.6.4.5 Ash

The ash content of the LBP was reported as 4.18% (Gernah *et al., 2*007) while Bello *et al.* (2008) reported 4.00% and Bot *et al.* (2013) reported 4.08%. Edigwe *et al.* (2012) also reported that the ash content in LBP was 8.05%. These values fall within the range of 2% in peas and 5% in soybeans (Ihekoroye and Ngoddy, 1995). The mineral composition of the LBP as reported by Musa *et al*. (2005) is presented in Table 2.2.

2.7 Utilization of Fibre in Poultry Nutrition

Nworgu and Ologhobo (2000) defined crude fibre as a mixture of largely undigestible substances of vegetable origin obtained as the residue of a precisely defined digestion procedure using acetic, nitric and trichloro-acetic acids. Crude fibre consists of cellulose and other vegetable cell wall substances. Crude fibre is the constituent of plant structural carbohydrates such as cellulose, hemicelluloses and lignin, which are highly indigestible material. It is important to know the fibre content of the various feed ingredients involved in monogastric feeds because fibers are of different origins and are often quite different naturally and are digested differently, for instance the digestibility of maize was stated to be 57% while that of wheat offal range between 53 to 90% (Vantsawa, 2001).

Generally, poultry require a certain amount of digestive fibre for proper development of the gastrointestinal tract physiologically. The amount of fibre in poultry diets should be kept below 7% for optimum performance, however, increasing dietary fibre level up to 8 -10% did not have detrimental effect on production (Salah, 2012)

According to Ojewola *et al*. (2001), crude fibre is bulky and plays an important role in the maintenance of the normal structure and function of the intestinal mucosa. Birds fed high fibre diets spend more time eating and are more calm than those fed low fibre diet, hence feather pecking and cannibalism is reduced (Hartini *et al*., 2003; Hetland *et al.,* 2004). Crude fibre may speed up the rate of passage of feed through the gastrointestinal tracts and may depress the digestibility, absorption, availability and utilization of nutrients (Jokthan *et al.,* 2006; Abeke and Otu, 2008). Isikwenu *et al*. (2005) also reported that an increase in dietary fibre reduces feed intake in poultry.

2.8 Anti-Nutritional Factors in Locust Bean Pulp

Omeje (1999); Abeke and Otu (2008) had reported several anti-nutrients that affect the optimum utilization of feeds by poultry and subdivided them into three groups. The first group comprise of naturally occurring intrinsic factors such as anti- trypsin factors, tannin, haemagglutinins, phytic acids, hydrocyanic acids, lectins, goitrogens, ureases, genistein, glucosinates (alkaloids), prussic acids, gossypol and many others. The second was said to arise from contamination of feed ingredients with bacteria, toxins, heavy metals pesticides and additives. While the third group was said to have originated from spoilage of feed ingredients such as aflatoxins, moulds and oxidation of fats.

Abeke and Otu (2008) expressed concerns over the effect of anti-nutrients in poultry feeds and indicated that sometimes a well formulated diet with the right combination of ingredients may not produce a good performance in birds. High mortality was observed in birds fed diets containing raw *Lablab purpureus* beans compared to those fed cooked *Lablab purpureus* beans (Abeke *et al.*, 2003). Bawa *et al.* (2003) also reported reduced weight gain and high mortality in pigs fed raw *Lablab purpureus* beans diets as opposed to better performance in the pigs fed diets containing

Table 2.2 Mineral content of locust bean pulp

Minerals	Composition (mg/100g)
Calcium	400
Magnesium	200
Sodium	100
Potassium	140
Iron	9
Manganese	8
Zinc	0.98
Lead	3

Source: Musa *et al*. 2005

cooked *Lablab purpureus* beans. These authors therefore concluded that the presence of anti-nutrients in the raw *Lablab purpureus* beans was responsible for the poor performance and high mortality recorded in the two classes of animals.

The presence of anti-nutritional factors such as saponin, tannin, oxalate, trypsin inhibitors and cyanide has been reported to mask the nutritive values of feedstuffs (Kakade *et al.,* 1974). They also inhibit energy utilization in birds (Udedibe and Carlini, 1998). According to Aro and Akinmoyegun (2012), the presence of some anti-nutritional factors in the feedstuff can destroy lymphocyte thereby predisposing the animal to infections. Reports by Oresegun and Alegbeleye (2001) also indicated that the presence of anti-nutritional factors in feedstuff especially at higher inclusion level negate growth and other physiological activities.

2.8.1 Phytate content of locust bean pulp

Edigwe *et al.* (2012) reported that LBP contained 3.30mg/100g phytic acid (myoinositol hexaphosphoric acid). This compound is made up of organic phosphorus and found in most cereals and legumes. It may exist as free phytic acid, as phytin or as calcium or magnesium salts of the acid (Irving, 1957). Most of the phosphorus in feedstuffs of plants origin are bound in the form of phytic acid. Phytic acid has 12 replaceable hydrogen atoms which could form stable chelates with divalent or trivalent metals such as calcium, iron, zinc, copper and magnesium (Osagie, 1998). The chelating activities of phytic acid with these minerals reduce their bioavailability and absorption in the intestinal tract. The endogenous phytase activity in the intestinal mucosa of monogastric animals is extremely low, therefore, monogastric animals cannot hydrolyze phytate phosphorus effectively (Taylor, 1982).

2.8.2 Saponin content of locust bean pulp

The finding of Gernah *et al*. (2007) indicated that LBP contained 17.8 mg/100g sample and that it could be a contributory factor to the foaming characteristic of the fruit pulp. The saponin content on LBP is lower than in other common foodstuffs like lima beans (24.50mg/100g) and millet (19.47mg/ 100g) as reported by Osagie (1998) and therefore considered to be safe. In addition, although saponin have been shown to be highly toxic under experimental conditions, acute poisoning is relatively rare, both in man and animals (Tannenbaum, 1979).

2.8.3 Tannin content of locust bean pulp

The bark of locust bean tree and the seed have been reported to contain tannin (Orwa *et al.,* 2009). The findings of Bot (2011) indicated that LBP contained 3.23mg/100g sample. Rao and Prabhavatti (1982) had earlier reported the ability of tannin to form complexes with proteins, thus interfering with the digestion processes by inactivating the digestive enzymes such as trypsin, chymotrypsin, amylase and lipase. Rao and Doesthale (1982) also reported growth depression in rats fed diets containing high level of tannin. Poultry diets high in tannin contents have been shown to decrease egg production and body weight gain (Rao and Prabhavatti, 1982).

2.8.4 Oxalates content of locust bean pulp

Alabi *et al.* (2005) gave a report that LBP contained 3.4mg/100g of oxalates while Bot *et al.* (2013) reported that oxalates content in the LBP was 150mg/100g. Oxalates are dibasic acid and widespread in plants and are composed of calcium, nitrogen and magnesium salts. Oxalates are naturally occurring anti-nutritional factors that are capable of interfering with the absorption of essential mineral elements such as calcium, iron and to some extent, zinc (Onwuka, 1996). They form complexes with these elements and there are soluble and insoluble oxalates. The soluble oxalates are broken down to form carbonates (CO_3^{2-}) and bicarbonates (CHO^{3-}). While the insoluble oxalates may result in the formation of gall stone (Bothwell and Charlton, 1982). The complex formed by oxalate with calcium reduces the bioavailability of dietary calcium (Oke *et al*, 1996). High concentration of oxalates in monogastric diets may results in distress, dullness, anorexia, incoordination and death in extreme cases (McDonald *et al.* 1987).

2.8.5 Trypsin inhibitor

Bello *et al.* (2008) reported that LBP contained 15.5mg/100g of trypsin inhibitor. Trypsin and chemotrypsin inhibitors are the most widely distributed of all anti-nutritional factors in legumes. Their concentration vary in many plants, they may be as low as to have no detrimental effects as they passed unnoticed through the gastrointestinal tract (Betterham *et al.*, 1986). Depressed feed intake, weight gain and pancreatic hypertrophy had been reported in pigs and chicks fed high trypsin inhibitor diets (Ogundipe and Adams, 1974; Fashina-Bombata and Tewe, 1995). Lyman and Lepkovsky (1957) reported that feeding of crude trypsin inhibitor or raw soyabean meal enlarged the pancreas and greatly stimulated its activity, they observed a reduction of trypsin in the gut shortly after the intake, this low trypsin activity was followed by an increased secretion of the enzyme such that after 6 hours, the secretion of trypsin was three times greater than normal. They concluded that growth depression caused by trypsin inhibitor was due to an endogenous loss of protein produced by hyperactive pancreas.

2.8.6 Flavonoids

Flavonoids are a large group of non-nutrient compounds naturally produced from plants as part of their defense mechanisms against stresses of different origins (Catoni *et al.*2008). They are mostly water-soluble polyphenols (Eastwood, 1999). Fruit and beverages such as tea and red wine constitute the main sources of polyphenols (Birt *et al.*, 2001; Manach *et al.*, 2004). Certain polyphenols such as quercetin are found in all plants and derivatives e.g (fruit, vegetables, cereals, leguminous plants, tea, wine, infusions, etc), while others are specific to particular foods (e.g., flavanones in citrus fruit, isoflavones in soy, and phloridzin in apples) (Manach *et al.*, 2004).

Flavonoids are strong antioxidants and are among the commonest found in fruits, which are a primary source of antioxidants for many animals. It is therefore likely that flavonoids play a beneficial role as dietary antioxidants, but their potential has been ignored in evolutionary ecology (Catoni *et al.*, 2008). Birds can obtain immunological benefits from the ingestion of flavonoids. Flavonoids can reduce oxidative stress by directly scavenging free-radicals, by interfering with free-radical producing mechanisms and by increasing the function of endogenous antioxidants (Nijveldt *et al.*, 2001).

Flavonoids may regenerate other antioxidants with known immune-enhancing activity, such as vitamin E (Zhu *et al.*, 2000) and Carotenoids (Pietta and Simonetti, 1998). In addition, *in vitro*, flavonoids can have profound direct effects on a variety of immune and inflammatory cell functions (Middleton and Kandaswami, 1992; Middleton *et al.*, 2000).

2.8.7 Alkaloids

Alkaloids occur mainly in various genera of seed plants, such as tobacco plant. Alkaloids can be found in almost all parts of this plant, including the leaves, roots, seeds, and bark (Childers, 1979). Each plant part usually contains several chemically related alkaloids. The function of alkaloids in plant metabolism is not known. Out of hundreds of alkaloids found in nature, only about 30 are used commercially (Kubo and Fukuhara, 1996). Some alkaloids, such as nicotine, are used in pesticides, and others are used as chemical reagents according to Stankiewicz and Evans (1980). The primary use of alkaloids, however, is in medicine, because they can act quickly on specific areas of the nervous system. Alkaloids are the active components of many anaesthetics, sedatives, stimulants, relaxants, and tranquilizers.

Kubo and Fukuhara (1996) reported that bitter taste in potatoes after the potatoes have been cooked is usually a good indication that excessive amounts of alkaloids are present. EFSA, (2012) gave a report that ergot alkaloids are produced by several members within the fungal orders of Hypocreales and Eurotiales and are classified as tryptophan-derived alkaloids. In the middle ages, the consumption of ergot alkaloids contaminated grains, flour or bread caused severe epidemics of the condition known as “St. Anthony’s fire” and today, the cause of the disease is called ergotism.

EFSA (2012) also reported that under normal conditions the risk of toxicosis in livestock is low. Furthermore, the risk of ergotism in livestock as a result of consuming contaminated cereal grains, or compounded feeds manufactured from them, is reduced when appropriate seed cleaning is carried out. Beier (1990) had earlier reported that exposure to ergot alkaloids to livestock and domestic animals was most likely to occur as a result of consuming rations containing cereal grains and cereal by-products, and in particular rye, sorghum and millet and by-products derived from them.

Poultry appear to be able to tolerate higher levels of ergot than other non-ruminant livestock. Studies published by EFSA (2005) indicated that 1.4 mg ergot alkaloids/kg feed is safe for poultry. Bailey *et al.* (1999) reported that feeding rations with high levels of *Ergot sclerotia* for an extended time can result in loss of appetite, increased thirst, diarrhea, vomiting and weakness in poultry. They also reported that convulsions, gangrene of the comb, wattles, or toes, paralysis and death may follow short-term feeding of ergot-contaminated rations. There are variation in both the quantity and type of the alkaloids present in *Ergot sclerotia*, hence, it was difficult to establish safe levels, although safe dietary levels of ergot for chickens appear to be in the range of 0.3 - 0.8 % by weight, depending on the actual alkaloid concentration (Bailey *et al*., 1999).

Mainka *et al*. (2005) reported an experiment in which they compared the effect of ergot contaminated feed on performance and health of piglets and chickens. The treatment groups were offered feed with levels of 0.0, 0.5, 1.0, 2.0 and 4.0 g of ergot/kg diet. Feed and water were available *ad libitum* throughout the experimental period. The ergot was analyzed to contain 2 775 mg of total alkaloids per kg. No mortality was observed in the groups fed 0.0, 0.5, 1.0 and 2.0 g of ergot per kg feed. Feed intake cumulative daily weight gain were not significantly affected by the dietary levels of ergot. The authors, concluded that the optimum safety level could be identified at 1.4 mg of ergot alkaloids/kg feed. In their study with *C. purpurea*, (an alkaloid) they observed a reduced body weight gains in pigs when alkaloids in the diet were fed in the range of 0.60 and 4.66 mg/kg diet and reported that no adverse effects typically associated with ergot poisoning were observed.

Stankiewicz and Evans (1980) in a feeding trial using ergotamine reported that 0.33 mg/kg per body weight per day was calculated for the incidence of tail muscular atrophy in a 13-week old rat. They also observed decreased body weight gain and changes in the levels of some hormones. Peters-Volleberg *et al*. (1996) observed decreased body weight gain associated with depressed feed intake in rats, which was likely to be due to dopaminergic effects of ergot alkaloids. They also observed a decrease in serum thyroxine (T4) levels in male and female rats treated with ergometrine. Janssen *et al.* (2000) reported a decrease in serum prolactin levels in the sub acute study on α-ergocryptine. The results for these hormonal levels were variable and could not be used for establishing a health-based guidance value.

EFSA (2005) reported that there was no evidence of accumulation of ergot alkaloids in meat and therefore concluded that there were no carry over effect of alkaloids on animal product. Mainka *et al.* (2005) reported a study in which growing and fattening pigs (30 - 115 kg body weight) were fed diets containing up to 4.66 mg ergot alkaloids/kg diet, but they were unable to detect any alkaloids in meat and back fat.

2.9 Locust Bean Pulp as Food for Man

Virtually every part of the locust bean tree is useful. It is an economically important food source in West Africa. The seed serves as a good condiment sold widely in the market and the young pods and pulp are also consumed. The bark and roots have useful medicinal properties and the leaves can also be used as fodder (Wilson *et al.,* 1998; Odetola *et al.,* 2006; Ouoba *et al.,* 2007).

The LBP contains natural sugars and it is therefore a potential source of energy. It is used in some rural part of Africa during emergencies when the grain stores are empty, this showed that it is edible and non-toxic (Owoyele *et al.,* 1989; Akoma *et al.,* 2001; Alabi *et al.*, 2005; Gernah *et al.,* 2007; Edem and Miranda, 2011). It is also used in the preparation of some indigenous drinks such as the popular "Kirbwang" (local yoghurt) in Borno state or pressed into cakes and preserved for later use (Akoma *et al.,* 2001; Musa *et al.,* 2005; Gernah *et al.,* 2007; Akande *et al.,* 2010). The pulp is also used as an ingredient in the preparation of various stews and soups (Odebunmi *et al.*, 2010).

The LBP is more than adequate to meet the FAO/WHO recommended daily allowance of protein of 0.59g/kg body weight for an average healthy individual and 0.88g/kg body weight for children aged 1 to 10 years (Uwagbuete, 1996). It is a source of dietary fiber for man, it is essential for good bowel movement and also helps in preventing some gastro intestinal ailments such as obesity, diabetes and cancer of the colon (Ihekoronye and Ngoddy, 1985 and Uwaegbuete, 1996).

2.10 Locust Bean Pulp as Animal Feed

There are reports from the literatures indicating the usage of the LBP in animal feed formulations. Sotolu and Byanyiko (2010) reported that the LBP contained nutrients that are capable of supporting fish growth and performance. The LBP can also be fed to pig and dogs. The husks and pods are also good food for feeding livestock (Obiozoba, 1998; Akande *et al.,* 2010). The LBP has been reported to aid growth performance of broiler chicken (Kwari and Igwebuike, 2002; Bot *et al.,* 2012). Afolayan *et al*. (2012) also indicated that the LBP contained nutrients which supported the growth of pullet chicks and that 22.5% inclusion level resulted in significant weight gain. However, Kwari and Igwebuike (2002) reported a depression in final weight and weight gain of broiler chickens when LBP was fed beyond 15% level of inclusion. Similarly, Bot *et al.* (2013) also reported that LBP has a depressive effect on feed intake of broiler finisher when fed beyond 25%.

2.11 Energy Requirement of Poultry

Energy is an important component of poultry ration and is usually expressed in terms of metabolizable energy. Metabolizable energy is the portion of dietary energy that is available to the animal for the production of meat, eggs and maintenance of the body temperature and other vital functions (Summer, 2000). An absolute requirement for energy in terms of kcal/kg of diet cannot be stated because poultry adjust their intake to obtain their necessary daily requirements; in other word they eat to satisfy their energy requirement (NRC, 1984; Summer, 2000; Afolayan *et al*., 2009a). However, the energy requirement cannot be precisely stated as the requirement for protein, amino acids and vitamins because optimum growth and egg production can be achieved with a wide range of energy levels (NRC, 1998; Oluyemi and Roberts, 2003). The energy levels recommended for broiler chickens are 2800-3000kcal/kg in the tropics while 3200kcal/kg is recommended for the temperate region. However, Sekoni (2002) recommended 3000 for broiler starter, also 3000 for finishers and 2650 for both the chicks and growers, 2600 kcal/kg for the layers and 2700 kcal/kg for breeders. Aduku (2004) recommended 2800 for broiler starter and 3000 for finisher and 2600 for the chicks and growers and 2400 kcal/kg for layers breeders. Oluyemi and Roberts (2000) recommended a range of 2500 to 2900 kcal ME/kg diet for pullet chicks. Olomu (1995) indicated that birds perform equally well on energy levels 10 – 15% below the recommended levels because a range of energy levels can be fed without adverse effect on the birds.

2.11.1 Relationship between feed intake and dietary metabolizable energy (ME)

Dietary energy is known to have a great influence on feed intake. In the study of Robinson *et al.* (2000b), overconsumption of energy may occur when dietary energy exceeds 12MJ/kg in layers. Average egg weight, ME intake, efficiency of conversion of energy to egg improved with increasing ME level in the diet. Abdullaziz *et al.* (2007) reported that moderate dietary metabolizable energy with balanced proteins gives optimal feed conversion ratio and egg production. Choct *et al.* (2001), reported that similarity exist in the dietary metabolizable values obtained with adult cockerels and hens. Tailor and Jones (2001) reported that coarse diets improve the apparent metabolizable energy (AME) due to the enhanced development of the gastro intestinal tract thus improving the feed conversion ratio. However, Ravindran *et al.* (2002) and Hartini *et al.* (2002) reported that an increase in weekly energy intake will reduce feeding time thereby increasing the incidence of social pecking.

2.11.2 Response of birds to high energy feed

In terms of total cost, energy is the main factor influencing feed cost. The higher the level of energy, the higher the feed cost (Robinson *et al.*,2000b; Afolayan *et al.*, 2009a). Dietary energy level is the most important factor influencing feed intake and feed efficiency. Diets with high levels of energy are referred to as having a higher nutrient density. This means that the same amount of nutrients is available in a smaller volume. This implies that the birds will need to eat less of it to obtain its nutrient requirements hence feed: gain ratio is reduced and feed efficiency is improved (NRC, 1989; Summers, 2000; Robinson *et al.*, 2000b; Afolayan *et al.*, 2010; Afrouziyeh *et al.,* 2011). In other word diets with higher concentration of energy are usually more efficiently used in terms of unit gain per feed consumed. Singh *et al.* (2000) indicated that high level of energy in the diet of a laying bird has a depressive effect on egg production. (Neoh *et al.*, 2007) reported that ME of 3050 kcal/kg depressed egg production while lower ME of 2650 kcal/kg supported egg production in the tropics. Robinson *et al.* (2000b) reported that birds on high metabolizable energy (ME) diet reached peak production earlier than those on low energy diet and that feed intake, feed efficiency, egg specific gravity, and caloric efficiency decline with the increase in dietary energy level. According to Hartini *et al*. (2002) high density diet decrease the length of time spent in eating.

2.11.3 Response of birds to low energy feed

Leeson and Summer (2001; 2005) observed that growth was adversely affected when low energy diets were used and that birds eat more of low energy diets (almost double of its normal intake) as the birds eat more of such diets a constant growth rate is maintained. Lumpkins *et al.* (2005) also reported that low energy diets resulted in poor feed efficiency and depression in egg production because hens were not fully meeting their caloric requirement. This report contradict the report of Robinson *et al.* (2000a) that birds on low energy diet converts energy and protein to egg more efficiently than those on high energy diet. Summer, (2000) observed that diet with the lowest feed efficiency may not always be the most economical. It was hypothesized that feeding lower energy diets during the hot season could help to lower cost of production of poultry products in the tropical regions (Afolayan *et al*., 2009b).

2.11.4 Energy requirement of pullet

Metabolizable energy requirement for pullet chicks ranges between 2,500 to 2,900 kcal/kg (Oluyemi and Roberts, 2000). Similarly, Yusuf *et al*. (2008) also reported that the energy requirement of pullet chicks obtainable in most of the commercial feeds ranges between 2,500 to 2,749 kcal /kg, while Afolayan (2008) in a study with broiler chicks gave a similar report that a range of 2,600 to 3,000kcal/kg of energy level may be used for broiler starters and finishers. Peguri and Coon (1991) indicated that moderate metabolizable energy (ME) level of 2830kcak/kg diet is the best for optimum feed conversion ratio and egg production.

2.12 Determination of the Nutrient Digestibility

Furlan *et al.* (2003) defined digestibility as the process of digestion and absorption which reflects enzymatic hydrolysis and microbial fermentation of ingested nutrients. Digestibility is the measure of how efficiently an animal uses its feed resources. The digestibility of ingredients determines the total energy value of the diet (Nworgu and Ologhobo, 2000 ; Aduku, 2004).

Digestibility is one of the most important aspects in evaluating the efficiency of foodstuffs. Khieu *et al.* (2002) reported that researchers and producers were more interested in the quantity and quality of a formulated feed that results in an optimum economic return, therefore it is necessary to estimate the level of digestion of the nutrients present in a feed ingredients to facilitate formulation of ration that will meet the required demands for productive purposes (Onimisi *et al.,* 2008). The digestibility of non starch carbohydrate is lower in chicken than in pigs because chickens have limited capacity to obtain energy from fermentation, (Singh *et al.* 2000). The digestibility of non starch polysaccharide (NSP) in pigs can be as high as 93% while in poultry it ranges between 13% to 21.9% because of processing methods, storage, grinding, granulation, enzyme supplementation, heat treatments (McNab, 2007). Age, genotype, sex and method of determination can also have effect on nutrient digestibility (Tailor and Francis, 2007).

2.13 Serum and Haematological Metabolites as Indices of Nutritive Value

Haematological indices such as packed cell volume (PCV), haemoglobin concentration (Hb), leucocyte count, mean corpuscular volume (MCV) and white blood cells (WBC) are essential in monitoring feed toxicity especially with feed constituents that affect the formation of blood (Aro and Akinmoyegun, 2012). Haematological and serum biochemical variables of the blood of livestock have a positive correlation with protein quality and quality of the diet. Also, blood is an important index of physiological and pathological changes in an organism and have been used in diagnosis, treatment and prognosis of many diseases, it is also used in assessing the body‘s ability to respond to nutritional challenges (Nworgu *et al.,* 2007; Aguihe *et al.,* 2012; Ojediran *et al.,* 2012). Among the blood variables, it is only (PCV), (RBC) and plasma protein that are mostly influenced by diets (Lawrence *et al*., 2012).Hence, the effect of diets on heamatology and serum metabolites are very important because blood transports gases, nutrients, hormones and excretory products within the body. Some anti-nutrients present in feedstuffs such as tannins and cyanide can destroy lymphocytes, consequently predisposing the animals to infection (Aro and Akinmoyegun, 2012).

The impact of haematological parameters on poultry have been shown to be influenced by various factors such as age, sex, season and nutrition (Islam *et al.,* 2004; Afolabi *et al.,* 2011). Adeyemo and Longe (2007), in an experiment on the effects of graded levels of cottonseed cake on performance, haematological and carcass characteristics of broilers fed from day old to 8 weeks of age, reported a range of 26.7 – 31% for PCV, 8.48 – 10.6g/100ml for Hb, 2.67 – 3.30 ^2.9x $10^{12}m^3$ for RBC, 1.90 – 2.32 x $10^6/mm^3$ for WBC. Yi *et al*. (2009) and Haifeng *et al.* (2012) reported the importance of red blood cell and erythrocyte in the measurement of anemia. Some of the symptoms of blood deficiency in chickens includes shrinking, loose feathers, waxy eyelid, pale tongue, low red blood count and decrease in hemoglobin content. Pampori and Iqbal (2007), Riddell (2011) and Afolabi *et al.* (2011) reported the normal range of Heterophill and Eosinophil in a healthy chicken as 10 to 53% and 0.00 to 15%

respectively. Kempert (2010) reported that the WBC plays a prominent role in disease resistance and the average value in a healthy chicken ranges between 6.95 – 18.65 x $10^6/mm^3$. Pampori and Igbal (2007) reported a range of 16.8 – 22.9 x 10^6mm^3, but Afolabi *et al.* (2011) reported a range of 9.20 – 31.0 x 10^6mm^3 while Islam *et al.* (2004) reported the value of 7.06- 9.37%, 26.56 – 34.60% and 84.27 – 163.5 fl for Hb, PCV and MCV respectively. Kwari and Igwebuike (2002) reported a depressive effect of the LBP on the red blood cell, haemoglobin concentration, blood glucose and blood protein in broiler finishers.

2.13.1 Blood glucose

Blood glucose level is the amount of glucose (sugar) present in the blood of a human or animal. The body naturally tightly regulates blood glucose levels as a part of metabolic homeostasis. John (2001), reported that glucose is the primary source of energy for the body's scells, and blood lipids are primarily a compact energy store. Glucose comes from carbohydrate foods, it is the main source of energy used by the body, except for the ruminant animals in which their dietary metabolizable carbohydrates tend to be used by rumen organisms. Khan and Zafar (2005) reported that the mean normal blood glucose level in humans is about 4mM (4mmol/L or 72mg/dL) however, this level fluctuates throughout the day. Glucose levels are usually lowest in the morning, before the first meal of the day. In animals the blood glucose level rises dramatically between the first 30 minutes to one hour after feeding on a glucose based diet, it then decline to optimal level within the next second hour.

An increase blood sugar is termed hyperglycemia, while low blood sugar is termed hypoglycemia. There are several factors that may lead to high blood glucose such as excess production of growth hormone, severe stress while low glucose level may be caused by malnutrition, kidney failure and tumor in the pituitary gland. Khan (2005) and USDA (2009) indicated that the ranges of blood sugar in ruminants were lower than in monogastrics as can be seen in the following animals; cow (42 – 75), sheep (44 – 82), goat (48- 76), pigs (66- 116), rabbits(75 – 155)mg/dl.

2.13.2 Blood cholesterol

Cholesterol is a lipid that the body produces in the liver. it is present in meat, eggs and dairy. The amount of cholesterol present depends on the animal and the part of the animal. Poultry and poultry products contain higher levels of cholesterol than many other types of animal products (Matt, 2011). Chicken meat contains cholesterol because all meat and animal by-products are sources of dietary cholesterol. Konjufca *et al.* (1997) and Pesti *et al.* (1994) indicated that dietary garlic or copper in the diet reduced cholesterol levels of broiler meat without altering growth of the chickens or feed efficiency. Daudu *et al.* (2012) also reported that ginger by product meal decreased the cholesterol content of the plasma of broiler chicks. Also, laying hens have higher blood cholesterol levels than immature hens or mature roosters. Similarly, average plasma triacylglycerol levels were lower in 3-wk-old broilers than in the laying hens (Pesti *et al.,* 1994).

2.14 Egg Quality

Consumer’s perception of egg quality depends on their intended use of the egg and individual preferences. The egg consists of three main components namely shell, albumen and yolk. The shell is about 11% of the entire egg weight, while albumen is about 58% and the yolk is about 38%. Eggs have the highest quality protein that is easily digestible, and it also have an important satiety effect that helps to control caloric intake and maintain a healthy weight (Donald, 2010; Basil, 2011).

The hen's egg is a high quality food with a natural balance of essential nutrients. The physical appearance of an egg is critical to consumer acceptance. Consumer confidence diminished if the product fail to meet perceived expectations (Aduku and Olukosi, 2000; Dafwang, 2006; Hosseini *et al.,* 2007; Buba *et al*., 2012).

2.14.1 Internal quality of an egg

2.14.1.1 Albumen quality

Albumen quality is a standard measure of egg internal quality, as well as an indicator of egg freshness. Egg quality is dependent on storage time and temperature (Samli *et al.,* 2005). According to Roberts and Ball (2000) and Hosseini *et al.* (2007), albumen height, Haugh unit and percentage shell deteriorate with the age of the hens while egg weight increases with the age of the hen. Mohammed (2011) indicated that the type of grain have effect on the egg and shell quality. Also Gongruttananun *et al.* (2000) reported that early introduction of layer diet to pullet results in production of smaller eggs with lower albumen weight and Haugh units due to protein deficiency. According to Haugh, (1937); Samli *et al.* (2005) ; Buba *et al.* (2012), Haugh unit (HU) is calculated from the height of the albumen and the weight of the egg.

2.14.1.2 Egg yolk quality

Egg yolk colour is an important factor for marketing eggs in some countries According to Haugh (1937); Samli *et al.* (2005); Buba *et al.* (2012); Catherine and Ulrich (2012), many consumers prefer a golden to pale yellow yolk which gives the yolk an appetizing look, therefore egg yolk pigmentation is of significance for the egg production industry. The colour of the yolk varies from yellow to deep orange. However, hens cannot synthesize yolk pigments therefore egg yolk colour closely depends on the fat soluble pigments in the diets fed. Poultry absorb xanthophylls from their feed and deposit them in the yolk, therefore as the pigment content of the feed increase, the pigment content of the yolks also increase (Donald, 2010). The amount of xanthophylls in the diet is one major determinant of yolk colour. Carotenoids also occur widely in nature as yellow and red pigments, they are found in green parts of plants, fruits and cereals. There are both natural pigments as well as synthetic form of yolk pigment. Examples of the natural yolk pigments are Zeaxanthin found in yellow maize, astaxanthin from marine micro algae. According to Roberts and Ball (2000), some countries had banned the use of synthetic yolk pigment, as a result of which natural yolk pigments are becoming popular. Report by Catherine and Ulrich (2012) indicated that the inclusion of soluble distillers dried grains resulted in a desirable egg yolk colour with scores of 6.4 – 6.9. They also reported that the simplest procedure for measuring the yolk colour is by visual comparison and matching the yolk colour with the various colours of a Roche Yolk Colour Fan. This fan made up of plastic paddles numbered from 1 to 15 starting from pale yellow to deep orange colour.

2.14.2 External quality of an egg

2.14.2.1 Shell Quality

The quality of egg shell is of primary concern to the poultry industry due to two major reasons. Firstly, the successful development of a chicken embryo is dependent upon a robust egg shell for mechanical protection from infection, water loss and as a source of calcium for the embryonic skeleton. Secondly, good shell quality such as can withstand rough handling to some extent is essential for the commercial production and marketing of eggs (Ken *et al.,* 1992; Roberts *et al.,* 1998; Pines, 2007). Weaker shelled eggs are more prone to cracks and breakages and subsequently microbial contamination. Also, type of cereal grains and heat stress affect egg shell quality. Wintle (2006) reported that adequate supply of minerals and vitamins is essential for good egg shell quality, however feeding high levels of calcium may interfere with the availability of other minerals and can have negative impact on the ability of the bird to utilize calcium (NRC, 1994).

2.14.2.2 Egg specific gravity (SG)

Egg specific gravity is an estimate of the amount of eggshell deposited and is related to the eggshell percentage. According to Hamilton (1982), egg specific gravity increases according to the thickness of the eggshell. Peebles and McDaniel (2004) considered in their work the egg specific gravity value of 1.080 as the threshold between the low and high quality of egg shells. Egg specific gravity can be calculated based on the weight of the egg and shell (Poultry Adviser, 1992). There is a general decline in egg specific gravity during heat stress.

2.14.2.3 Egg surface area

Egg size and shape are very important to the farmers, consumers and to the engineers involved in the developments of machinery and equipments used in egg handlings. There is no easy formula available for egg shape calculation because there is no uniform shape for an egg. Therefore, a lot of estimation and approximation are involved. According to Carter (1968), surface area of a hen’s egg can be calculated using a mathematical model as follows:

$S = (3.155 - 0.0136L + 0.0115B)\ LB$

Where L= length (mm)

B = breadth (mm)

S = surface area

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The feeding trial was conducted at the Poultry Unit of the Animal Science Teaching and Research Farm, Ahmadu Bello University, Samaru- Zaria, Kaduna State. It is located within the Northern Guinea Savannah zone of Nigeria, Latitude 11^o 12'N and Longitude 7^o 33'E, at an altitude of 610m above sea level. The climate is relatively dry, with a mean annual rainfall of 700-1400mm, occurring between the months of April and September. The dry season begins around the middle of October, with cold weather that ends in February. This is followed by relatively hot-dry weather from March to April, before the onset of rain. The mean minimum daily temperature ranges between 14^{o}C to 24^{o}C during the cold season while the mean maximum daily temperature is from 19^{o}C to 36^{o}C during the hot season. The relative humidity varies between 19 to 35% during the hot Season, and 63 and 80% in the wet Season as reported by Oluwasemire, (1999).

3.2 Sample Preparation

The LBP used for this study was obtained from Giwa market, in Giwa local government area, Kaduna State. The matured locust bean pods are harvested from trees and then sundried. The pulp is then removed from the pods and the seeds. The pulp was further air - dried at room temperature to prevent growth of mould. Samples of the pulp were then stored in air tight polythene bags and kept until when needed.

3.3 Proximate and Chemical Composition of Locust Bean Pulp

The proximate composition (crude protein, crude fibre, moisture, ether extract, ash and NFE) of the LBP were determined using the standard methods described by AOAC, (1990) in the Biochemical laboratory of the National Research Institute for Chemical Technology (NARICT), Bassawa, Zaria. Kaduna State, Nigeria. The calcium and phosphorus content of the locust bean pulp were also determined using atomic absorption spectrophometry (Perkin Elmer model 403) as described by AOAC (1980). Beta -carotene and vitamin C were determined colorimetrically as described by Falade, *et al.* (2003) using a (GENESYS 10 UV spectrophotometer, Thermo Electron Corporation, England).

3.4 Determination of the Anti-Nutritional Factors of Locust Bean Pulp

The presence of anti-nutritional factors such as: oxalate, phytate, saponin, tannin, trypsin inhibitor, cyanide, alkaloids and flavonoid were detected quantitatively by the standard methods described by AOAC (1980) at the Biochemical laboratory of the National Research Institute for Chemical Technology (NARICT). Bassawa, Zaria. Kaduna State, Nigeria.

3.4.1 Determination of tannin

Tannin was determined using the standard method described by AOAC (1984). Two grams of the sample of LBP was boiled with 300ml of distilled water. This was diluted in a standard volumetric flask and filtered through a non- absorbent cotton wool. Twenty five mls of the distilled water was measured into a 2 liter porcelain dish and titrated with 0.1N potassium permanganate (0.1N potassium permanganate was standardized against 0.1N oxalic acid) until the blue solution turned green, then few drops of 0.1N potassium permanganate was added. The titre was multiplied by 0.0066235 to obtain the amount of tannin in the sample.

3.4.2 Determination of phytate

Phytate was determined using the standard method described by Reddy and Love (1999). A known weight (5g) of ground sample of LBP was soaked into 100ml of 2% Hcl for 5 hours and filtered through a filter paper and 25ml of the filtrate was taken and 50cm^{3}of 0.3% potassium thiocynate solution was added in a conical flask. The mixture was titrated using a standard solution of ferric chloride ($FeCl_3$) until a brownish – yellow color persisted for 5 minutes. The concentration of the $FeCl_3$ was 1.04% w/v

Calculation:

Mole ratio of $FeCl_3$ to Phytate = 1:1

Concentration of Phytate phosphorus

$$= \frac{\text{Titre value} \times 0.064}{1000} \times \text{weight of sample}$$

3.4.3 Determination of oxalate

The method of Munro and Bassir (1969) was used to determine the oxalate content in the LBP. The total oxalic acid of the powdered samples was determined by weighing 2g into a 250ml flask. Then 190 ml distilled water and 10ml of 6M hydrochloric acid were added. The mixture was heated for 1hour in boiling water bath, cooled, then transferred into a 250ml volumetric flask, and diluted to volume and filtered. Four drops of methyl red indicator was added followed by concentrated ammonia till the solution turned faint yellow. It was then heated to 100^{o}C and allowed to cool and filtered to remove precipitate containing ferrous ions. The filtrate was boiled and 10ml of 5% calcium chloride was added with constant stirring. It was then allowed to stand overnight. The mixture was filtered through Whatman No 40 filter paper. Then the precipitate was washed several times with distilled water and transferred to a beaker and 5ml of 25% sulphuric acid was added to dissolve the precipitate. The resultant solution was maintained at 80^{o}C and titrated against 0.5% potassium permanganate until the pink colour persisted for approximately one minute. A blank was also run for the test sample from the amount of potassium permanganate used, the oxalate content of the LBP sample was calculated using the formula below:

1ml of potassium permanganate = 2.24mg oxalate.

3.4.4 Determination of crude saponin

The standard method of AOAC (1984) was used to determine Saponin content of LBP sample. A gravimetric method employing the use of a soxhlet extractor and two different organic solvents was used. The first solvent extracted lipids and interfering pigments while the second solvent extracted the saponin proper.

A known weight (2g) of the sample was weighed into a thimble and transferred into the soxhlet extraction chamber fitted with a condenser in a round bottomed flask. Acetone was poured into the flask, and the sample was exhaustively extracted of its lipids and interfering pigments for 3 hours by heating the flask on a hotplate and the solvent was distilled off.

For the second extraction, a pre - weighed round bottom flask was fitted into the Soxhlet apparatus which had the thimble containing the sample. Then methanol was poured into the flask. The saponin was then exhaustively extracted for 3 hours by heating the flask on a hotplate after which the solvent was distilled off. The flask was reweighed, and the difference between the final and initial weights of the flask represented the weight of the saponin extracted.

$$\%\ \text{saponins} = \frac{\text{weight of saponins}}{\text{weight of sample}} \times 100$$

3.4.5 Determination of trypsin inhibitor

The method outlined by Kakade *et al.* (1974) was used in determination of trypsin inhibitor content of LBP. A known weight (1g) of ground sample was weighed and dispersed into 50cm^{3}of 0.5M NaCl solution. The mixture was stirred for 30 minutes at room temperature and centrifuged. The supernatant was filtered through Whatman No 41 filter paper. The filtrate (extract volume) was used for the assay.

Preparation of standard trypsin and substrate in 0.1M phosphate buffer pH 7.7 was prepared and 1cm^{3}of trypsin inhibitor was added into 2cm^{3}of trypsin standard solution and incubated for 10mins at 37^{o}C and then 5cm^{3}of substrate and 2cm^{3}of trypsin was added into a test tube and incubated at 37^{0}C for 10 minutes. A blank of 5cm^{3}substrate was prepared in a test tube (without trypsin inhibitor extract added). The contents in the test- tube was left for 10 minutes and the reaction was stopped by adding 3cm^3 5% of the blank substrate. It was then filtered and then measured spectrophotometrically at 410nM. The trypsin inhibitor activity was expressed as the number of trypsin unit incubated (TUI) per unit weight of the sample analyzed.

Calculation:

$$\frac{\mathrm{TUI}}{\mathrm{mg}} = \frac{(\mathrm{b}-\mathrm{a})}{0.1} \times \mathrm{T}$$

Where b = absorbance of test sample solution

a = absorbance of the blank

$$\mathrm{T} = 1 \times \frac{\mathrm{V_f}}{\mathrm{V_a}} \times \mathrm{D} \times \frac{1}{\mathrm{W}}$$

Where W = weight of sample

V_f= total volume of extract used in the assay

D = dilution factor

V_a = volume of standard solution

T = Trypsin Inhibitor

3.4.6 Determination of alkaloid

The alkaloid content in LBP was determined gravimetrically according to the method described by (Harborne , 1973)**.** Five grams (5g) of the sample was weighed on a weighing balance and dispersed into 50ml of 10% acetic acid solution in ethanol. The mixture was then shaken vigorously and allowed to stand for about four hours before it is filtered. The filtrate was then evaporated to one quarter of its original volume on hot plate. Concentrated ammonium hydroxide was added drop wise in order to precipitate the alkaloids. A pre weighed filter paper was used to filter off the precipitate and it was then washed with 1% ammonium hydroxide solution. The filter paper containing precipitate was oven dried at 60^{o}C for 30minutes, after which it was transferred into a desicator to cool and then reweighed until a constant weight was obtained. The constant weight was recorded. The weight of the alkaloid was determined by weight difference of the filter paper and expressed as a percentage of the sample weight analyzed.

3.5 Biological Studies

3.5.1 Experiment 1: Determination of metabolizable energy value of locust bean pulp

The objective of this experiment was to determine the metabolizable energy value of LBP. Adult ShikaBrown$^{(R)}$ cocks were used for this study because matured cocks maintain a steady metabolic state and do not become obese. A total of fifteen cocks were housed in battery cages singly for one week, to get them used to the cage environment. During this period they were fed the control layer diet (Table 3.1) see Appendix 1 for unit cost of the ingredients. The feed used in this study was a practical layer diet. The treatment diet was a mixture of 80% of the control diet and 20% of the LBP. At the commencement of the experiment, all the cocks were fasted for 24 hours to empty their gut. Only water was provided during these 24 hours. The birds were then randomly allocated to three groups (3 treatments) of five cocks each. Each cock in a

Table 3.1 Composition of Layer Diet Fed to the Cocks for the Metabolizable Energy Study

Ingredients	Quantity (%)
Maize	49.00
Groundnut Cake	12.30
Soya cake	11.00
LBP	0.00
Wheat Offal	5.00
Maize offal	10.00
Fishmeal	2.00
Limestone	7.00
Bone meal	2.50
Common Salt	0.30
Methionine	0.30
Lysine	0.30
Premix **	0.30
Total	100.00
Calculated Analysis	
ME kcals/kg	2647
Crude Protein %)	16.66
Crude Fibre (%)	3.93
Calcium (%)	3.71
Available Phosphorus (%)	0.58
Methionine (%)	0.58
Lysine (%)	1.05
Cost/ kg (₦)	53

**Biomix layer premix provide per kg of diet: Vit. A, 10,000 I.U: Vit D_3, 2000 I.U; Vit. E, 23mg; Vit. K, 2mg; calcium pantothenate,7.5mg; Vit. B_{12}, 0.015mg; folic acid, 0.75mg; choline chloride, 300mg; Vit B_1, 1.8mg;Vit B_2, 5mg;Vit B_6, 3mg ; manganese,40mg; iron, 20mg; zinc, 53.34mg; copper, 3.mg; iodine, 1mg; cobalt, 0.2mg; selenium, 0.2mg, zinc 30mg.

treatment served as a replicate. An empty cage was left between each of the replicates and the feathers around the vent of the birds were removed to avoid possible contamination of droppings between replicates. The first group of five cocks was fed the control (layer) diet. The second groups were fed diet containing 80% of the control diet and 20% of the LBP while the third group of five cocks were given a negative treatment (i.e. no feeding) for four days of feacal collection to determine the fasting energy and endogenous nitrogen loses. Water was given *ad libitum* to all groups of cocks throughout the period of the experiment. As soon as feed was placed in the feeders, polythene sheets were tied under each cage for feacal collection, for all groups. Feacal collection commenced twenty – four hours after the commencement of feeding; The faecal collection was done for four days up to twenty- four hours after feeding had stopped. Feathers and other foreign particles were carefully removed from the feaces. The faecal samples were carefully labeled according to replicates and kept in freezer to prevent deterioration. On the third day of the fecal collection, all the birds were starved to empty their gastro intestinal tract and the last batch of feaces were collected on the fourth day and then bulked, weighed and oven dried at 70^{o}C for 72 hours. Samples of the dried faeces and the two diets were grounded and analyzed for nitrogen composition according to A.O.A.C (1990) methods. Gross energy values of the samples were also determined with the aid of (automatic) Parr Adiabatic Bomb calorimeter at the Department of Chemical Engineering laboratory, Ahmadu Bello University, Zaria. The apparent metabolizable energy (AME) of the diets was calculated using the formula of Hill and Anderson (1958) as shown below;

$$\text{AME/g of feed} = \frac{(F_I \times G_{EF}) - (E \times GE_e)}{F_I}$$

Where F_I = Feed intake (g)

E = Excreta output (g)

G_{EF} = Gross energy of feed (kcal/kg)

GE_e= Gross energy of excreta (kcal/kg)

The AME of the test ingredient was calculated using a simple algebraic equation.

If AME of the basal diet (control diet) " X" is "a " kcal/kg and that of the 20% substituted ration "Y" is "b" kcal/kg, then the equation becomes:

$X = a$ kcal

$X = a$ kcal $+ 0.2Y = b$ kcal

$0.8a$ kcal $+ 0.2Y = b$ kcal

$0.2Y = b - 0.8a$

$Y = b - 0.8a/0.2$

A correction was made for nitrogen retained in the body. Since body nitrogen when catabolised is excreted as energy containing products, it is therefore important to bring AME data to a basis of nitrogen equilibrium (Sibbald, 1979). Nitrogen corrected apparent metabolisable energy (AMEn) was thus calculated from the following equation according to the method of Hill and Anderson (1958).

AMEn = AME – 8.22(gN/g feed – gN/g feaces)

Where;

AMEn = Nitrogen corrected apparent metabolizable energy (kcal/kg)

gN/g feed = Nitrogen in feed

gN/g feaces = Nitrogen in feaces

The efficiency of utilization of AME and AMEn were calculated using the formula below:

Efficiency of energy utilization (%) $= ME \ or \ MEn \times {}^{100}/_{GE}$

Where ; GE is the gross energy of the feed sample.

The true metabolisable energy (TME) of the control and substituted rations were also calculated using the equation according to Sibbald (1979);

$$\text{TME (kcal/kg)} = \mathrm{Ge^f} \times \mathrm{W} - \frac{(\mathrm{Ye^f} - \mathrm{Ye^c})}{\mathrm{W}}$$

Where $\mathrm{Ge^f}$= Gross energy of the feedstuff.

$\mathrm{Ye^f}$= Energy voided as excreta by fed birds

$\mathrm{Ye^e}$= Energy voided as excreta by unfed birds

W= Weight of feed fed

3.5.2 Experiment 2: Performance of pullet chicks fed - graded levels of dietary locust bean pulp (0 -8 Weeks) - growth study

This study was conducted to determine the effect feeding graded dietary levels of LBP on the performance of pullet chicks from 0-8 weeks of age. Five iso-nitrogenous but not iso- caloric rations were formulated containing LBP at 0, 7.5, 15, 22.5 and 30 %, respectively (Table 3.2). A total of three hundred and seventy five (375) pullet chicks were used. Seventy- five (75) birds were randomly assigned to each of the dietary treatments having 25 chicks per replicate in a completely randomized design. The birds were raised in a deep litter open sided poultry house screened with wire mesh. Kerosene stoves were used to provide additional heat while electric bulbs were installed in each pen to provide light and heat during the brooding period. The open sided house was covered with polythene to conserve heat. Feed and water were provided *ad libitum* and all other routine management practices were observed. The experiment lasted for 8 weeks. The average initial weights of the chicks were taken before the commencement of the experiment. The chicks were subsequently weighed every week to determine the weight gained. Feed supplied and the left- over were also weighed weekly to determine weekly feed intake. The experiment started when the chicks were one day- old and they were exactly 8 weeks of age when the experiment was terminated. Average weight, feed intake, weight gain, feed to gain ratio, and percentage mortality were computed.

Table 3.2 Composition of Experimental Diets Fed to Chicks (0 – 8 weeks)

	Dietary Inclusion Levels (%)				
Ingredients	**0 %**	**7.5%**	**15%**	**22.5%**	**30%**
Maize	55.85	48.00	40.50	33.00	25.50
LBP	0.00	7.50	15.00	22.50	30.00
Groundnut cake	24.00	24.35	24.35	24.35	24.35
Soyabean cake	5.00	5.00	5.00	5.00	5.00
Wheat offal	10.00	10.00	10.00	10.00	10.00
Fishmeal	1.00	1.00	1.00	1.00	1.00
Limestone	1.00	1.00	1.00	1.00	1.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Common Salt	0.30	0.30	0.30	0.30	0.30
Methionine	0.30	0.30	0.30	0.30	0.30
Lysine	0.30	0.30	0.30	0.30	0.30
Premix **	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
Calculated Analysis					
ME (kcals/kg)	2870	2791	2715	2639	2563
Crude Protein %)	20.16	20.22	20.16	20.09	20.03
Crude Fibre (%)	4.07	4.76	5.44	6.11	6.79
Calcium (%)	1.00	1.04	1.08	1.13	1.17
Available Phos.(%)	0.45	0.45	0.46	0.46	0.46
Methionine (%)	0.58	0.58	0.58	0.57	0.56
Lysine (%)	1.04	1.05	1.06	1.06	1.06
Cost (₦ / kg) diet	78	75	72	69	66

**Biomix chick premix supplied the following per kg of diet: Vit. A 10,000 I.U, Vit D 32,000 I.U, Vit.E 23,000mg,Vit. K_3 2,000mg, vit B_1 1,800mg, Vit B_2 5,000mg, Niacin 27,500mg, pantothenic acid 7,500mg, Vit. B_6 3,000mg, Vit B_{12} 150mg, folic acid 750mg, Biotin H_2 60, choline chloride 300,000mg, cobalt 200mg, copper 3,000mg, iodine 1,000mg, iron 20,000mg, manganese 40,000mg, selenium 200mg, zinc 30,000mg, Antioxidant 1250mg.

3.5.3 Experiment 3: Performance of growers fed- graded levels of dietary locust bean pulp (9-20 weeks) - growth study

This study was conducted to determine the effect of feeding graded dietary levels of LBP on the performance of growing pullet from 9-20 weeks of age. Five iso-nitrogenous but not iso-caloric diets were formulated containing LBP at 0, 7.5, 15, 22.5 and 30 % respectively (Table 3.3). Each diet constituted a treatment and each treatment was replicated three times. A total of three hundred and thirty (330) growing pullets were used in this study. Sixty six birds were randomly allocated to each of the dietary treatments in a completely randomized design having 22 birds per replicate; feed and water were provided ad libitum. The initial weight of the birds was taken before the commencement of the experiment and the birds were subsequently weighed every week to determine the weight gained. At the end of each week, the weight of the left over feed was taken and deducted from the total feed supplied to determine the total feed intake for the week. Daily water intake was also recorded, average daily feed intake, feed conversion ratio, feed cost per bird and mortality were computed. Mortality was recorded as it occurred. The grower phase lasted from 9 - 20 weeks of age when the final group weights of the birds were taken per replicate.

3.5.4 Experiment 4: Effect of feeding graded levels of dietary locust bean pulp on the subsequent laying performance of egg type pullet (20 – 42 weeks)

This study was carried out to determine the effect of graded dietary levels of LBP fed during the growing phase on subsequent laying performance of the birds from 20-42 weeks of age. Table 3.4 showed the gross composition of the common diet fed to the pullets. A total of three hundred and thirty (330) hens obtained from the grower phase were used for the study without randomization, the previous five (5) treatments and three (3) replicates were maintained. The initial weights of the birds were recorded at the commencement of the experiment. All the birds were fed a common layer diet containing 17% CP and 2727 ME kcal /kg for three months period, water and feed were given *ad libitum.* The final weights of the birds were taken at the end of twenty two weeks laying period to determine percent change in body weight. Other parameters recorded included feed intake, water intake, average weight of eggs , hen-day eggs production and hen- housed % egg production at peak of lay and feed cost per crate of eggs were computed for each treatment. Ages at first egg up to peak of lay were also calculated.

3.5.5 Experiment 5: Effect of feeding graded levels of dietary locust bean pulp on the performance of laying hens (42-53weeks)

This study was conducted to determine the effect feeding graded dietary levels of LBP on the performance of laying hens. Table 3.5 showed the composition of diets fed to the laying hens. Two hundred and seventy (270) 42 weeks old hens were randomly assigned into five treatments with three replicates per treatment, 18 birds per replicate. Five experimental diets were formulated containing LBP at 0, 7.5, 15, 22.5 and 30% respectively. Egg production was recorded daily, egg laying performance parameters measured include; average weight of eggs, hen-day and hen- housed egg production, feed cost per crate of eggs and income above feed cost per crate of eggs was computed for each treatment. The average initial weight of the birds were taken before the commencement of the feeding trials, the birds were weighed again at the end of the experiment.

Table 3.3 Composition of Experimental Diets Fed to the Growing Pullets (9 –20 weeks)

	Dietary Inclusion Levels (%)				
Ingredients	**0 %**	**7.5%**	**15%**	**22.5%**	**30%**
Maize	46.00	38.50	31.00	23.50	16.00
Groundnut cake	9.00	9.00	9.00	9.00	9.00
Soya cake	10.00	10.00	10.00	10.00	10.00
LBP	0.00	7.50	15.00	22.50	30.00
Wheat Offal	9.35	9.35	9.35	9.35	9.35
Maize offal	20.60	20.60	20.60	20.60	20.60
Limestone	1.00	1.00	1.00	1.00	1.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Common Salt	0.30	0.30	0.30	0.30	0.30
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Premix **	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100
	Calculated Analysis				
ME kcals/kg	2656	2643	2630	2617	2602
Crude Protein %)	16.20	16.14	16.07	16.01	16.02
Crude Fibre (%)	5.36	6.03	6.71	7.38	8.08
Calcium (%)	1.51	1.55	1.59	1.63	1.68
Available-Phosphorus (%)	0.57	0.57	0.57	0.58	0.58
Meth. (%)	0.51	0.50	0.50	0.49	0.48
Lysine (%)	0.91	0.91	0.91	0.92	0.92
Cost/ kg diet (₦)	60.00	58.00	55.00	52.00	49.00

**Biomix grower premix supplied the following per kg of diet: Vit. A 8,000 I.U, Vit D3 1,500 I.U, Vit. E 7,000mg, Vit. K_3 1,500mg,Vit B_1 2,000mg, Vit B_2 2,500mg, Niacin 15,000mg, pantothenic acid 5,500mg,Vit. B_6 2,000mg, Vit B_{12} 10mg, folic acid 500mg, Biotin H_2 250, choline chloride 175,000mg, cobalt 200mg, copper 3,000mg, iodine 1,000mg, iron 21,000mg, manganese 40,000mg, selenium 200mg, zinc 31,000mg, Antioxidant 1250mg.

Table 3.4 Composition of Common Layer Diet (20-42 weeks)

Feed Ingredients	**Quantity (%)**
Maize	45.00
Groundnut cake	11.00
Soya cake	15.40
LBP	0.00
Maize offal	16.50
Fishmeal	2.00
Limestone	5.00
Bone meal	4.00
Common Salt	0.30
Methionine	0.25
Lysine	0.25
Premix **	0.30
Total	100
Calculated Analysis	
ME kcals/kg	2727
Crude Protein %)	17.06
Crude Fibre (%)	3.80
Calcium (%)	3.48
Available Phosphorus(%)	0.57
Methionine. (%)	0.59
Lysine (%)	1.13
Cost/ kg (₦)	51

**Biomix layer premix supplied the following per kg of diet: Vit. A 8,500 I.U, Vit $D_3$1,500 I.U, Vit. E 10,000mg, Vit. K_3 1,000mg, Vit B_1 1,500mg, Vit B_2 4,500mg, Niacin 15,000mg, pantothenic acid 4,500mg, Vit. B_6 3,000mg, Vit B_{12} 15mg, folic acid 600mg, Biotin H_2 500, choline chloride 175,000mg, cobalt 200mg,copper 3,000mg, iodine 1,000mg, iron 20,000mg, manganese 40,000mg, selenium 200mg, zinc 30,000mg, Antioxidant 1250mg.

Table 3.5 Composition of Experimental Diets Fed to the Laying Hens (42 –53 weeks)

	Dietary Inclusion Levels (%)				
Ingredients	**0 %**	**7.5%**	**15%**	**22.5%**	**30%**
Maize	45.00	37.5	30.00	22.50	15.00
Groundnut cake	11.00	11.00	11.00	11.00	11.00
Soya cake	15.30	15.30	15.30	15.30	15.30
LBP	0.00	7.50	15.00	22.50	30.00
Fishmeal	2.00	2.00	2.00	2.00	2.00
Maize offal	15.00	15.00	15.00	15.00	15.00
Limestone	7.00	7.00	7.00	7.00	7.00
Bone meal	3.50	3.50	3.50	3.50	3.50
Common Salt	0.30	0.30	0.30	0.30	0.30
Methionine	0.30	0.30	0.30	0.30	0.30
Lysine	0.30	0.30	0.30	0.30	0.30
Premix **	0.30	0.30	0.30	0.30	0.30
Total	100	100	100	100	100
	Calculated Analysis				
ME kcals/kg	2727	2717	2700	2688	2675
Crude Protein %)	17.06	16.99	16.93	16.87	16.81
Crude Fibre (%)	3.80	4.47	5.15	5.82	6.50
Calcium (%)	4.07	4.11	4.15	4.20	4.24
Available Phosphorus(%)	0.57	0.58	0.58	0.58	0.58
Methionine. (%)	0.59	0.58	0.57	0.56	0.55
Lysine (%)	1.13	1.14	1.14	1.15	1.15
Cost (₦ /kg)	51	48	45	42	38

**Biomix layer premix supplied the following per kg of diet: Vit. A 8,000 I.U, Vit D_3 1,500 I.U, Vit. E 7,000mg, Vit. K_3 1,500mg,Vit B_1 2,000mg, Vit B_2 2,500mg, Niacin 15,000mg, pantothenic acid 5,500mg,Vit. B_6 2,000mg, Vit B_{12} 10mg, folic acid 500mg, Biotin H_2 250, choline chloride 175,000mg, cobalt 200mg, copper 3,000mg, iodine 1,000mg, iron 21,000mg, manganese 40,000mg, selenium 200mg, zinc 31,000mg, Antioxidant 1250mg.

3.5.5.1 Egg quality assessments

The external egg quality characteristics measured were;

1. Egg weight,
2. Egg length ,
3. Egg diameter (breadth)
4. Egg shell weight and
5. Egg shell thickness.

While the internal egg quality characteristics measured were;

1. Albumen height,
2. Albumen width (diameter),
3. Albumen weight,
4. Yolk diameter
5. Yolk height
6. Yolk weight.

Two freshly laid eggs were randomly picked from each replicate and the egg weight was recorded after which each egg was carefully broken into a flat plate. The shell was washed with water to remove adhering albumen, the egg shell was then dried at room temperature and weighed. Eggs were weighed using an electronic top loading balance. Egg length and diameter were measured with vernier caliper and egg shape index were calculated as egg diameter divided by the length. Egg shell weight and thickness were measured using digital electronic scale and micrometer screw gauge respectively. Yolk index was calculated as yolk diameter divided by yolk height. The Haugh unit which is the unit for describing egg freshness, based on the thickness of the albumen was calculated from the measured height of the albumen and weight of egg using the following formula proposed by Haugh (1937);

$$\mathrm{HU} = 100\mathrm{Log}_{10}(\mathrm{h} - 1.7\mathrm{W}^{0.37} + 7.6)$$

Where

HU = Haugh unit

h = observed height of the albumen in mm

W = weight of egg in g

Scores of 90 and above are considered excellent, 70 is acceptable, and consumers usually reject eggs that score below 60. According to USDA, (2000) the HU value ranges from 20-100 or can even be more than 100, and is ranked as follows

AA: 72 HU and above

A: 60-72 HU

B: < 60

C: 30 or less

The higher the HU value, the better the egg quality. Egg yolk colour was also determined with the aid of a Roche Yolk Colour Fan.

Egg surface area was calculated relating egg weight to its surface area according to Carter (1968) using the formula;

SA = K x EW 2/3

Where

SA = surface area
K = constant with a value of 4.834 for egg weight $\geq$ 60g
EW = egg weight

Egg shell Index was calculated according to Iposu *et al.* (1994) using the formula

I = (100 x SW) / SA

Where

I = Egg Shell Index

SW = Shell weight (g)

SA = Surface Area (cm^2)

Egg specific gravity was calculated based on the weight of the egg and shell using the formula postulated by Poultry Adviser (1992);

$$ESG = \frac{EW}{[0.9680(EW - SW) + (0.4921)]}$$

Where

ESG = Egg specific gravity

EW = Egg weight

SW = Shell weight

3.5.5.2 Effect of graded dietary levels of locust bean pulp on nutrients digestibility (53 weeks)

A total of ten birds 53 weeks old were used for this study. The objective of this study was to assess the digestibility of the diets containing LBP. Two birds were taken from each treatment and housed individually in cages. They were fed a common layer diet and allowed to adjust to the cage for seven days before the commencement of feacal collection. One hundred and twenty grams of the appropriate treatment diets were supplied to each bird daily for seven days, after which the total feacal output for each bird was bulked together. Sample of the diets and that of the droppings from each bird were sent to the Biochemistry laboratory, Department of Animal Science, Ahmadu Bello University, Zaria for proximate analysis according to the standard method described by AOAC (1990). The percentage digestibility of dry matter, crude protein, ether extract, crude fibre, total ash and nitrogen free extract were determined using the following equation:

$$\%\ \text{apparent nutrient digestibility} = \frac{\text{Nutrient intake} - \text{Nutrient output}}{\text{Nutrient intake}} \times 100$$

3.5.5.3 Effect of feeding graded dietary levels of locust bean pulp on serum and haematological indices of laying hens

A total of thirty hens were used for this study, two birds were taken from each replicate, hence a total of six birds from each treatment. Two mls of blood samples were collected from the wing vein of the birds. The blood samples were placed in bottles containing Ethylene diamine tetra-acetic acid (EDTA) to prevent blood coagulation. Another 2mls of blood samples were taken into separate sample bottles without EDTA for serum chemistry, all the blood samples were taken to the Clinical Pathology Laboratory at the Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria for analysis. The samples were analyzed for Packed Cell Volume (PCV), Haemoglobin (Hb), Total Protein (TP), total cholesterol, glucose and albumin. Total White Blood Cell count (TWBC) was calculated using the formula described by Campbell (1995):

$$\text{TWBC/mm}^3 = \frac{\text{number of cells counted} \times 10 \times 32 \times 100}{(\text{H}+\text{E}) \times 18}$$

Where

TWBC = Total white blood cell

N = Neutrophil

E = Eosinophil

3.6 Statistical Analysis

All data obtained were subjected to analysis of variance (ANOVA) using the SAS (2002) general linear model procedure**.** Trend analysis was carried out on performance parameters using Microsoft Excel®. Contrast analysis was run to verify the level of significance and principal component analysis was run on the performance parameters using PROC Factor in SAS software (SAS, 2002). The Eigenvalues of the principal component were used to explain the amount of variance that is accounted for by a given component, (Burstyn, 2004) – see Appendix 3.

In order to compensate for variance in experiment 4, the measured body weight of the birds were normalized before subjecting the data to statistical analysis. Microsoft Excel® package was used for normalization of the data using the mean and standard deviation of the entire group using the formula described by Juszczak *et al.* (2002) as shown below:

$$N = a + \frac{(X - A) \times (b - a)}{(B - A)}$$

Where N = normalized data point

X = data point to be normalized

a = minimum range desired

b = maximum range desired

A = minimum range from the data

B = maximum range from the data

CHAPTER FOUR

4.0 RESULTS

4.1 Proximate and Chemical Composition of Locust Bean Pulp

The results of the proximate composition of the locust bean pulp (LBP) used in this study are as shown in Table 4.1. LBP contained 3.19% crude protein, 6.03% crude fibre, 1.84% ether extract, 6.86% ash, 88.45% dry matter, 66.39% nitrogen free extract (NFE), 22.177mg/g of calcium and 3.14mg/g of phosphorus. Beta Carotene content in locust bean pulp was 1.046mg/g while Vitamin C was 542mg/100g.

4.2 Anti - Nutrients Content of the Locust Bean Pulp

The anti-nutritional factors in the locust bean pulp used in this study are shown in Table 4.2. Locust bean pulp (LBP) contained 0.32mg/100g tannin, 0.93mg/100g oxalate, 1.67mg/100g phytate, 0.34mg/100g saponin, 0.08mg/100g cyanide, 0.41mg/100g trypsin inhibitor, 19.72% alkaloid and 40.20% flavonoid.

4.3 Determination of the Metabolizable Energy Value of Locust Bean Pulp.

Table 4.3 shows the gross energy (GE), apparent metabolizable energy (AME), true metabolizable energy (TME), the metabolizable energy (MEn) corrected for nitrogen and the efficiency of utilization of the control diet, substituted diet and that of the locust bean pulp used for this study. Results indicated that the gross energy (GE) of locust bean pulp was 4164 kcal/kg which was higher than 3990 kcal/kg for the control and 3774kcal/kg for 20% LBP substituted ration.. The apparent metabolizable energy (AME) for the locust bean pulp was 2344 kcal/kg while that of the control diet was 2755 kcal/kg and that of 20% locust bean pulp substituted diet was 2501 kcal/kg. The efficiency of utilization of the metabolizable energy of the locust bean pulp was 56.29%

Table 4.1 Proximate and chemical composition of locust bean pulp

Parameters	Composition
Crude protein (%)	3.19
Crude Fibre (%)	6.03
Ether Extract (%)	1.84
Total Ash (%)	6.86
Dry Matter (%)	88.45
NFE (%)	66.39
Calcium (mg/g)	22.177
Phosphorus (mg/g)	3.14
Beta Carotene(mg/g)	1.046
Vitamin C (mg/100g)	542.40

NFE : Nitrogen Free Extract

Table 4.2 Levels of Anti – nutritional factors in locust bean pulp

Parameters	**Value**
Tannin (mg/100g)	0.32
Oxalate (mg/100g)	0.93
Phytate (mg/100g)	1.67
Saponin (mg/100g)	0.34
Cyanide (mg/100g)	0.08
Trypsin inhibitor (mg/100g)	0.41
Alkaloid (%)	19.72
Flavonoid (%)	40.20

Table 4.3 Metabolizable energy (kcal / kg) and efficiency of utilization (%) of the locust bean pulp

Rations	GE (kcal/kg)	AME (kcal/kg)	AME$_n$ (kcal/kg)	TME (kcal/kg)	TME$_n$ (kcal/kg)	EOU of AME (%)	EOU of AME$_n$ (%)	EOU of TME (%)	EOU of TME$_n$ (%)
Control diet	3990	2755	2757	2764	3970	69.04	69.09	69.27	99.50
80% control + 20% LBP	3774	2501	2506	2508	3757	66.26	66.26	66.46	99.55
LBP	4164	2344	-	-	-	56.29	-	-	-

EOU (Efficiency of utilization) = AME or AME$_n$ x 100/GE

GE: Gross Energy

AME: Apparent Metabolizable Energy

AMEn : Nitrogen corrected apparent metabolizable energy

TME : True Metabolizable energy

while that of the control diet was 69.04% and that of 20% LBP substituted diet was 66.26%. True metabolizable energy (TME) for the control diet was 2764 kcal/kg and its efficiency of utilization was 69.27%. However, the efficiency of utilization of TME_n was 99.50%.

4.4 Performances of Pullet Chicks Fed Graded Levels of Dietary Locust Bean Pulp (0 -8 Weeks)

The performance of the chicks fed Graded levels of dietary locust bean pulp is shown in Table 4.4. Final weight and weight gain were similar (P>0.05) for birds fed 0.0, 7.5 and 15 LBP diets. However, birds fed 22.5% LBP diet had a significantly (P<0.05) higher final weight and total weight gain when compared to those fed 30% LBP diets but similar to those fed 0.0, 7.5, 15% LBP diets. Trend analysis (figure 4.1) showed a quadratic relationship between the level of locust bean pulp and weight gain, indicating a linear increase in weight as the level of LBP increased in the diets up to 22.5% before a sudden decline at 30%. Total feed intake were significantly (P<0.05) higher for the birds fed 22.5 and 30% locust bean pulp diets when compared with those fed control diets. However, the birds fed 7.5 and 15% LBP diets were not (P>0.05) different and were comparable to those on the other diets, while birds fed 22.5 and 30% LBP diets had the highest feed intake. Trend analysis (figure 4.2) showed a positive linear increase in the feed intake across the dietary treatments. Consequently, efficiency of feed utilization was significantly (P<0.05) poor at 30% inclusion level of LBP when compared with that of the control. There were no significant difference (P>0.05) in the feed cost/ bird among all the birds fed LBP diets. Trend analysis (figure 4.3) showed a positive quadratic relationship between the levels of locust bean pulp and feed cost per bird. Mortality was significantly low and similar at 15, 22.5 and 30% levels of LBP.

Table 4.4 Performance of pullet chicks fed graded levels of dietary locust bean pulp (0-8 weeks)

	Dietary Inclusion levels (%)						
Parameters	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Initial Weight (g/bird)	32.00	32.00	32.00	32.00	32.00	0.00	NS
Final body weight (g/bird)	418.68^{ab}	425.00^{ab}	431.45^{ab}	458.86^{a}	415.77^{b}	5.45	*
Total weight Gain (g/bird)	386.68^{ab}	393.21^{ab}	399.45^{ab}	426.86^{a}	383.77^{b}	5.45	*
Total Feed Intake(g/bird)	1131.37^{b}	1323.24^{ab}	1265.48^{ab}	1403.02^{a}	1465.19^{a}	4.25	*
Feed conversion ratio	2.92^{a}	3.36^{bc}	3.17^{ab}	3.28^{ab}	3.81^{c}	0.05	*
Feed Cost(₦)/ bird	88.25^{a}	93.74^{b}	93.77^{b}	96.81^{b}	96.70^{b}	1.18	*
Feed Cost (₦) /kg gain	227.76^{a}	239.92^{b}	228.26^{a}	226.67^{a}	239.15^{b}	2.24	*
Total cost (₦ /bird)	313.25^{a}	324.24^{b}	316.11^{a}	321.81^{b}	321.70^{b}	2.23	*
Mortality %	4.00^{b}	8.00^{bc}	3.00^{a}	3.00^{a}	3.00^{a}	1.39	*

^{abc}means within the same row with different letter superscripts are significantly different ($P < 0.05$)

LOS = Level of Significance NS= Not Significant, SEM = Standard Error of Means,*= Significance

Total cost (N/bird) = Cost of day old chicks + cost of feed + cost of vaccination + cost of labour

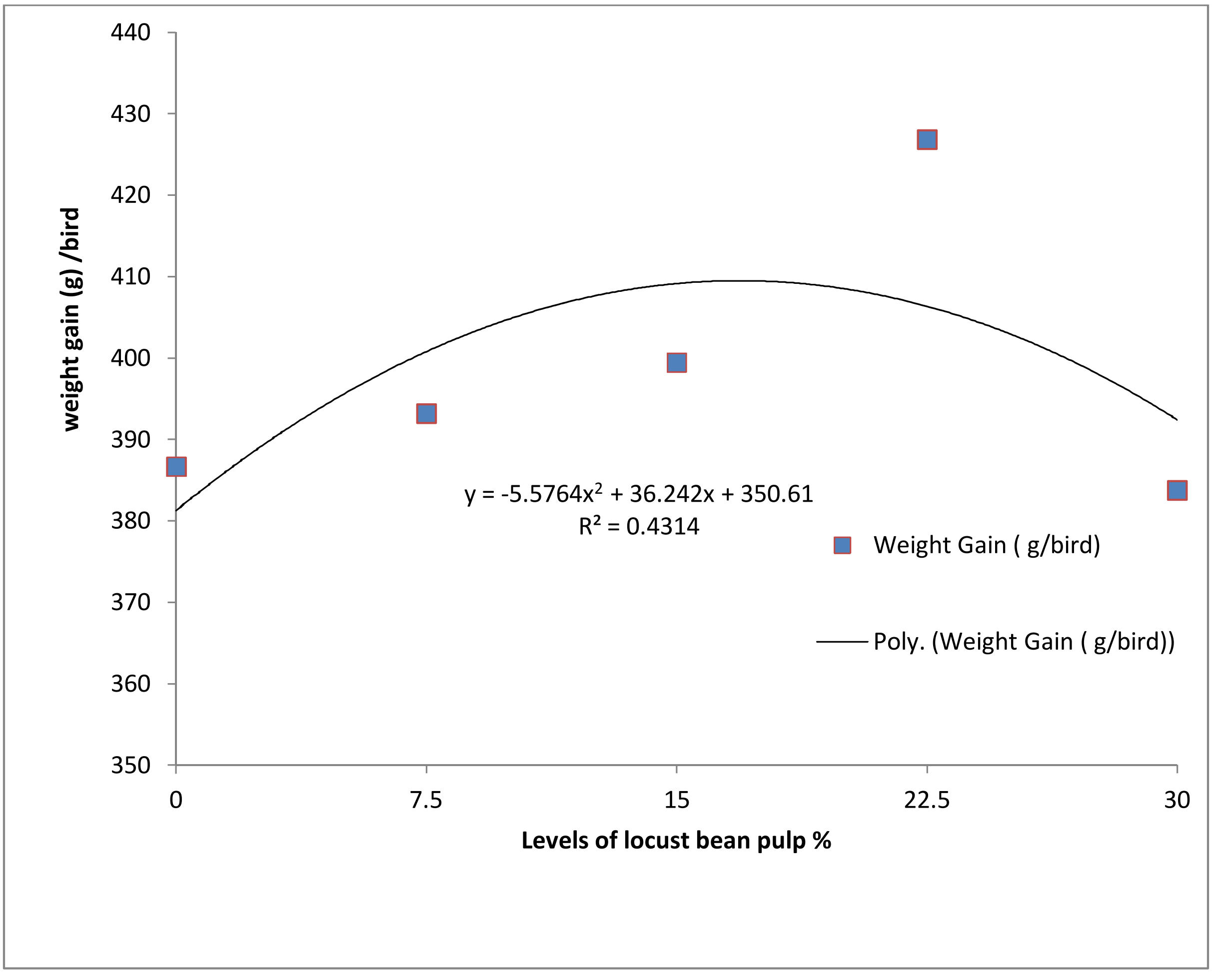

Figure 4.1: Trend line of weight gain of the chicks fed Graded levels of dietary LBP.

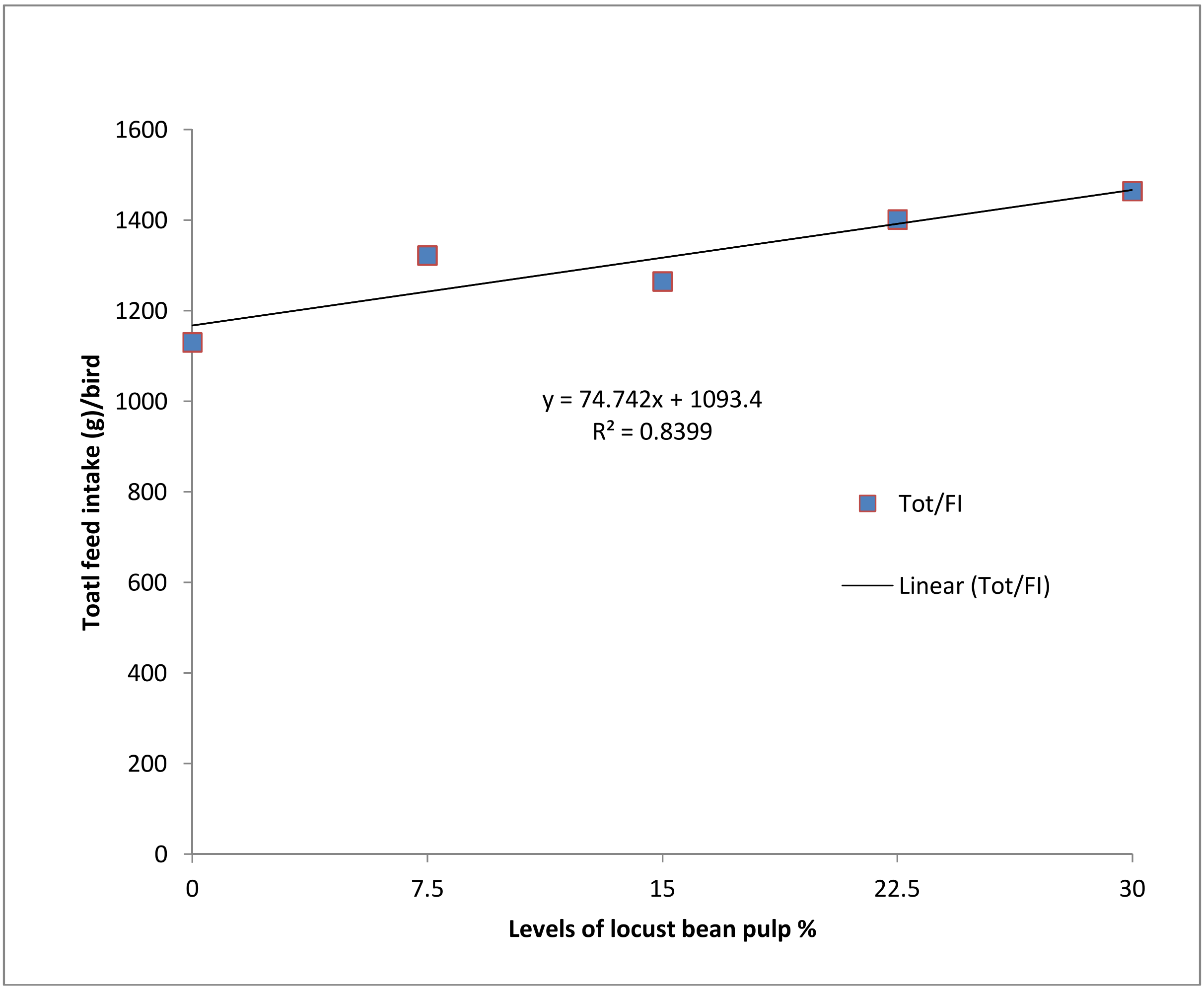

Figure 4.2: Trend line of total feed intake of the chicks fed Graded levels of dietary LBP

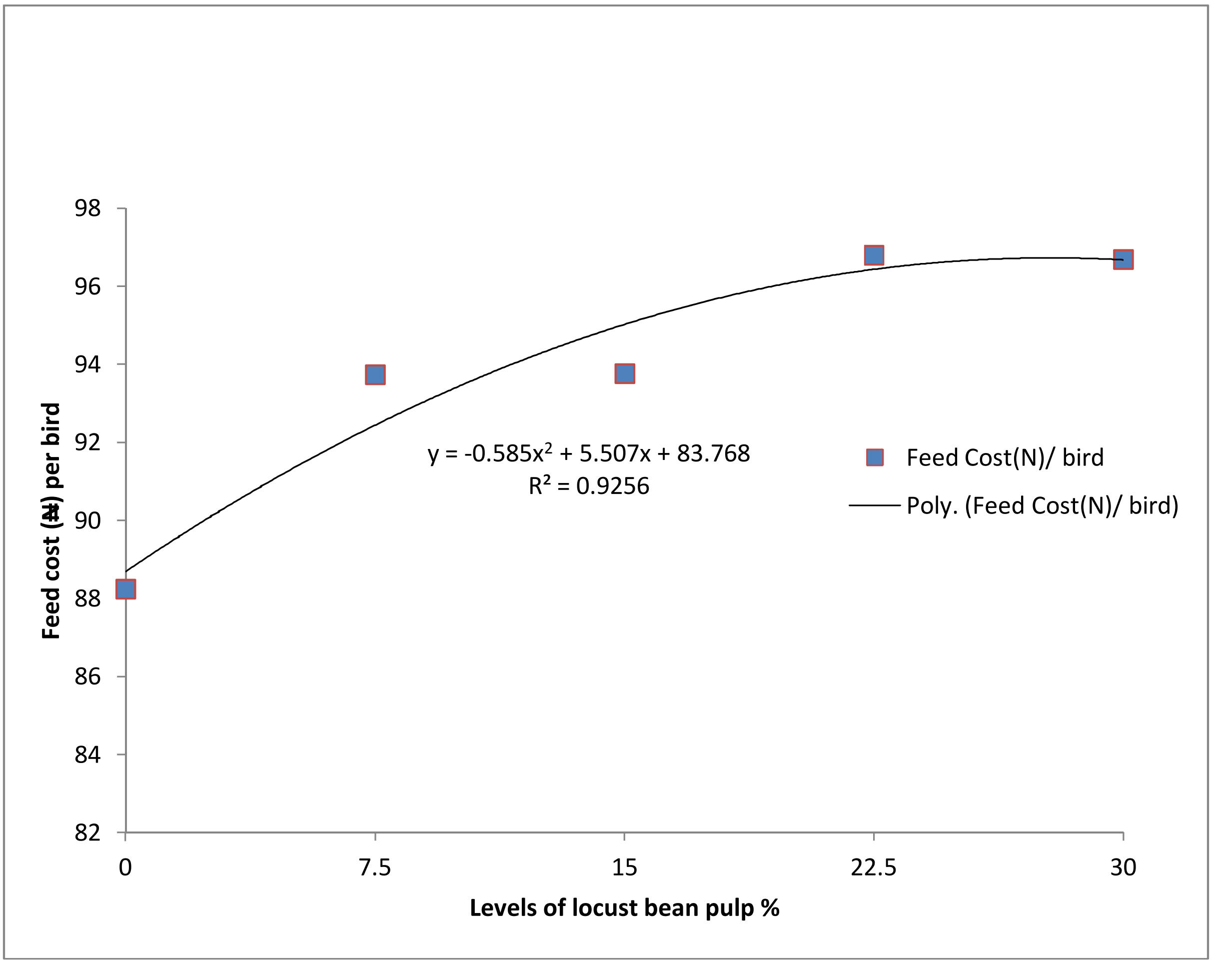

Figure 4.3: Trend line of feed cost per chick fed Graded levels of dietary LBP

4.5 Performance of Growing Pullets Fed Graded Levels of Dietary Locust Bean Pulp (9 -20 Weeks)

Table 4.5 shows the performance of growing pullets fed graded levels of dietary LBP. There were significant ($P<0.05$) differences in the final weight and weight gain of the birds across the dietary treatments. The trend analysis (Figure 4.4) showed a quadratic relationship between the final weight and the levels of LBP in which there was a linear decrease in the final weight up to 15% after which there was a significant increase in weight up to 30% and this is an indication that LBP can be fed up to 30% without negative effect on the growth performance of the growing pullets. Feed intake (g)/bird increased significantly ($P<0.05$) as the level of LBP increased in the diets. Birds on the control diet had the least feed intake, but there were no significant ($P>0.05$) difference among the birds fed LBP diets. Trend analysis (figure 4.5) showed a linear increase in feed intake as the level of locust bean pulp increased across the treatments. Similarly, there was a significant ($P<0.05$) increase in feed conversion ratio with increase in the level of locust bean pulp across the treatments up to 22.5% level of LBP after which there was a decline at 30%. However, birds on diet 7.5% had the best feed to gain ratio among the birds fed LBP diets and was to those on the control diet. Whereas, the birds on the diet 15% LBP was not different from those on 30% LBP diet.

Daily water intake and water to feed ratio also increased with an increase in the level of locust bean pulp across the dietary treatments. Trend line (figure 4.6) showed a significant linear increase in the water intake of birds.

Table 4.5 Performance of growing pullets fed graded levels of dietary locust bean pulp (9 -20 weeks)

	Dietary Inclusion Levels (%)						
Parameters	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Initial body weight (g/bird)	512.88	513.64	507.58	515.15	514.39	3.94	NS
Daily feed intake(g)/bird	71.26^{b}	78.39^{a}	79.17^{a}	81.60^{a}	81.89^{a}	0.49	*
Final body weight (g /bird)	$1,448.48^{a}$	$1,433.33^{ab}$	$1,384.85^{c}$	$1,398.48^{c}$	$1,419.70^{b}$	8.36	*
Weight gain(g/bird)	935.61^{a}	919.70^{ab}	877.27^{c}	883.33^{c}	905.30^{b}	7.91	*
Feed conversion ratio	4.92^{a}	5.55^{ab}	5.92^{b}	6.08^{c}	5.96^{b}	0.044	*
Daily Water intake (ml)/bird	179.37^{e}	$210\cdot35^{d}$	221.25^{c}	243.91^{b}	279.59^{a}	4.29	*
Water/feed	2.47^{d}	2.61^{cd}	2.72^{c}	2.91^{b}	3.32^{a}	0.03	
Daily Feed cost (₦)/bird	4.28^{b}	4.55^{a}	4.54^{ab}	4.24^{b}	4.01^{c}	0.03	*
Feed cost (₦) /kg gain	326.73^{ab}	356.08^{c}	357.35^{c}	345.85^{bc}	319.10^{a}	2.92	*
Mortality %	0.00	0.00	0.00	0.00	0.00	0.00	NS

^{abc}Means within the same row with different letter superscripts are significantly different ($P < 0.05$),LOS = Level Of Significance, NS= Not Significant, SEM = Standard error of the means, *= Significant

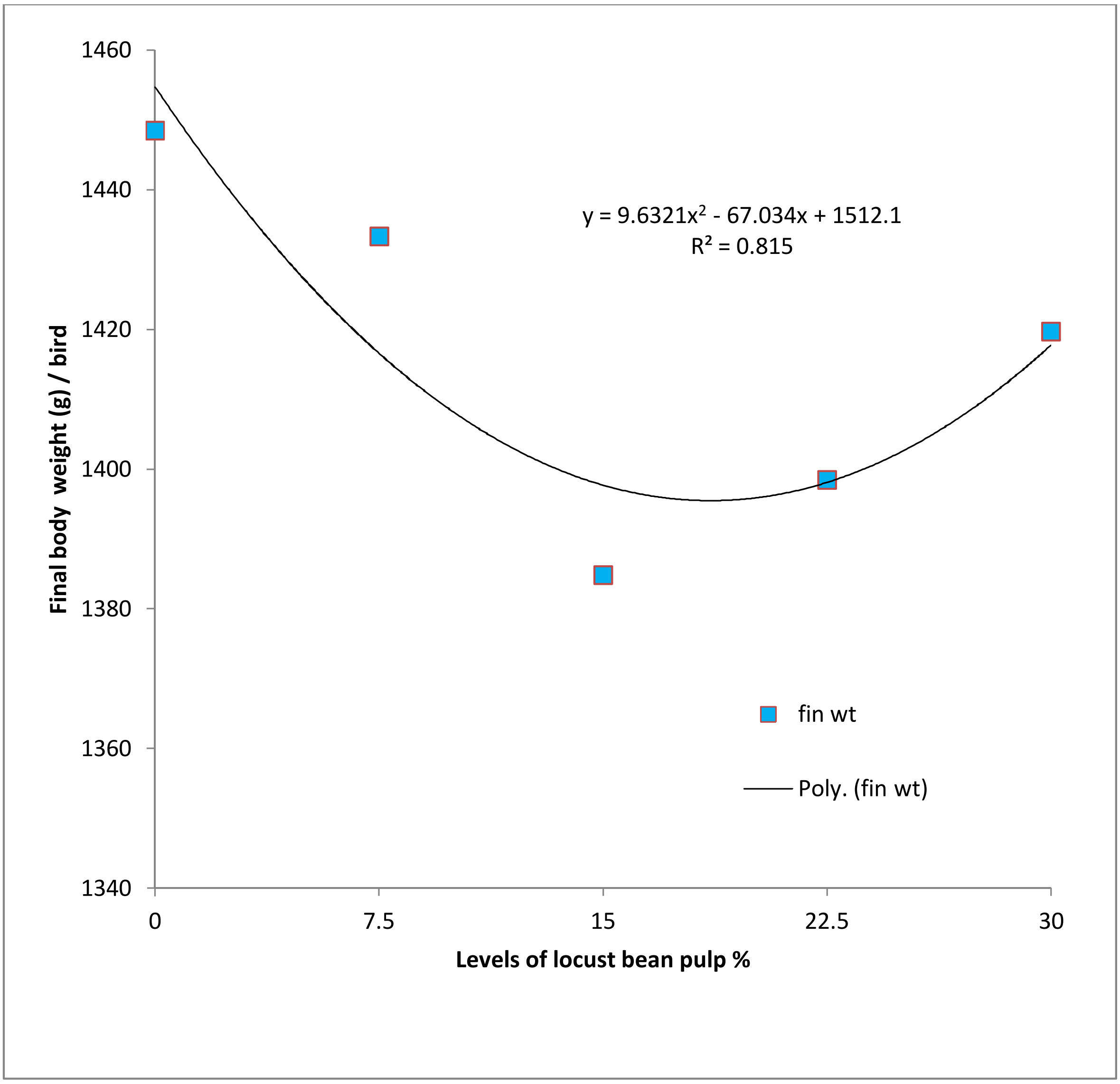

Figure 4.4: Trend line of final body weight of growing pullets fed Graded levels of dietary LBP

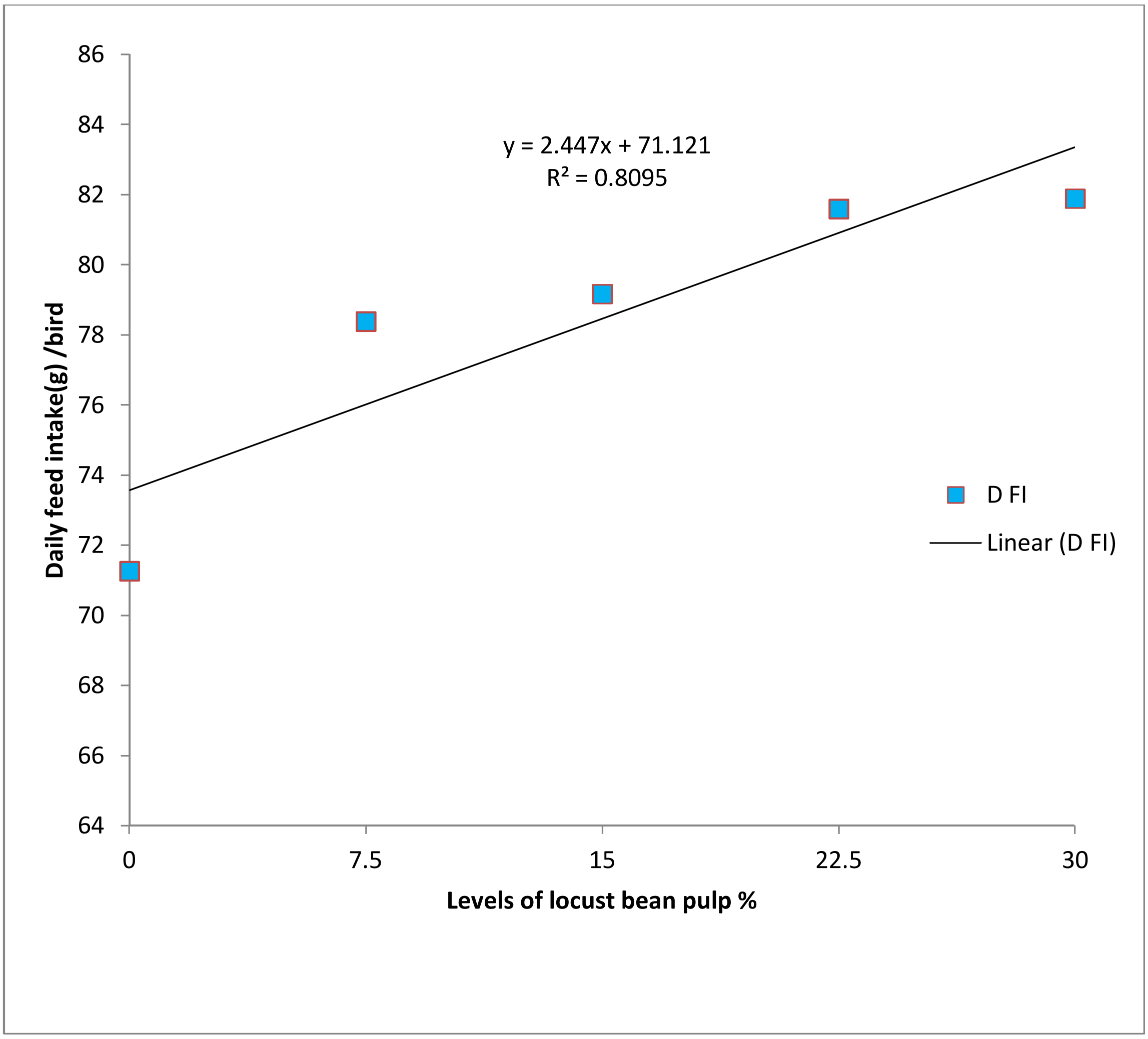

Figure 4.5: Trend line of feed intake of growing pullets fed Graded levels of dietary LBP

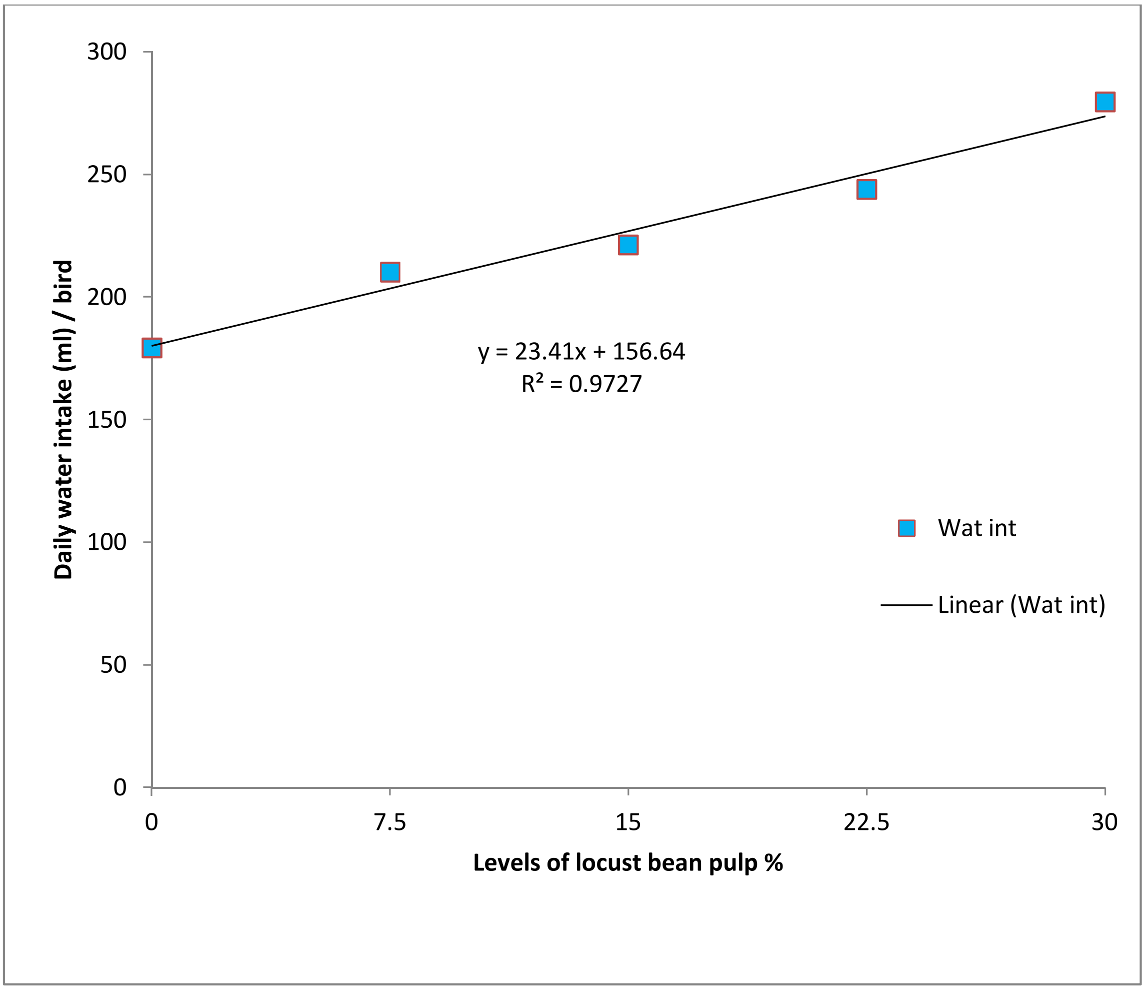

Figure 4.6: Trend line of water intake of growing pullets fed Graded levels of dietary LBP

There was no significant ($P > 0.05$) difference in the daily feed cost between birds fed 7.5% and 15% LBP diets, whereas birds fed 22.5% LBP diets were not significantly ($P > 0.05$) different from those on the control diet and birds on 30% LBP had the least feed cost. Trend analysis (figure 4.7) showed a quadratic relationship between the daily feed cost and levels of locust bean pulp. There was an increase in feed cost between 0% and 7.5% LBP level after which the feed cost decreased gradually and the cheapest feed was observed at 30% LBP level. There was no mortality recorded throughout the growing period.

4.6. Economy of Production of Point of Lay Pullet Fed Graded Levels of Dietary Locust Bean Pulp (9-20 Weeks).

The economy of production of growers fed graded levels of dietary LBP is shown in table 4.6. There was a significant increase in all the cost parameters between 0 and 7.5% LBP diets after which it declined linearly and quadratic at 30%. Cost of daily feed intake and total feed cost per bird during the growing period were similar for birds on 0% and 22.5% diets and comparable to those fed diet 15% whereas daily feed cost for the birds fed 7.5% diet was significantly higher while those on 30% LBP had the least cost. Similarly, feed cost /kg gain was significantly ($P<0.05$) low at 30% level of inclusion and was not significantly different from that of the control. Trend analysis (figures 4.8 and 4.9) showed a polynomial trend for the total feed cost per bird and feed cost per gain. While figure 4.10 showed an inverse polynomial trend for the gross margin. The total cost per bird were significantly ($P<0.05$) different across the dietary levels and was significantly higher ($P<0.05$) at 7.5 and 15% LBP diet. Gross marginal profits were significantly ($P<0.05$) different across the dietary levels, birds fed 30% LBP diet had a significantly ($P<0.05$) higher gross marginal profit than those on other diets. Both the total cost per bird and gross marginal profit for the birds fed 22.5% LBP diet were similar to those on the control diet.

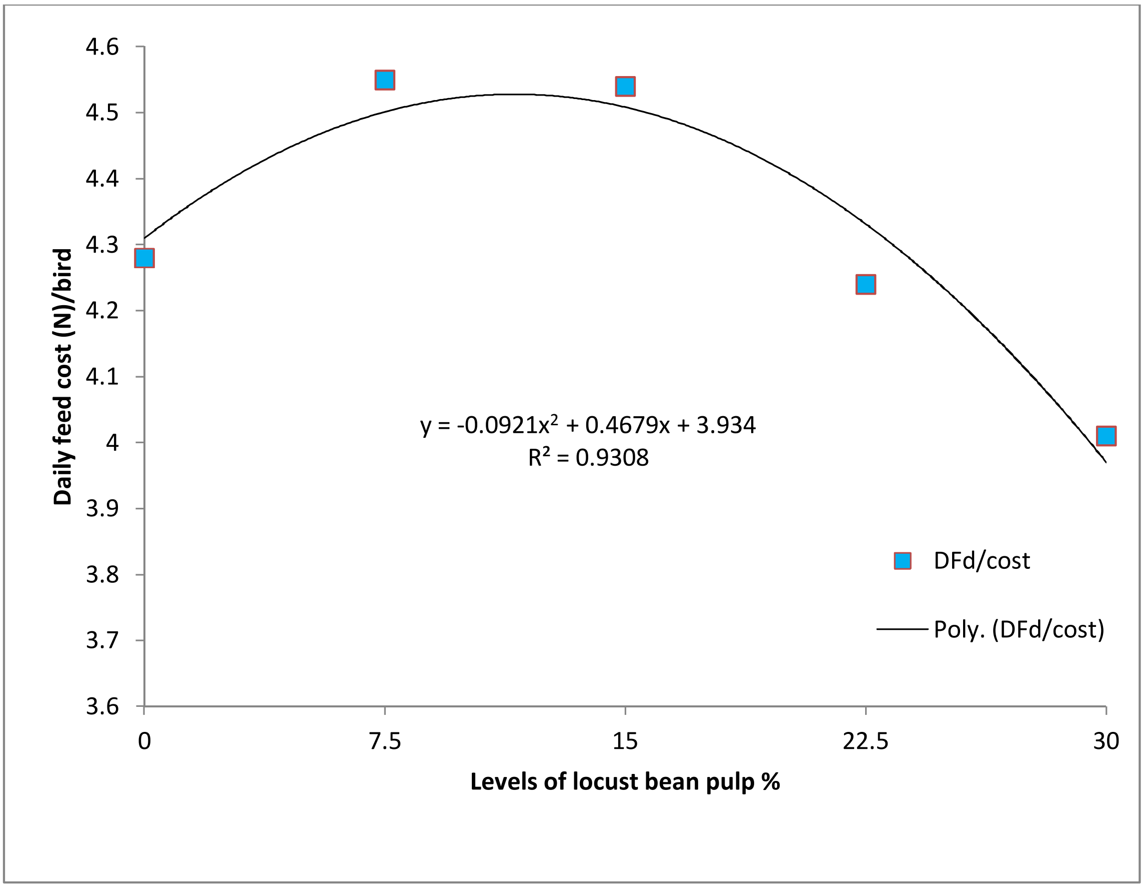

Figure 4.7: Trend line of daily feed cost per bird of growing pullets fed Graded levels of dietary LBP

Table 4.6 Economy of production of growers fed graded levels of dietary locust bean pulp (9-20 weeks)

	Dietary Inclusion Levels (%)						
Parameters	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Initial Cost of bird(₦)	318.04	319.93	318.53	319.51	319.49	2.24	NS
Cost of Daily feed Intake (₦)/bird	4.28^{bc}	4.55^{a}	4.35^{b}	4.24^{bc}	4.01^{c}	0.03	*
Total Feed Cost(₦)/ bird	304.92^{b}	327.37^{a}	313.51^{b}	305.50^{b}	288.92^{c}	3.58	*
Feed cost(₦) /kg gain	326.73^{bc}	356.08^{a}	357.35^{a}	345.85^{ab}	319.10^{c}	2.92	*
Total cost (₦) / bird	782.96^{c}	807.30^{a}	792.34^{b}	785.01^{c}	768.41^{d}	3.32	*
Gross marginal Profit (₦)	217.04^{b}	192.70^{d}	207.66^{c}	214.99^{b}	231.59^{a}	3.58	*

^{abc} means within the same row with different letter superscripts are significantly different ($P < 0.05$)
Variable cost (cost of labour + medication) = ₦160/bird
Value of bird at the end of 20 weeks = ₦,1000
Total cost/bird = initial cost of bird + total feed cost + variable cost
Gross marginal Profit = Value at the end of 20 weeks – Total cost
LOS = Level of significance
NS= Not significant
SEM = Standard error of means.
*= Significant

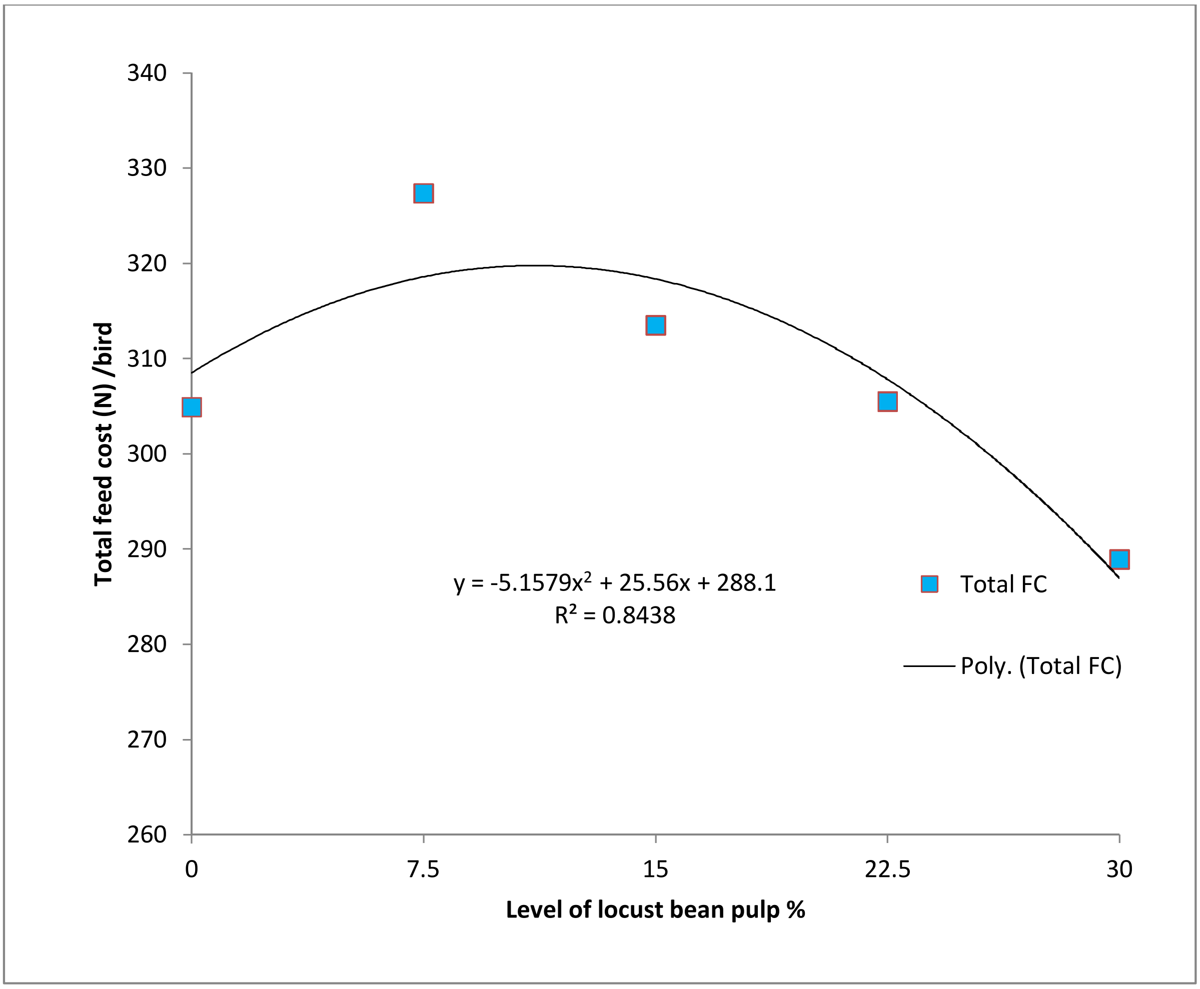

Figure 4.8: Trend line of Total feed cost per bird of growing pullets fed Graded levels of dietary LBP

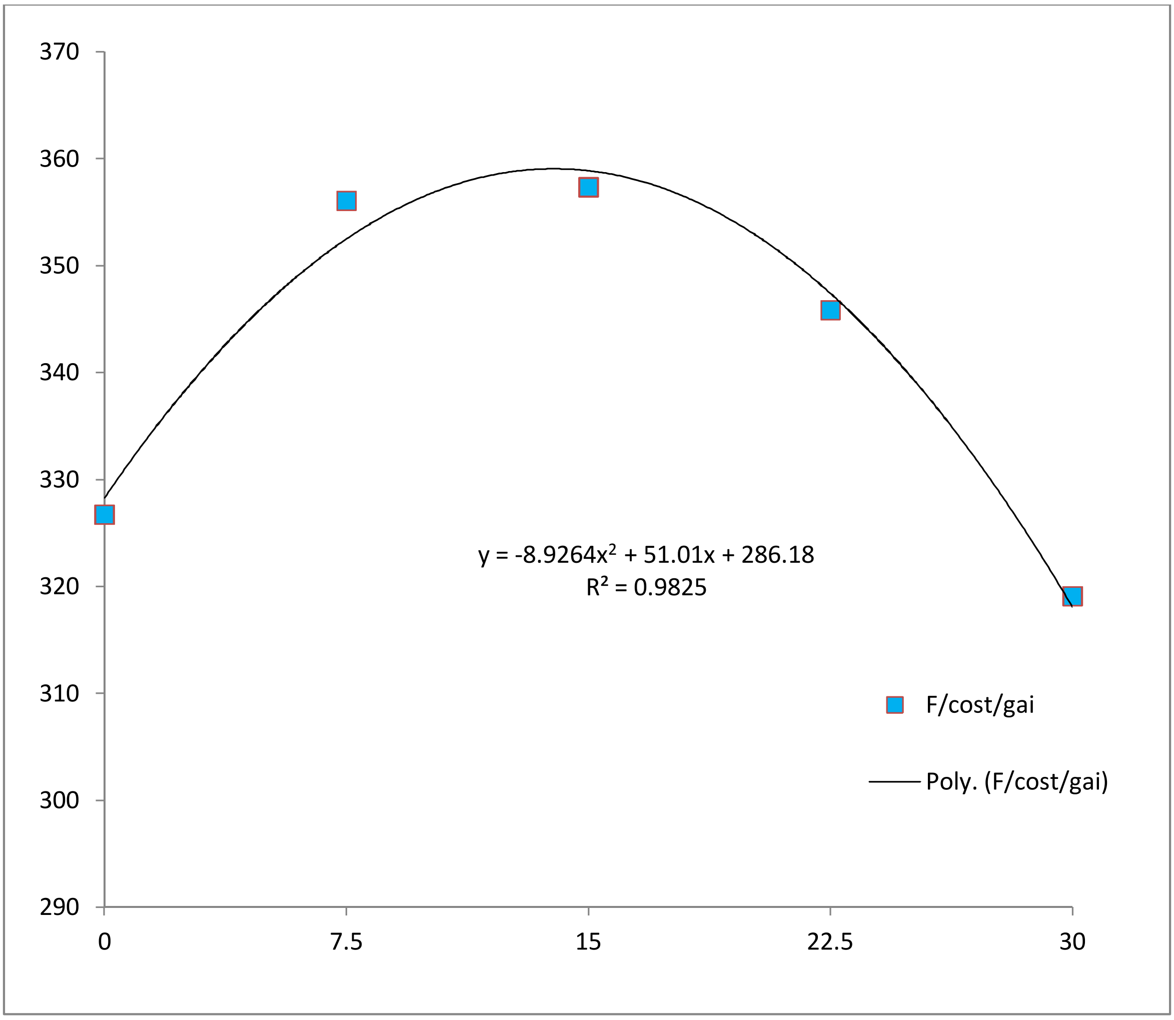

Figure 4.9: Trend line of daily feed cost per gain of growing pullets fed Graded levels of dietary locust bean pulp (LBP)

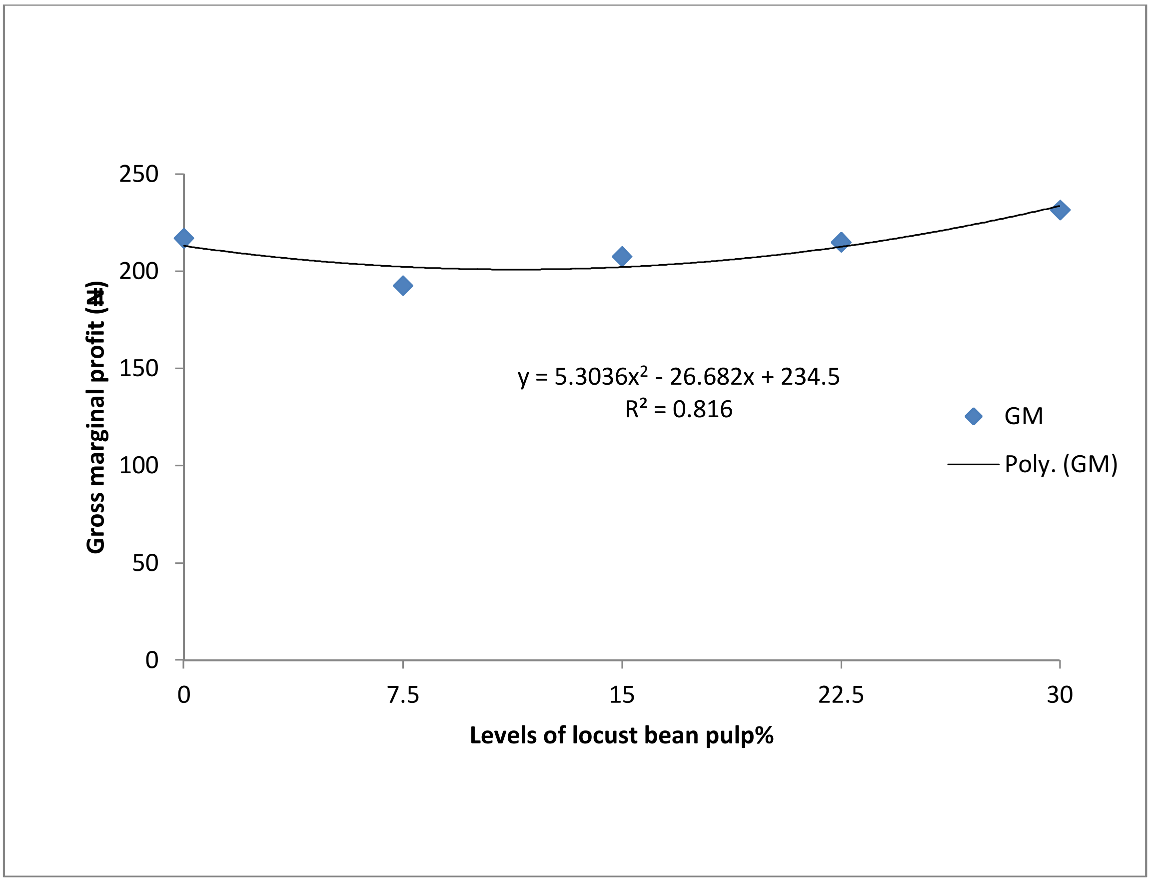

Figure 4.10: Trend line of gross marginal profit of pullets fed Graded levels of dietary locust bean pulp (LBP)

4.7 Subsequent Performance of Pullets (20 – 42 weeks) Fed Graded Levels of Dietary Locust Bean Pulp During the Grower Phase

Table 4.7 showed the results of the effect of feeding LBP diet during the growing phase on subsequent laying performance of egg type pullets .Results of this study indicated that LBP fed during the growing phase of the study had significant ($P<0.05$) effects on all the parameters recorded except for the final weight. There were no significant ($P>0.05$) difference in final weight of the hen across the dietary treatments. The age of birds at first egg, age at peak of production, first egg weight and egg weight at peak production (figures: 4.11, 4.12 4.13 and 4.14) were all significantly different across dietary levels. The birds on diets containing 15, 22.5 and 30% LBP had significantly ($p<0.05$) bigger eggs than those on 0% and 7.5% diets. There was a positive linear response to the dietary levels of LBP in the previous diets fed to the birds. The feed intake increased with increase in the level of LBP in the diets and birds on the control (0%LBP) diet had the least feed intake. Consequently, there was a gradual decrease in feed efficiency as the level of LBP increased in the previous grower diets. The trend analysis showed that the efficiency (figure 4.15) of feed utilization reduced as the level of LBP increased in the previous diets fed to the birds. Trend analysis (figure 4.16) showed a linear increased in water intake with increased level of LBP and water/ feed ratio. Feed cost per crate of egg and income above feed cost, hen day egg production (HDP) and hen housed egg production (HHP) were also significantly ($P<0.05$) affected by LBP diets. Birds fed 7.5% LBP diet were similar to those fed 30% LBP diet, However, birds fed 15% LBP diet and those on 22.5% LBP diets were not significantly ($P>0.05$) different from the birds fed control diet. Trend analysis showed a polynomial

Table 4.7 The Effect of locust bean pulp fed during the grower phase on subsequent performance of pullets (20-42 weeks)

	Dietary Inclusion Levels (%)						
Parameters	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**contrast**
Initial Weight (g/bird)	1444.06	1441.91	1435.02	1436.96	1439.97	8. 34	-
Final Weight (g/bird)	1546.30	1559.94	1548.45	1593.68	1586.87	19.51	-
% change in weight	6.78^{b}	9.13^{ab}	8.02^{ab}	10.93^{a}	10.08^{a}	1.46	-
Age at 1st egg (day)	160^{b}	157^{a}	166^{d}	163^{c}	160^{b}	1.29	-
Age at 50% lay (day)	183^{b}	180^{c}	185^{a}	185^{a}	182^{b}	0.80	-
Age at Peak lay (day)	194^{ab}	201^{a}	195^{ab}	197^{ab}	199^{a}	1.31	-
1st egg weight (g)	46.00	52.00	49.00	50.67	49.67	0.74	-
Egg weight at peak (g)	54.67^{b}	54.00^{b}	56.33^{a}	56.33^{a}	56.00^{a}	0.49	linear
Daily Feed Intake (g)/ bird	91.38^{d}	97.33^{c}	103.55^{ab}	105.39^{a}	108.21^{a}	1.93	linear
FCR (Total feed in kg/ Total egg no)	3.37^{a}	3.27^{ab}	3.15^{ab}	3.11^{b}	3.12^{b}	0.12	-
Daily water intake (ml) / bird	164.20^{b}	172.15^{ab}	176.59^{ab}	178.34^{ab}	183.49^{a}	3.88	linear
Water / feed ratio	3.29^{a}	3.24^{a}	3.13^{b}	3.10^{b}	3.11^{b}	0.03	-
Feed Cost/crate of eggs(₦)	435^{b}	405^{c}	440^{a}	383^{e}	397^{d}	0.27	-
Income above feed cost (₦) per crate of eggs	165^{c}	195^{b}	160^{c}	217^{a}	203^{b}	4.57	-
%HDP at Peak Lay	88.57^{b}	98.25^{a}	85.40^{b}	89.32^{ab}	98.49^{a}	1.16	quartic
%HHP at Peak Lay	81.82^{c}	89.39^{ab}	80.30^{c}	87.88^{b}	90.91^{a}	1.39	-

^{abc}Means within the same row with different letter superscripts are significantly different ($P < 0.05$), LOS = Level Of Significance, NS= Not Significant, SEM = Standard error of the means, *=Significant ($P>0.01<0.05$), ** very significant ($P<0.01<0.001$), *** highly significant ($P< 0.001$) FCR = Feed conversion ratio

Cost per crate of egg = ₦600; HDP = Hen Day Egg Production; HHP = Hen Housed Egg Production

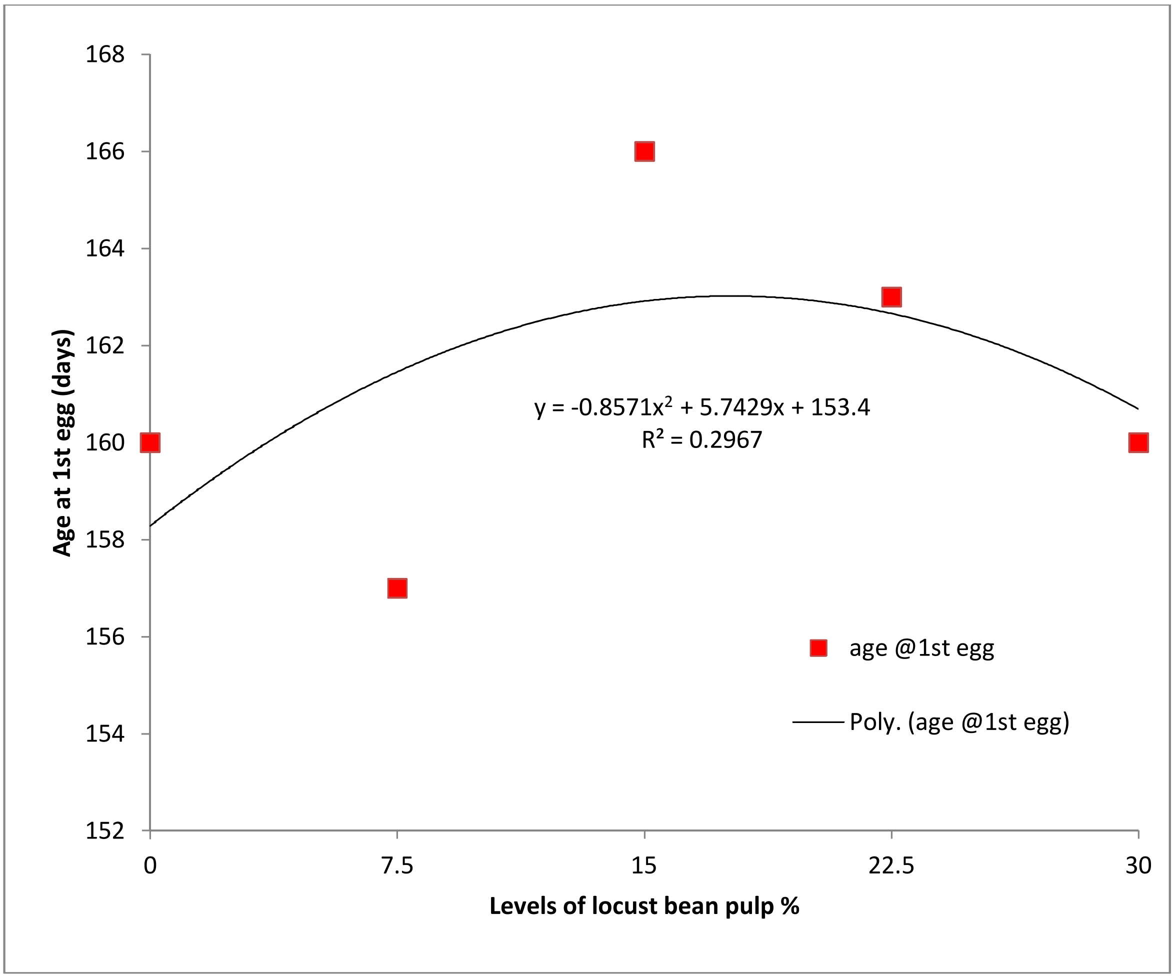

Figure 4.11: Trend line of age at first egg of pullets fed Graded levels of dietary LBP during the growing phase.

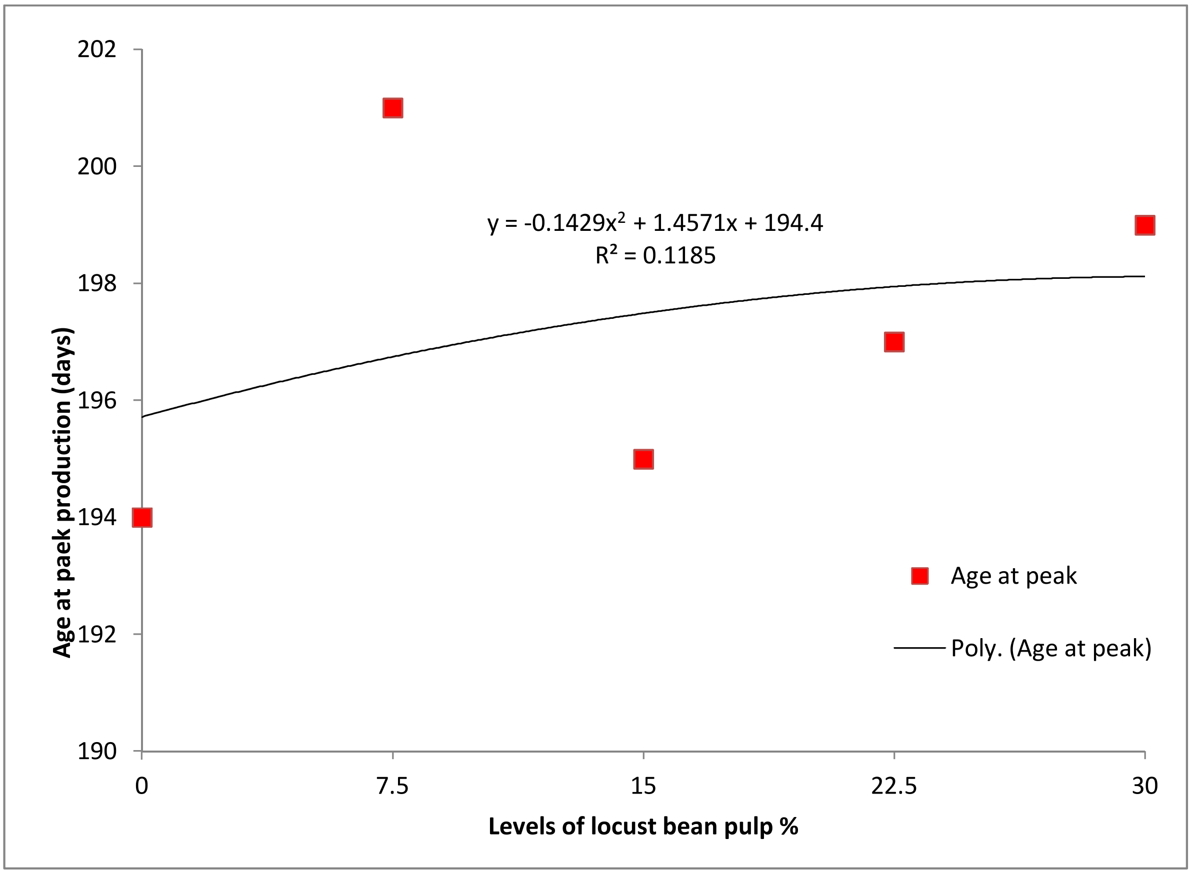

Figure 4.12: Trend line of age at peak egg production of pullets fed Graded levels of dietary LBP during the growing phase.

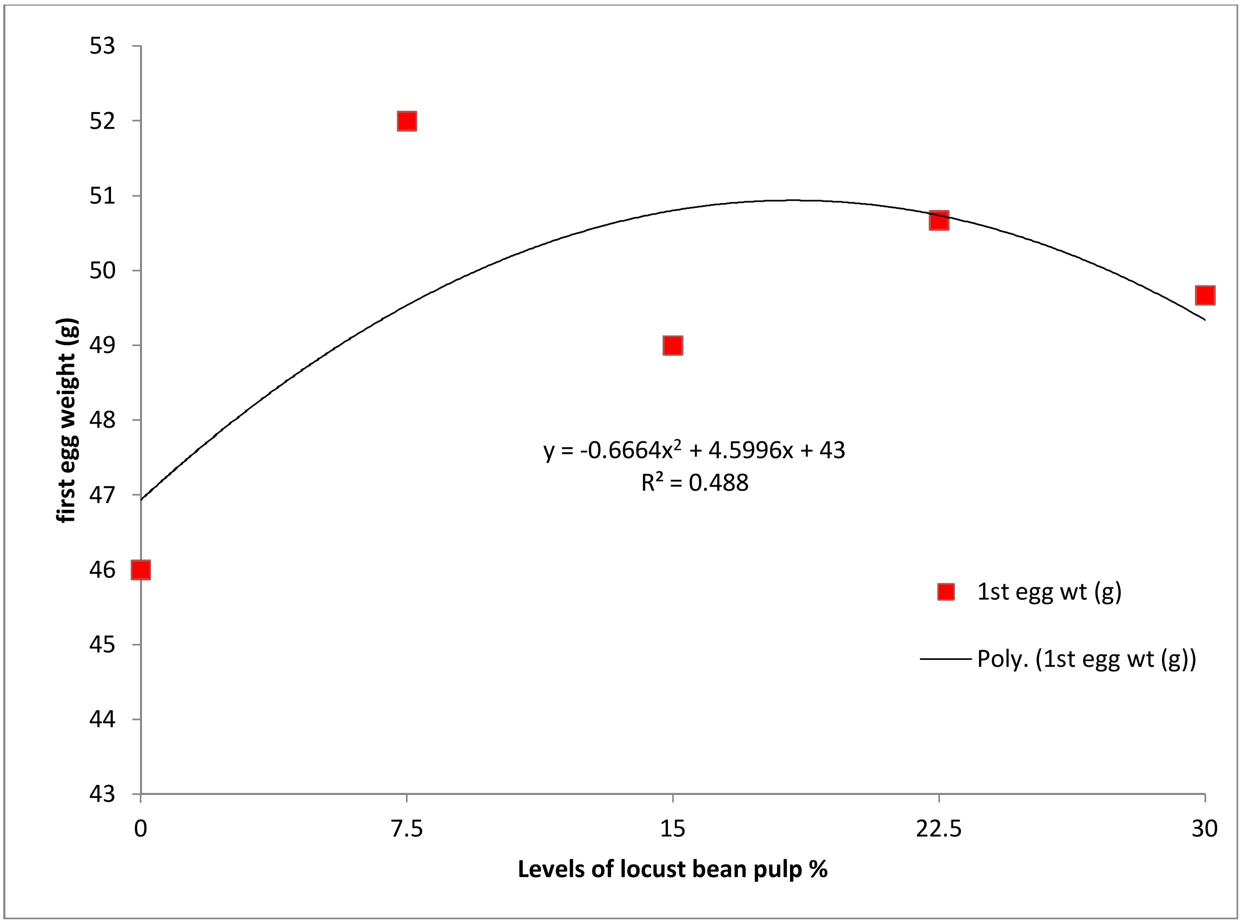

Figure 4.13: Trend line of first egg weight (g) of pullets fed Graded levels of dietary LBP during the growing phase.

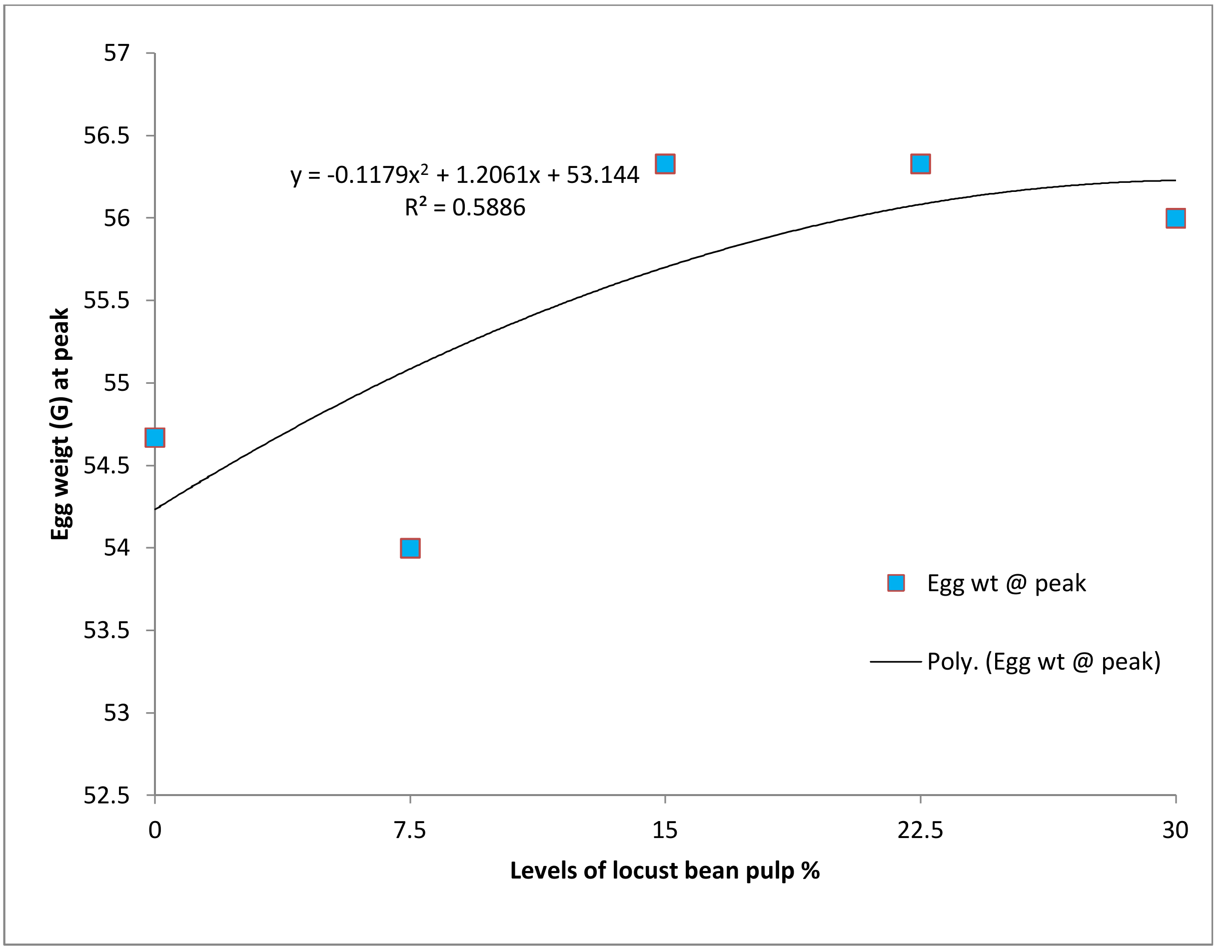

Figure 4.14: Trend line of egg weight (g) at peak production of pullets fed Graded levels of dietary LBP during the growing phase.

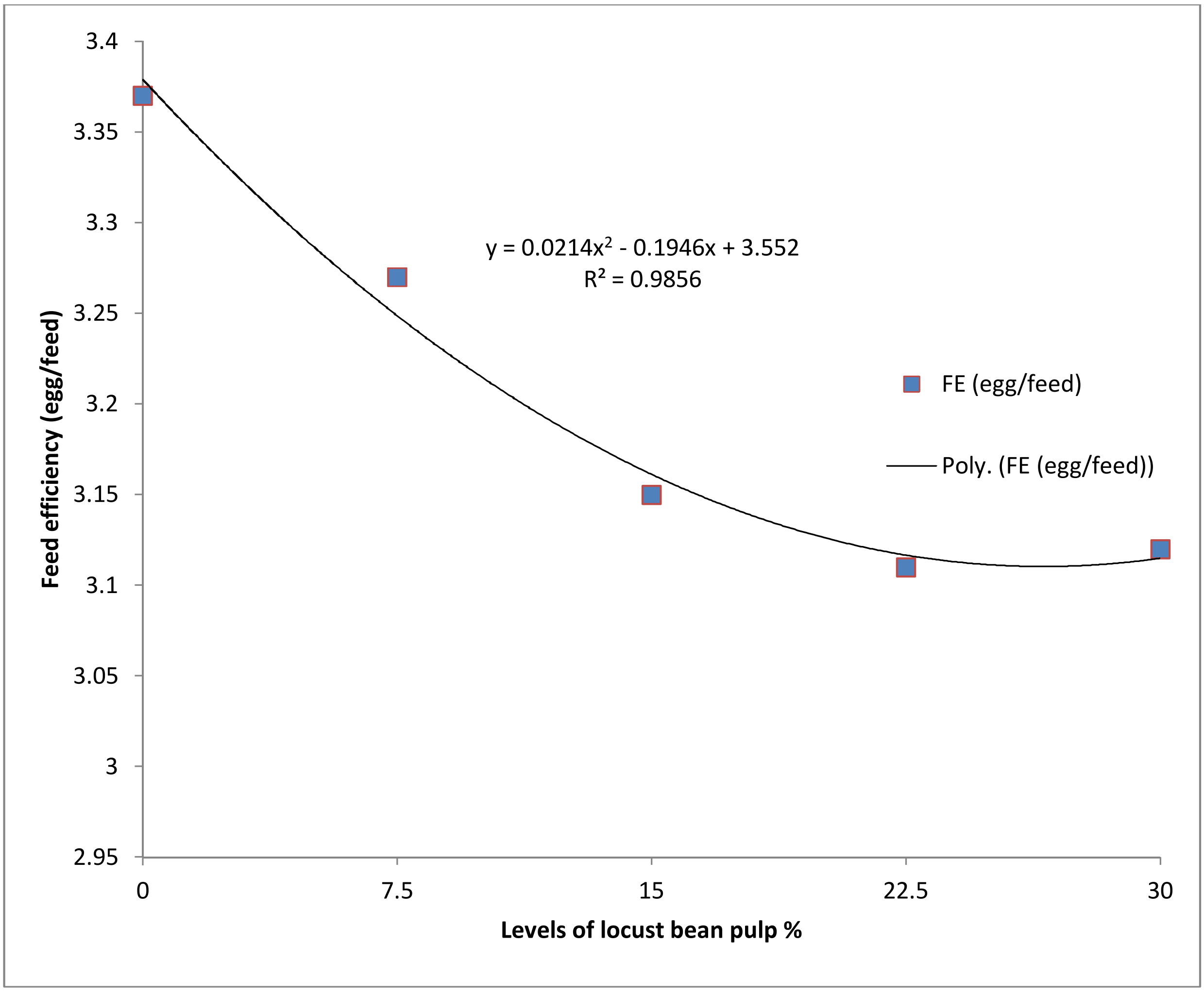

Figure 4.15: Trend line of feed efficiency (egg/feed) of pullets fed Graded levels of dietaryLBP during the growing phase.

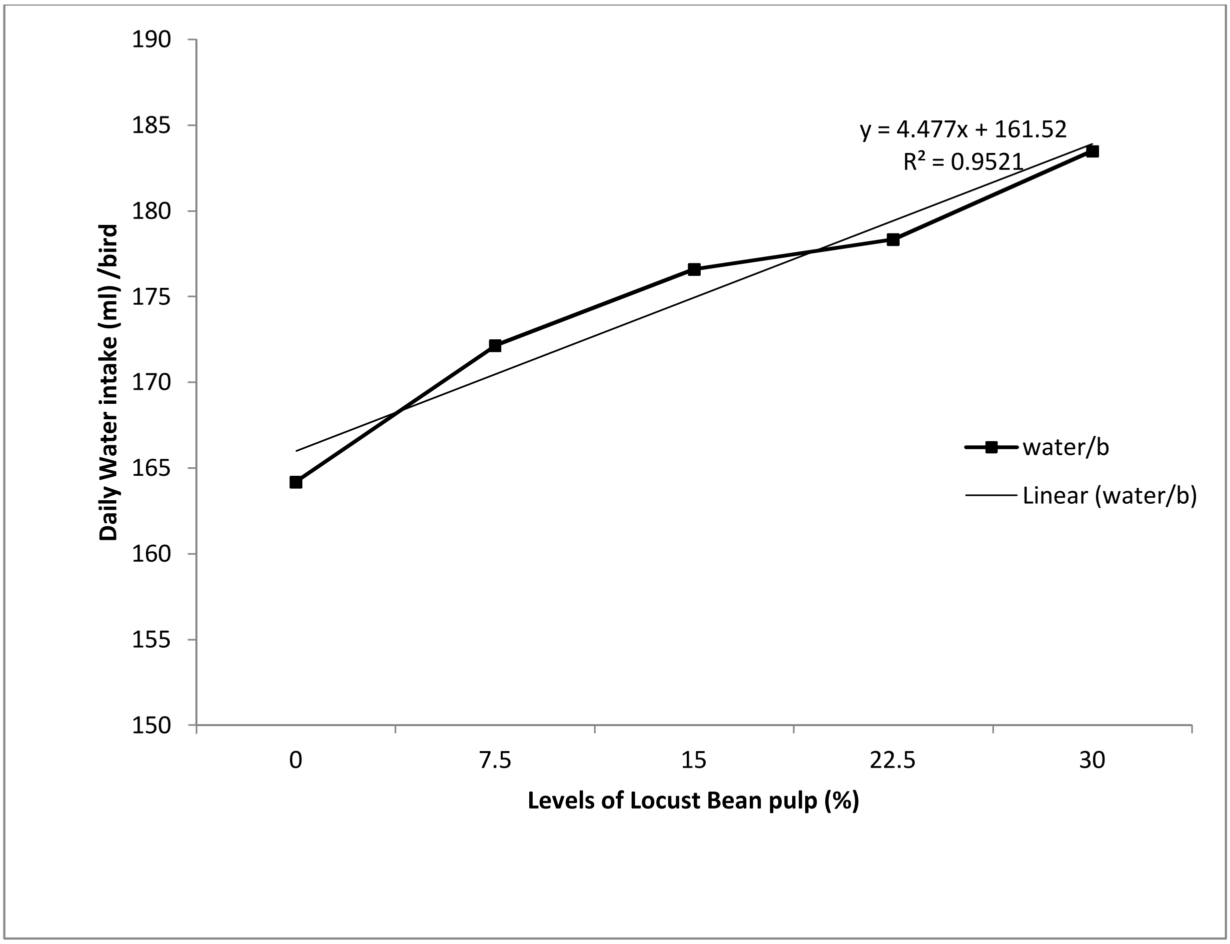

Figure 4.16: Trend line of daily water intake per bird of pullets fed Graded levels of dietaryLBP during the growing phase

trend for the income above feed cost (figure 4.17). However, contrast analysis showed no significant (P< 0.01) difference for all the parameters except daily water intake of the birds on which the LBP has linear effects across the dietary levels and hen day egg production (HDP) on which the LBP has polynomial effect.

4.8 Effect of Graded Levels of Dietary Locust Bean Pulp Meal on the Performance of Laying Hens (42-53weeks)

The effect of feeding graded levels of dietary LBP on the performance of laying hens (42-53 weeks) is shown in Table 4.8. There was a significant (P <0.05) difference in the final weight of the birds across the dietary treatments. There was a slight depression in final weight and the % change in weight at 7.5% level of LBP. However, the birds on the control diets had better final body weight. In addition, daily feed intake of the birds fed LBP diets at 15 and 22.5% were similar. Contrast analysis showed a significant (P <0.05) quadratic effect of the LBP on the final weight and daily feed intake of the birds across the dietary levels. Daily water intake pattern of the laying hens is similar to what was obtained in the previous studies where the least intake was recorded for the birds on the control diet. Feed efficiency (egg/feed) was significantly (P <0.05) better for the hens on diet 0 and 7.5% LBP than for those on the other diets (Figure 4.18). The trend analysis showed a gradual reduction in the feed efficiency as the level of LBP increased in the diets of the hens. Contrast analysis also showed highly significant (P<0.001) linear effect of the LBP on the feed efficiency. However, there was an inverse relationship between egg number and egg weight (Figure 4.19 and 4.20). Feed cost per crate of egg showed a linear increase with increased in LBP level across the dietary treatments, with attendant result of linear decrease in income above feed cost (Figure 4.21). There was a significant difference in mortality across the treatment but may not be due to the effect of LBP in the diets of the birds.

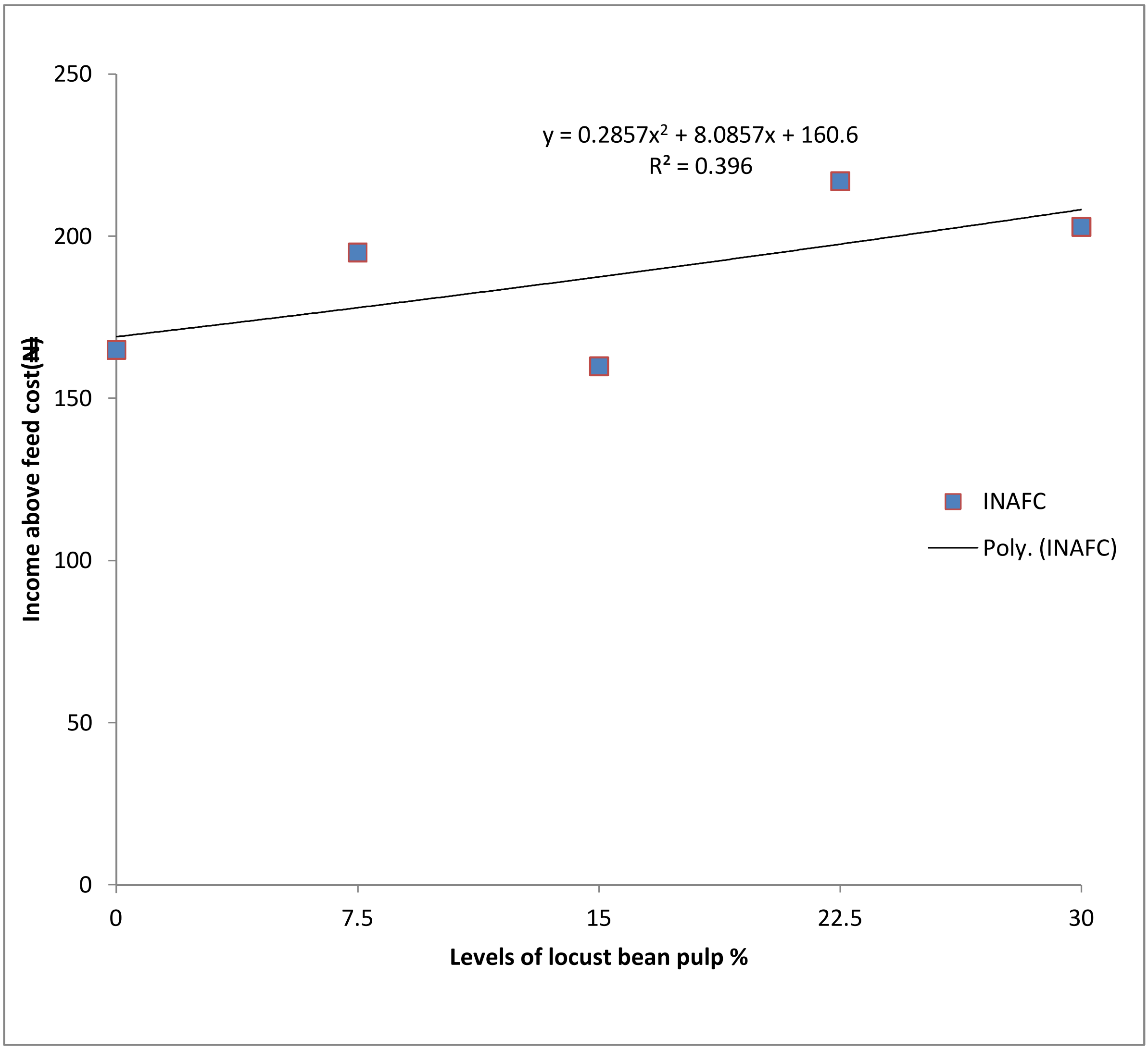

Figure 4.17: Trend line of income above feed cost per bird of pullets fed Graded levels of dietary LBP during the growing phase

Table 4.8 Effect of Graded levels of dietary locust bean pulp meal on the performance of laying hens (42-53 weeks)

	Dietary Inclusion Levels (%)							
Parameters	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**contrast**	**LOS**
Initial Weight (g/bird)	1546.30	1559.94	1548.45	1593.68	1586.87	19.51	-	NS
Final Weight (g/bird)	2333.88^{a}	1910.68^{d}	2030.03^{bc}	2020.83^{c}	2096.95^{b}	35.74	quadratic	*
% Change in weight	50.93^{a}	22.48^{d}	31.10^{b}	26.80^{c}	32.14^{b}	1.58	-	NS
Daily feed intake (g/bird)	126.07^{a}	114.90^{c}	122.68^{ab}	121.50^{b}	107.96^{d}	1.75	linear	*
FE (egg/ feed)	5.32^{a}	5.31^{a}	3.79^{b}	2.71^{d}	3.40^{c}	0.12	linear	***
Daily water Intake (ml/bird)	221.52^{e}	247.67^{d}	258.91^{c}	269.91^{b}	285.99^{a}	3.88	linear	***
Water to Feed Ratio	1.76^{e}	2.16^{c}	2.21^{b}	2.13^{d}	2.65^{a}	0.03	-	**
Average egg weight (g)	60.39^{c}	61.22^{c}	62.28^{b}	62.11^{b}	64.67^{a}	0.43	linear	***
Total egg no	671^{a}	607^{b}	464^{c}	330^{e}	388^{d}	10.38	linear	***
Feed (kg)/crate of eggs	2.42^{a}	2.41^{a}	3.16^{b}	4.39^{c}	4.52^{d}	2.50	Linear,cubic	***
Feed Cost (₦/ crate of egg)	346.80^{c}	407.10^{b}	426.00^{b}	429.60^{b}	553.50^{a}	8.20	Linear,cubic	***
Income above feed Cost (₦ /crate of eggs)	353.25^{a}	292.71^{b}	273.78^{c}	270.45^{c}	146.49^{d}	8.20	Linear,cubic	***
% Hen Day Egg Production	52.08	47.94	39.00	27.66	28.87	1.04	Linear,cubic	***
% Hen Housed Egg Production	45.22	41.52	30.78	20.83	24.80	1.06	Linear,cubic	***
Mortality (%)	1.85^{b}	3.70^{b}	9.26^{a}	9.26^{a}	3.70^{b}	1.23	-	*

^{abc} Means within the same row with different letter superscripts are significantly different ($P < 0.05$) ,LOS = Level Of Significance , NS= Not Significant ;
SEM = Standard error of the means, *=Significant (P>0.01<0.05), ** very significant (P<0.01<0.001), *** highly significant ($P< 0.001$) Cost per crate of egg = ₦700.

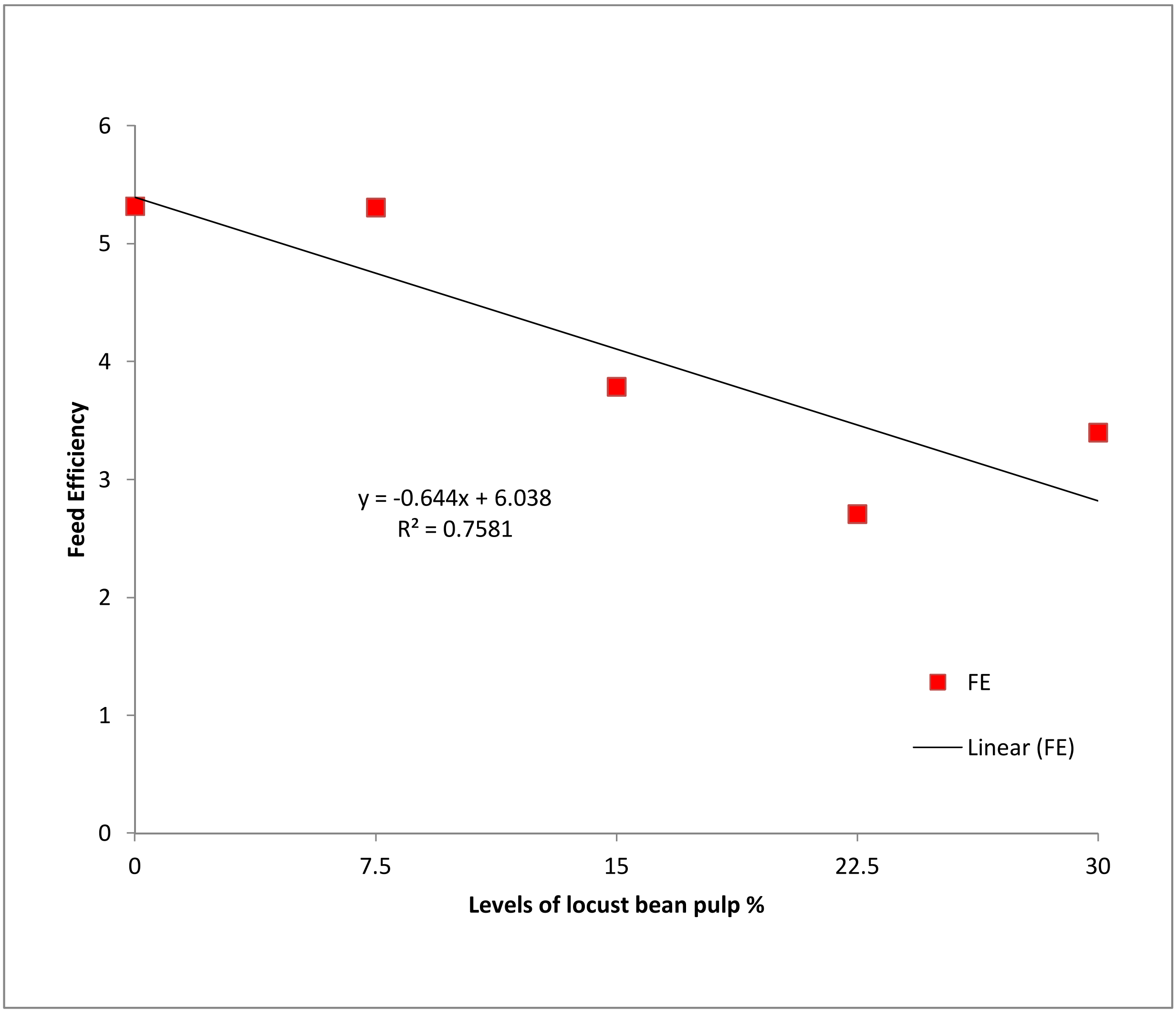

Figure 4.18: Trend line showing feed efficiency of the laying hens fed Graded levels of dietary LBP

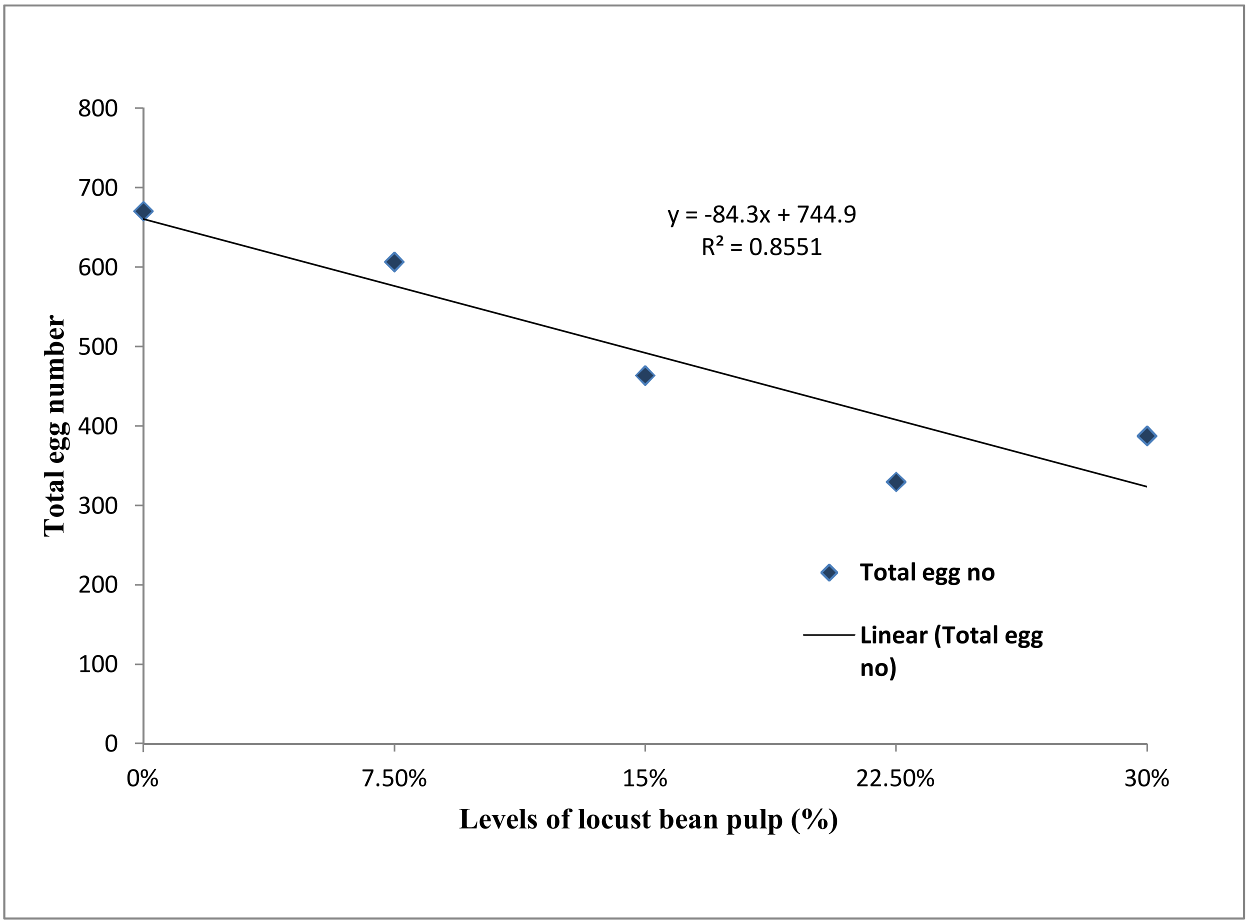

Figure 4.19: Trend line showing total egg number produced by laying hens fed Graded levels of dietary LBP

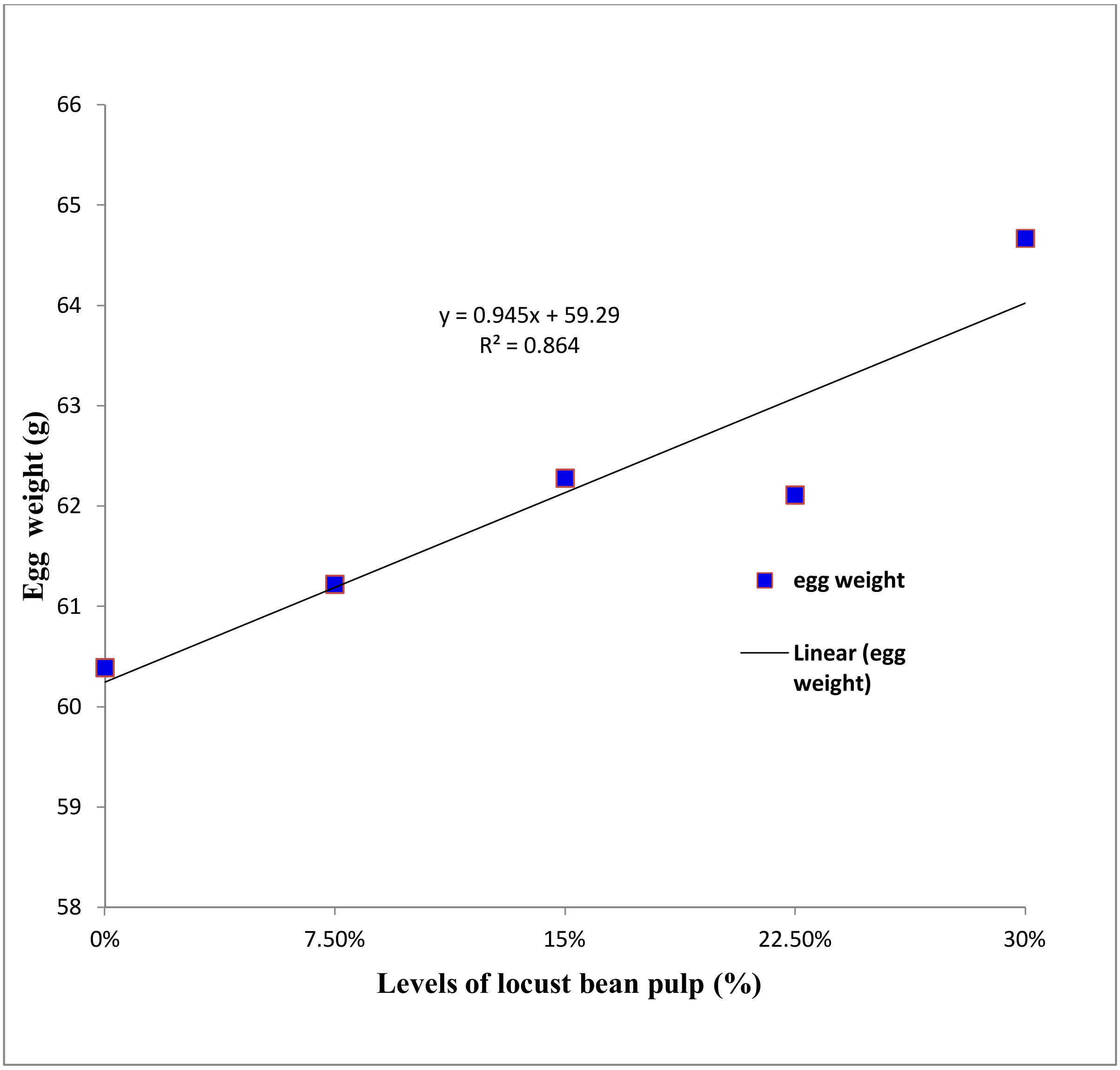

Figure 4.20: Trend line showing the average egg weight (g) of laying hens fed Graded levels of dietary LBP

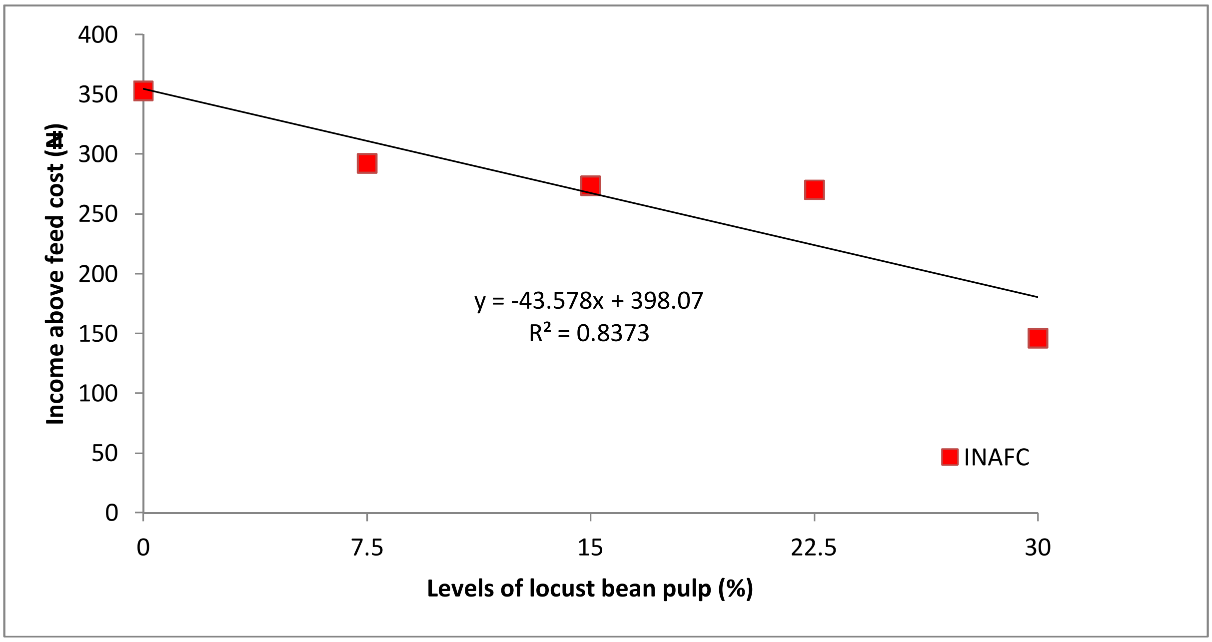

Figure 4.21: Trend line showing the income above feed cost (₦) of laying hens fed Graded levels of dietary LBP

in the diets of the birds. Contrast analysis showed that the effect of LBP on water intake, water to feed ratio, and egg numbers was very significant ($P<0.001$)

4.9 Effect of Graded Levels of Dietary Locust Bean Pulp on the Egg Quality Parameters

The result of the effect of Graded levels of dietary locust bean pulp on the egg quality parameters is presented in Table 4.9. Egg weight was observed to increase as the level of LBP increased in the diets. This is an indication that the locust bean pulp had positive effect on the egg size. However, there were no significant ($P>0.05$) differences in the shell thickness, shell index, shell percentage across the dietary treatments. This is an indication that the LBP had no detrimental effect on the egg shell formation. The values obtained for Egg shape index in this study were significantly different across the dietary treatments. Egg surface area was observed to be significantly ($P<0.05$) better at 30% LBP. Locust bean pulp had a significant ($P<0.05$) positive effect on the yolk colour, There was a gradual increase in the Roche yolk colour fan score (RYCF score) as the level of LBP increased in the diet, the yolk colour of the control diet was pale yellow with the value of 1.27 when compared with bright yellow colour obtained for the 30% LBP inclusion level with the value of 5.5 on the RYCF score. Trend analysis showed a positive linear relationship between the yolk colour and the level of locust bean pulp in the diets (Figure 4.22). Contrast analysis further justified the non significant effect of LBP on most of the parameters such as shell thickness, shell index, shell percentage, egg specific gravity, and Haugh unit. Whereas, the effect of LBP was significant ($P>0.01$) on the egg weight, egg shape index, egg surface area, albumin index and yolk index.

Table 4.9 Effect of graded levels of dietary locust bean pulp on the egg quality parameters

	Dietary Inclusion Levels (%)							
Parameters	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**contrast**	**LOS**
Egg Weight (g)	60.39^{b}	61.22^{ab}	62.28^{ab}	62.11^{ab}	64.67^{a}	0.43	-	NS
Shell Thickness (mm)	29.50	29.33	29.78	30.28	29.56	0.27	-	NS
Shell Index	14.61	14.97	14.56	15.32	14.62	0.16	-	NS
Shell percentage (%)	10.68	10.89	10.53	11.09	10.47	0.12	-	NS
Egg shape Index	1.28^{a}	1.27^{ab}	1.23^{b}	1.26^{ab}	1.24^{ab}	0.06	quartic	*
Egg specific gravity	1.15	1.15	1.14	1.15	1.14	0.05	-	NS
Egg surface area (cm^{3})	44.12^{ab}	44.53^{ab}	45.04^{ab}	44.96^{ab}	45.94^{a}	0.21	linear	*
Albumin Index	0.13	0.12	0.14	0.15	0.14	0.04	linear	*
Yolk index	0.49	0.50	0.50	0.49	0.51	0.05	-	*
Haugh Unit	96.89	101.32	103.12	102.91	101.40	1.05	-	NS
RYCF Score	1.00^{c}	2.50^{b}	3.00^{ab}	3.50^{a}	4.50^{a}	0.09	linear	**

^{abc} Means within the same row with different letter superscripts are significantly different, ($P < 0.05$), LOS = Level of Significance, NS= Not Significant,
SEM = Standard Error of the Means , *=Significant ($P>0.01<0.05$), ** very significant ($P<0.01<0.001$), *** highly significant ($P< 0.001$)
RYCF = Roche Yolk Color Fan Score.

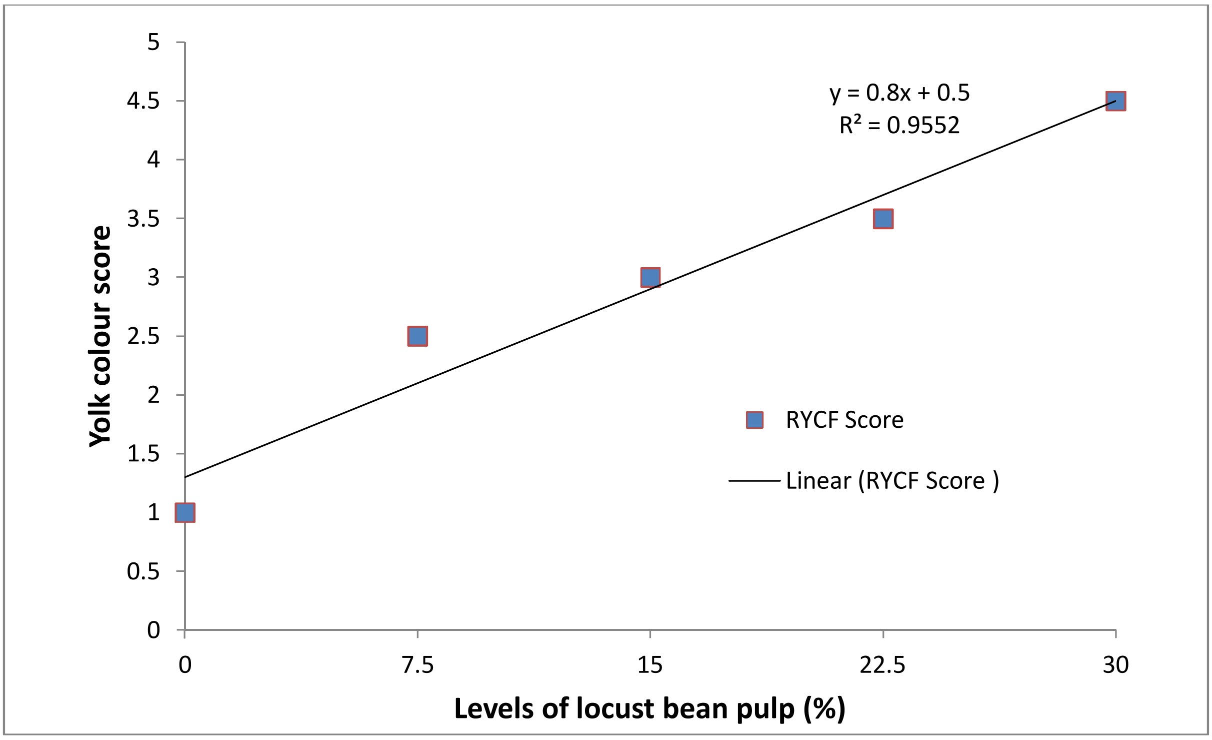

Figure 4.22: Trend line showing egg yolk colour of laying hens fed Graded levels of dietary LBP

4.10 Haematological and Serum Indices of Laying Hens Fed Locust Bean Pulp

The haematological and serum biochemical profiles obtained for laying hens fed on graded levels of locust bean pulp are presented in Table 4.10a and 4.10b respectively. Most of the parameters evaluated such as: Hb (%), MCV (%), MCH (pg), MCHC (%), and RBC showed no significant ($P>0.05$) differences between the dietary treatments. PCV was slightly better at 15% inclusion level of LBP, however the value obtained for birds on 7.5 and 22.5% inclusion level of LBP were similar to those fed control diet. Trend analysis (figure 4.23) showed a polynomial relationship. The total white blood cells (TWBCmm^3) was significantly ($P<0.05$) higher at 30% (19.09 mm^3) but this was comparable to 7.5% LBP. Trend analysis (figure 4.24) showed a polynomial relationship. However, lymphocyte was significantly ($P<0.05$) higher for the birds fed 30% LBP diet than for those on the other diets, while the birds on the control and 22.5% LBP diet had significantly ($P<0.05$) low count. Neutrophil was observed to be significantly ($P<0.05$) higher for birds fed 0% and 22.5% LBP and lower at 30% LBP. Birds fed 7.5% and 15% LBP diets were similar whereas birds fed 22.5% LBP diet were not significantly different from those fed control diet and birds fed 30% LBP diet had the least Neutrophil count.

Serum biochemical indices of laying hens fed Graded levels of dietary LBP were not significantly ($P>0.05$) different in all the parameters (total protein, cholesterol, glucose and albumin) measured.

4.11 Effect of Graded Levels of Dietary Locust Bean Pulp on Nutrients Digestibility

The result of the effect of Graded levels of dietary LBP on nutrients digestibility is presented in table 4.11. There were significant ($P<0.05$) differences in all the parameters across the treatments. Also, there was no defined pattern observed. Percentage digestibility of crude protein (CP) was significantly ($P<0.05$) better at 7.5% (Figure 4.25) inclusion level of LBP when compared to other treatments, significantly ($P<0.05$) low digestibility was observed at 15%. Trend analysis showed a quadratic relationship between level of locust bean pulp and crude fibre digestibility. There was a positive linear decrease in the digestibility of crude fibre up to 22.5% inclusion level of LBP, after which an increased digestibility was observed at 30% level and the least value was recorded at 22.5% (Figure 4.26). Digestibility of ether extract was significantly ($P<0.05$) higher at 0% LBP followed by diet containing 22.5%.. Nitrogen free extract digestibility (Figure 4.27) was significantly higher at 7.5 and 22.5% inclusion levels of LBP when compared with other dietary treatments.

Table 4.10a Hematological Indices of Laying Hens Fed Locust Bean Pulp

	Dietary Inclusion Levels (%)							
Parameters	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**contrast**	**LOS**
PCV (%)	25^{ab}	25^{ab}	26.83^{a}	25.33^{ab}	22.33^{b}	0.54	-	NS
Hemoglobin (%)	8.30	9.97	8.90	8.42	7.40	0.46	-	NS
RBC(mm^{9})	3.50^{c}	4.12^{b}	4.42^{a}	3.55^{c}	3.68^{c}	0.12	-	*
MCV (%)	72.48	60.72	60.74	72.55	60.61	1.65	cubic	*
MCH (pg)	20.08	20.19	20.21	20.12	20.15	0.02	-	NS
MCHC (%)	33.16	33.12	33.16	33.22	33.12	0.02	-	NS
TWBC (mm^{3})	10.12^{c}	13.73^{b}	12.38^{b}	9.98^{c}	19.09^{a}	0.78	Linear, cubic	*
Lymphocyte (%)	83.5^{b}	86.17^{ab}	85.33^{ab}	82.83^{b}	90^{a}	0.75	cubic	*
Eosiniphil (%)	1.33	1.67	0.17	1.33	0.33	0.18	-	NS
Neutrophil (%)	16.50^{a}	11.83^{ab}	14.50^{ab}	16.50^{a}	9.67^{b}	0.66	-	NS

^{abc} Means within the same row with different letter superscripts are significantly different ($P < 0.05$),LOS = Level Of Significance
NS= Not Significant, SEM = Standard Error of the Means, *=Significant ($P>0.01<0.05$), ** very significant ($P<0.01<0.001$), *** highly significant ($P< 0.001$)
PCV = Packed Cell Volume, RBC= Red Blood Cell, MCV= Mean Corpuscular Volume, MCH= Mean Corpuscular Haemoglobin, MCHC= Mean Corpuscular Haemoglobin Concentration, TWBC= Total White Blood Cell

Table 4.10b Serum Biochemical Indices of Laying Hens Fed Locust Bean Pulp

	Dietary Inclusion Levels (%)							
Parameters (g/dl)	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**contrast**	**LOS**
Total Protein	6.57	6.78	7.00	6.70	7.53	0.25	-	NS
Cholesterol	4.13	4.96	4.62	5.05	4.73	0.32	-	NS
Glucose	4.35	6.52	4.68	5.08	4.63	0.38	-	NS
Albumin	43.5	38.17	43.00	36.17	36.33	2.14	-	NS
Globulin	36.93	31.39	36	29.47	28.8	2.08	-	NS

^{abc} Means within the same row with different letter superscripts are significantly different ($P < 0.05$),LOS = Level Of Significance
NS= Not Significant, SEM = Standard Error of the Means, *=Significant (P>0.01<0.05), ** very significant (P<0.01<0.001), *** highly significant (P< 0.001)

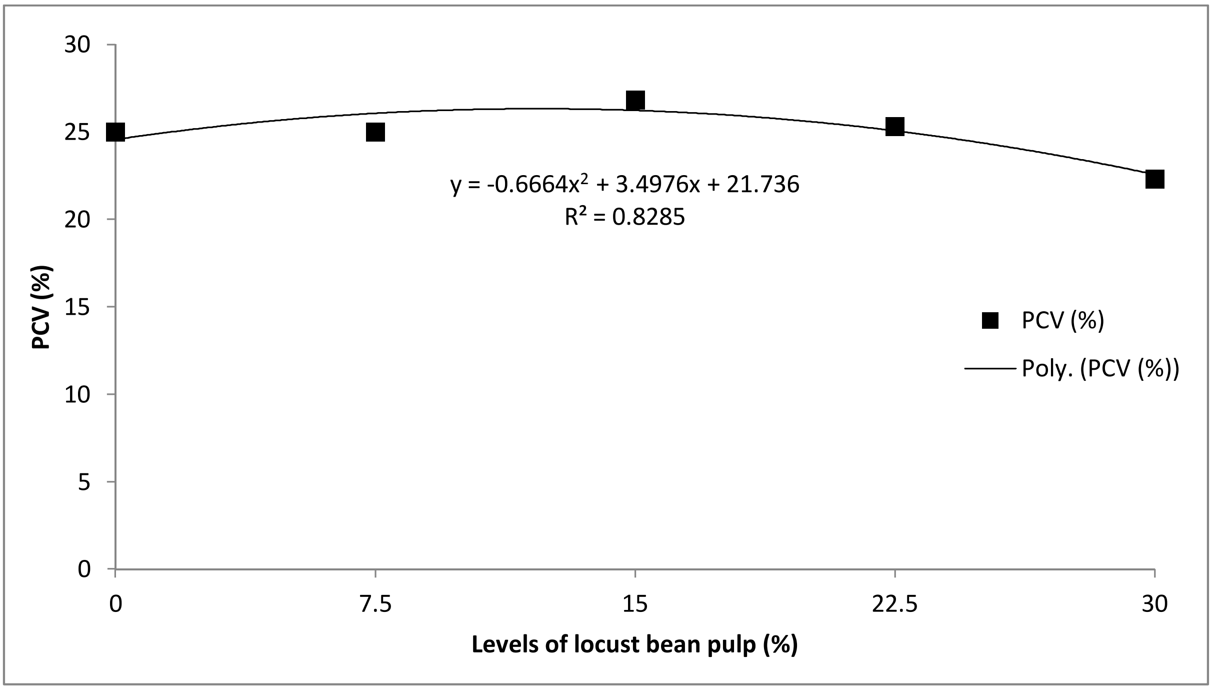

Figure 4.23: Trend line showing PCV level of laying hens fed graded levels of LBP.

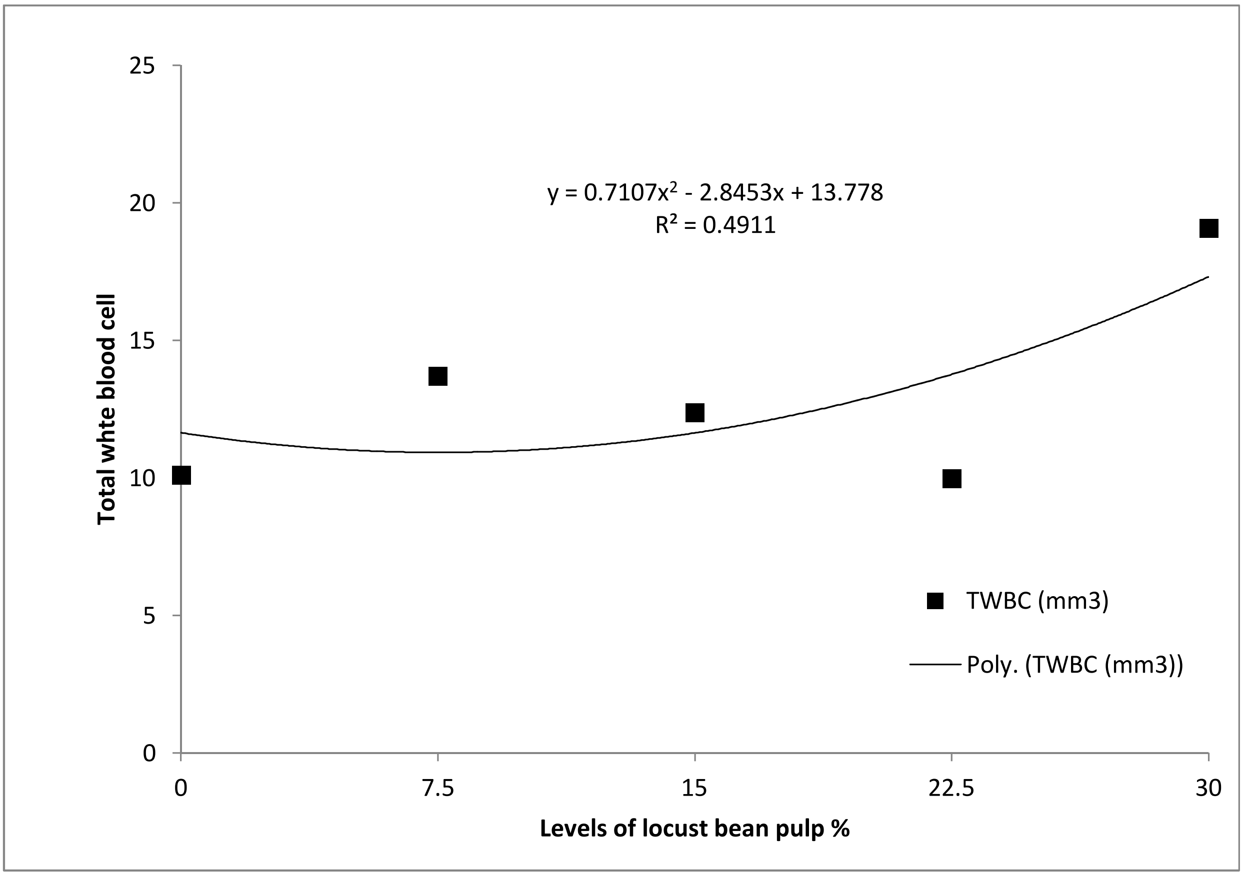

Figure 4.24: Trend line showing total white blood cell count of laying hens fed graded levels of LBP.

Table 4.11 Effect of graded levels of dietary locust bean pulp on nutrients digestibility

	Dietary inclusion level (%)							
Parameters	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**contrast**	**LOS**
Dry matter	80.22^d	80.33^a	80.32^b	80.29^c	79.93^e	0.01	Cubic	***
Crude protein	79.55^c	80.06^a	79.15^e	79.65^b	79.35^d	0.02	Quadratic	***
Crude fibre	61.98^a	50.69^c	41.57^d	40.71^e	51.27^b	0.12	Quadratic	***
Ether extract	81.53^a	79.14^d	78.22^e	79.96^b	79.15^c	0.01	Cubic	***
Ash	85.46^b	84.52^c	85.92^a	77.21^e	79.83^d	0.11	cubic	***
NFE	80.12^d	83.06^a	81.15^c	83.10^a	82.88^b	0.02	Cubic	***

^{abc} Means within the same row with different letter superscripts are significantly different ($P < 0.05$),LOS = Level Of Significance, NS= Not Significant, SEM = Standard Error of the Means
*=Significant ($P>0.01<0.05$), ** very significant ($P<0.01<0.001$), *** highly significant ($P< 0.001$)

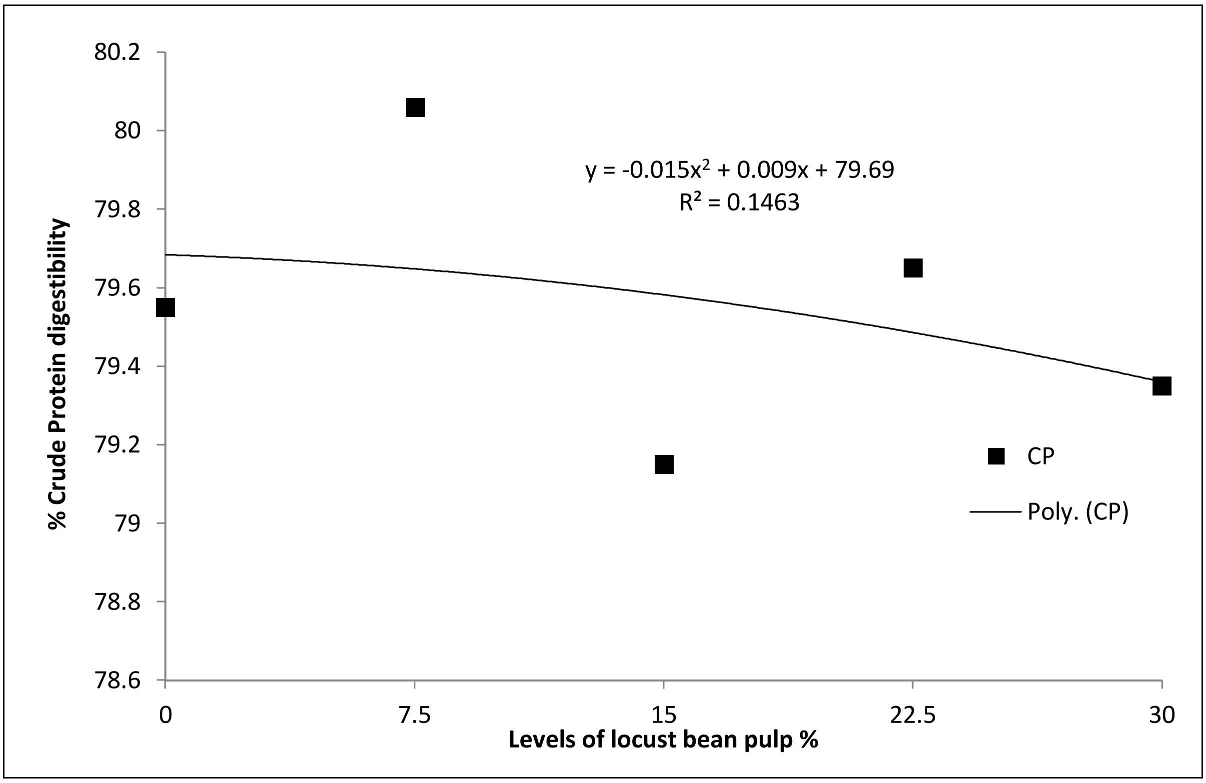

Figure 4.25: Trend line showing crude protein digestibility of laying hens fed Graded levels of dietary LBP

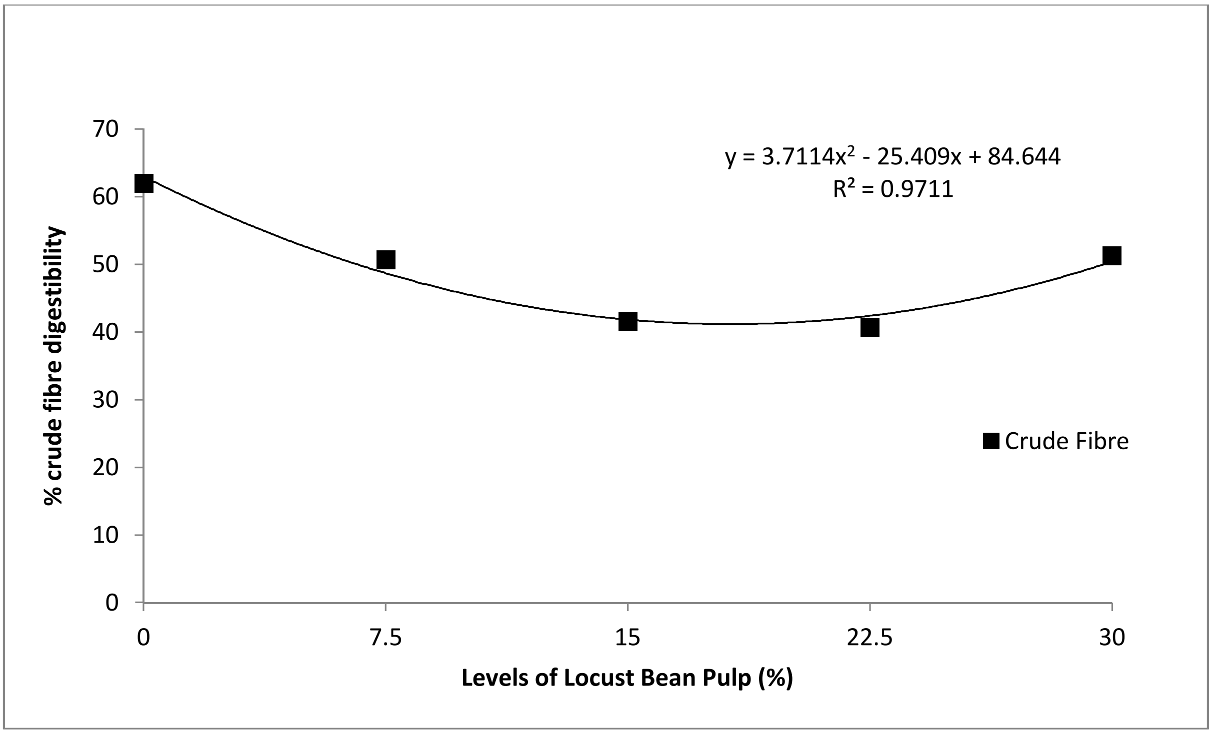

Figure 4.26: Trend line showing crude fibre digestibility of laying hens fed Graded levels of dietary LBP

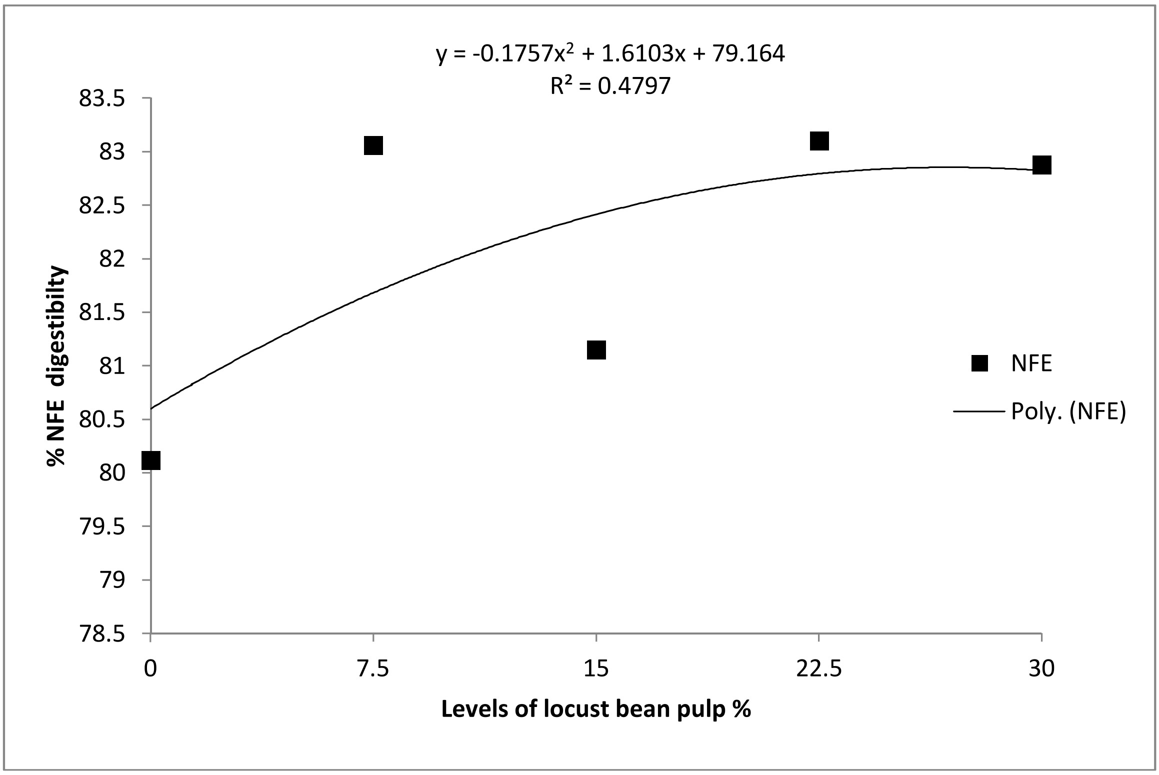

Figure 4.27: Trend line showing NFE digestibility of laying hens fed Graded levels of dietary LBP

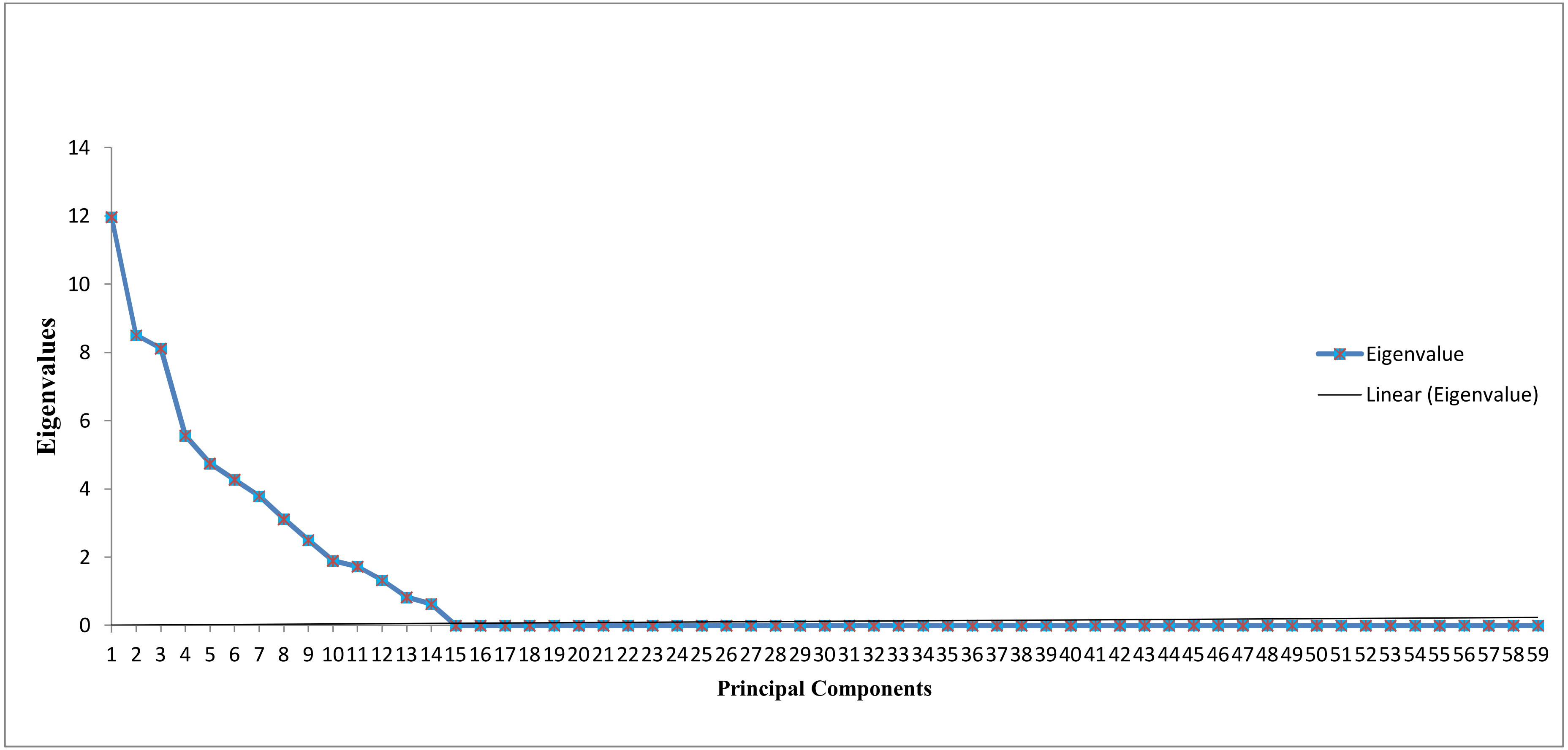

Figure 4.28: The number of principal components against the eigenvalues

CHAPTER FIVE

5.0 DISCUSSION

5.1 Proximate and Chemical Composition of Locust Bean Pulp

The laboratory analysis results indicated that LBP has low crude protein content of 3.19% compared to a range of 4.81 to 11.52% reported in literature. Crude protein content of the LBP recorded in this study was in agreement with the value reported by Nordeide *et al.* (1996). The authors reported that LBP contained 3.3% of crude protein. However, Alabi *et al.* (2005) reported a higher value 6.62%, and also Sotolu and Byanyiko (2010) reported that LBP contained 9.51% of crude protein. The variation may be due to differences in the varieties of LBP used. Value of 6.03% recorded for crude fibre was lower than the value reported by Aduku (2004), the author reported that %CF content in LBP was 11%. Gernah *et al.* (2007) also reported a higher value of 11.75%. The low value recorded for the crude fiber in this study when compared with the reports of researchers may be due to the processing method employed in separation of the pulp from the seed. Ether extract (EE) content of the LBP recorded in this study (1.84%) was lower than the value reported by Bot *et al.* (2013) who gave a value of 3.09% for ether extract, this may be due to the different batches of LBP used. Ash content was 6.86%, which was lower than 15.40% reported by Sotolu and Byanyiko (2010). This may be due to different varieties of the samples used. NFE value of 66.39% obtained in this study is in agreement with 67.30% reported by Gernah *et al.* (2007) and 68.75% reported by Bello *et al.* (2008). However, Musa *et al.* (2005) reported a lower value (46.59%). NFE value obtained in this study was an indication that LBP could be a potential source of carbohydrate (energy) for poultry and other livestock. This observation is in agreement with the findings of Kwari and Igwebuike (2002) who had earlier reported that the LBP was high in carbohydrates. Calcium and phosphorus were selected for analysis in this study because, they were essential for bone and egg shell development in poultry.

Calcium content of LBP recorded in this study was 22.177mg/g, while the phosphorus content was 3.14mg/g. This is an indication that LBP is rich in essential minerals required for bone and egg shell development in poultry and also agreed with the reports of Bello *et al.* (2008). These authors reported that calcium concentration in LBP is very high. The carotenoid (precursor of Vitamin A) content of the LBP used for this study was 1.046 mg/g, while that of Vitamin C was 542mg/100g which is about 2.5 times the value reported by Musa *et al.* (2005) and Bello *et al.* (2008). They reported that LBP contained 215mg/100g ascorbic acid. The high value obtained for vitamin C suggests the potential of LBP in improving the performance of chickens under heat stress conditions. However, Bot *et al.* (2013) reported a lower value. The authors reported that the content of ascorbic acid in LBP was 24.22mg/100g , the wide variation may be due to the differences in the varieties of LBP used. Edigwe *et al.* (2012) also reported that the LBP is very rich in nutrients.

5.2 Anti - Nutritional Content of the Locust Bean Pulp

Generally, the laboratory results of this study showed that the anti-nutritional contents of LBP were relatively lower than the values reported in literature. Tannin was 0.32mg/100g which was moderate and lower than the value reported by Bot (2011). The author gave a report that LBP contained 3.23mg/100g of tannin. The reason for wide variation may be due to differences in the batches of LBP used or due to variation in the reagents used for analysis. Oxalate content of LBP used in this study (0.93 mg/100g) was lower than the value reported by Alabi *et al.* (2005). The authors reported that LBP contained 3.5mg/100g of oxalates. The low oxalates value obtained in this study is an indication that inclusion of LBP in poultry diet may not have negative effect on feed intake and digestibility of minerals such as calcium. Phytate level recorded in this study (1.67mg/100g) was moderate and lower than the value reported by Edigwe *et al.* (2012). The authors reported a higher value of 3.30mg/100g for phytate. The variation observed may be due to differences in laboratory procedures for analysis. Saponin value was 0.34mg/100g, while Cyanide value was 0.08mg/100g and is an indication that LBP may not have detrimental effect on the birds if incorporated into poultry rations. Trypsin inhibitor value of 0.41mg/100g recorded for LBP in this study was also lower than 15.5mg/100g reported by Bello *et al.* (2008). Generally, the variation observed between literature reports and the results obtained in this study may be due to differences in the varieties of LBP used or differences in method used for sample preparation before laboratory analysis.

The alkaloid content (19.72%) of LBP reported in this study seemed to be on the high side and therefore may have negative effects on the birds. Although, (EFSA, 2012) reported that under normal conditions the risk of toxicosis in livestock is low , and that the risk of ergotism in livestock as a result of consuming contaminated cereal grains, or compounded feeds manufactured from them, was reduced where appropriate seed cleaning was carried out. However, Orwa *et al.* (2009) reported that the alkaloid parkine that occurs in pods and bark of locust bean fruit may have poisonous effects on livestock. Bailey *et al.* (1999) had earlier reported that feeding rations with high levels of ergot sclerotia (an alkaloid) for an extended time can result in loss of appetite, increased thirst, diarhorea, vomiting and weakness in poultry. They also reported that convulsions, gangrene of the comb, wattles, or toes, paralysis and death may follow short-term feeding of ergot-contaminated rations. The findings of Bailey *et al.* (1999) indicated that the safe dietary levels of alkaloids for chickens appear to be in the range of 0.3 - 0.8 % by weight. The alkaloid content (19.72%) of LBP recorded in this study was therefore much higher than the safe levels reported by these authors. Mainka *et al.* (2005) in a study to compare the effect of ergot (alkaloid) contaminated feed on performance and health of piglets and chickens fed diets containing 0, 0.5, 1, 2 and 4 g of ergot/kg diet concluded that the optimum safety level could be identified at 1.4 mg of ergot alkaloids/kg feed.

The flavonoids level (40.20%) reported in this study may not have negative effect on the performance of the birds and therefore this agreed with the findings of Paola and Maria (2006) and Catoni *et al.* (2008). These authors reported that flavonoids were dietary antioxidants, and are beneficial dietary components safe for the birds and that birds usually preferred flavonoid diets if given the chance to select feed among various diets. Nijveldt *et al.* (2001) had earlier reported that birds can obtain immunological benefits from the ingestion of flavonoids and that flavonoids can reduce oxidative stress by directly scavenging free-radicals, by interfering with free-radical producing mechanisms and by increasing the function of endogenous antioxidants. Kirk *et al.* (1998) and Ricketts *et al.* (2005) reported that adult human diets rich in flavonoids resulted in significantly decreased serum concentrations of total cholesterol, low-density lipoproteins (LDL) and triglycerides. Cassidy *et al.* (2000) had also reported reduced incidence of cardiovascular diseases with flavonoids diets. Dang and Lowik (2005) reported that flavonoids diets reduced osteoporosis.

5.3 Determination of Metabolizable Energy Value of Locust Bean Pulp

The metabolizable energy (ME) study showed that the ME content of LBP used in this experiment was 2344 kcal/kg diet. This value was close to the ME value 2420 kcal/kg reported by Aduku (1993). This value was lower than that of maize, which ranges between 3350 -3447 kcal/kg diet. The value was also an indication that LBP can serve as alternative source of energy in the diet of pullet chicks, grower and laying hens. The Metabolizable energy value (2344 kcal/kg diet) of LBP was also lower than that of millet which was 2560 kcal/kg diet and maize offal (2550 kcal/kg diet) but higher than that of palm kernel cake dry 2200 kcal/kg diet.

The gross energy (GE), apparent metabolizable energy (AME), true metabolizable energy (TME) and their efficiency of utilization recorded in this study showed that LBP has high gross energy value of 4164kcal/kg . Apparent metabolizable energy (AME) of LBP was 2344kcal/kg which was close to 2420 kcal /kg reported by Aduku (1993 and 2004). The efficiency of utilization of the AME of LBP was just above average (56.29%). This may be an indication that only 56.29% of the total energy intake will be digested, absorbed and utilized by the bird.

5.4 Response of Pullet Chicks Fed-Graded Dietary Levels of Locust Bean Pulp (0 -8 Weeks)

The significant final weight and weight gain observed in the birds fed 22.5% level of LBP could be an indication that it can be used up to 22.5% in the diet of starter chicks. This result disagreed with the report of Kwari and Igwebuike (2002). The authors reported that the optimum level of inclusion of LBP in the broiler diets was 15%. Bot *et al.* (2012) also reported a significant decreased in final weight and weight gain across the dietary treatments in broiler chicks fed graded level of LBP. However, the trend observed in the final weight and weight gain was an indication of satisfactory performance up to 22.5% and the decreased final weight and weight gain observed in birds fed 30% LBP diet may be due to the low energy content of the diet at higher inclusion level, because LBP has low metabolizable energy when compared to maize. From the feed composition table, a gradual decline in the ME kcal/kg diet was observed as the level of LBP increased in the diet. Therefore, the overall energy content of the diet was reduced at higher inclusion level which could not support the growth of the bird since chick starter requires high nutrients for better performance. This observation agreed with the reports by Summers (2000). The author reported that birds fed low energy diet had poor performance in term of growth, because the energy requirements of the birds were not met on low energy diets. Similarly, Nelson (1984) also reported depressive effects of brewers dried grain (BDG) on weight gain of broiler starter when fed above 25% inclusion level. The low feed intake observed for the birds fed control diet may be due to the high density of the diet which is in agreement with the findings of Olomu (1984) who reported that feed intake of chickens was inversely related to the dietary energy concentration. Reports by Singh *et al.* (2000), Afolayan *et al.* (2010) and Afrouziyeh *et al.* (2011), also agreed with the result of this study, they all attested to the fact that birds eat less of high density energy diet.

Higher feed intake observed in birds fed locust bean diets is an indication of the palatability and good aroma of the LBP. This observation also agreed with the findings of Nidaullah *et al.* (2010) who reported that smell and taste were critical traits in food selection by animals. However, Bot *et al.* (2012) reported that low energy level of LBP diets had a negative effect on the palatability of the diet. The linear increase observed for feed intake across the treatments is contrary to the report of Kwari and Igwebuike (2002). These authors reported a decrease in feed intake across the treatments in broilers fed graded levels of LBP. Although, the feed conversion ratio recorded for the birds fed LBP diets was higher than those on the control diet, it was able to support growth of the birds up to 22.5% level. This is an indication that the birds were able to utilize the diets consumed up to 22.5% without negative effect on the growth performance. This observation agrees with the findings of Gebhart (2001) who reported that better feed conversion ratio signified that more feed was retained in the animals and less waste to the environment. Kwari and Igwebuike (2002) however, reported that feed conversion ratio was negatively affected as the level of LBP increased in the diets of broiler chickens.

The linear increase in feed cost per bird is an indication that inclusion of LBP in the chicks diets did not bring down the cost of feed consumed per bird appreciably because all the cost parameters (feed cost per bird, feed cost / kg gain and total cost /bird) for the LBP diets were not better than that of the control diet. The reason for this observation may be due to the high feed conversion ratio observed in birds fed locust bean diets when compared to those on the control diet. Generally, the higher feed intake recorded for all the birds fed LBP diets consequently resulted in poor feed conversion ratio, with attendant result of increase in the cost of feed /bird. Whereas the birds on the control diet had significantly lower feed intake with better feed conversion ratio and low feed cost/bird. The implication of this observation is that LBP could be used as alternative source of energy when maize is scarce, but should not be used absolutely as energy source in chick diets. This is in agreement with the findings of Summers (2000) who reported that birds ate more of low energy diets (almost double of its normal intake). The mortality recorded in this study may not be due to the experimental diets, but may be due to environmental factor such as inconsistent supply of electricity.

5.5 Response of Growing Pullets to Graded Dietary Levels of Locust Bean Pulp (9 -20 Weeks)

The trend observed for the growth performance in terms of final weight (g)/bird and weight gain (g)/bird fed control and 7.5% LBP diets was in agreement with the report by Bot (2012) who observed that birds fed 10% LBP diet had similar weight gain with those fed control diet. This may be due to the high energy level of the diets and also, the energy requirement of the birds was fully met at these levels. This observation agreed with the reports of Steve (2000) and Afrouziyeh *et al.* (2011). These authors reported that diets with higher concentration of energy support growth performance.

The increase in final weight and weight gain observed at 30% inclusion levels of LBP was an indication that LBP could be fed up to 30% in the diet of growing pullets. This observation was contrary to the findings of Bot *et al.* (2013). The authors reported a significant decrease in the growth performance of broiler chickens as the replacement levels of LBP for maize increased. Kwari and Igwebuike (2002) also reported a significant decrease in final weight and weight gain of broilers as the levels of LBP increased across the dietary treatments. Report by Vantsawa (2007) was similar to the result obtained in this study. He observed no significant difference in final weight and weight gain across the treatments in growers fed graded levels of *dusa* (Maize offal). Higher daily feed intake observed in birds fed LBP diets when compared with those on the control diet is an indication that the birds consumed more of the LBP diet which may be due to the palatability of LBP and the low energy content of the diet. Bello et al. (2008) had earlier reported that LBP has sweet taste. Reports by Nidaullah *et al.* (2010) also agreed with this observation. The Authors reported that smell and taste were critical traits in food selection by animals. The vitamin C and beta carotene content of the LBP could have also improved the appetite of the birds to consume more of the LBP diets than the control. This agreed with the reports by Muller (1988) and Edigwe *et al.* (2012), these authors reported that the yellow colour of the LBP is an indication of the presence of beta carotene (precursor of vitamin A) which is very important for normal feed intake and that LBP is rich in ascorbic acid. However, the observation made over feed intake in this study disagreed with the reports of Kwari and Igwebuike (2002) and Bot *et al.* (2013). These authors reported that LBP had significant depressive effect on feed consumption of broiler chickens. Similarity observed in feed intake of the birds fed LBP diets in this study is an indication that LBP had no negative effect on feed intake across the dietary treatments. The linear trend observed suggests that LBP can be fed beyond 30% in grower ration. This is contrary to the findings of Kwari and Igwebuike (2002) who recommended that LBP should not be fed beyond 15% in broiler diets. The trend observed for feed intake may also be due to the increase in fibre load in the diets. Reports by Ukachukwu *et al.* (2011) agreed with this observation, the author fed graded dietary levels of composite cassava meal to weaned rabbits and reported increased feed intake and increased crude fiber level as the level of cassava increased in the diets. They further attributed the increased feed intake to be due to energy dilution of the diet, because high dietary fibre encouraged higher feed consumption. The findings of Ojewola *et al.* (2001) also agreed with this study, the author reported that crude fibre was bulky and that birds ate more of bulky diets. Alabi *et al.* (2005) and Sotolu and Byanyiko. (2010) also reported that LBP was high in crude fibre and hence has the potential of enhancing feed intake.

The significantly better feed conversion ratio observed in birds fed the control diet compared with those on LBP diets in this study agreed with the findings of Kwari and Igwebuike (2002) who reported a reduced efficiency of feed conversion as levels of LBP increased in the diets of broiler chickens. Similarly, the observation made in this study agreed with the reports of Ogundipe *et al.* (2003). These authors reported a significant increase in feed conversion ratio and that the diets were less efficiently utilized as the level of lablab increased in the diets of pullet chicks. The trend observed for the water intake and water to feed ratio in this study is in agreement with the findings of Aduku (2004) who reported that poultry consumed two to three times the amount of water per unit dry feed consumed.

The linear increase observed in the water and water/feed ratio may be due to the powdery nature of the LBP which might have also enhanced increase water intake at high LBP inclusion level. This was also an indication that LBP could be fed up to 30% in growers ration without negative effect on the water to feed ratio and on the growth performance of birds. The increased water to feed ratio may also be due to the bulky nature of the feed, it is possible that bulkiness of feed ingredient supports more water consumption at higher inclusion levels, this observation is in agreement with the report by Onimisi (2004) who observed that increased feed intake enhanced increased water intake. The trend observed for feed cost/bird is an indication that least cost ration could be obtained with the inclusion of LBP in grower rations and it could be incorporated beyond 30% in grower diet to obtain a least cost ration. This is in agreement with the reports by Vantsawa (2007) who reported that *dusa* (Maize offal) has an overall advantage over maize in terms of cost in growers' diet. This is also in agreement with the findings of Bawa *et al.* (2003) who reported a significant drop in all the cost parameters as the level of lablab increased in the diet of weaner pigs. Abeke *et al.* (2003) also reported that feed cost was reduced when non conventional feedstuffs were used in poultry feed formulations.

The similarity observed in feed cost /gain for the birds fed 7.5, 15 and 22.5% is an indication that LBP had no detrimental effects on the growth performance of the birds. There were no mortalities throughout the 11 weeks of this study. This could be attributed to good management and to the safety of the LBP. This observation agreed with the findings of Akoma *et al.* (2001) who reported the edibility and non - toxicity of the LBP.

5.6 Economy of Production of Point of Lay Pullets Fed Graded Levels of Dietary Locust Bean Pulp (9-20 Weeks).

The trend observed in feed cost per bird and feed cost per kg gain showed that the cost of feed for the birds fed LBP diet was not better than that of the control diet except at 30% level of LBP in which a significant reduction in feed cost was recorded. This may not be due to the effect of LBP in the diet and the significant reduction in feed cost observed at the 30% inclusion level is an indication that inclusion of LBP in growers' diets is cost effective. Total cost of raising a pullet from day old to point of lay also followed a similar trend as total feed cost. This was normal as all other expenses incurred (medication, vaccination and labour) were the same across the treatments except the feed cost. This was in agreement with the findings of Oluyemi and Roberts (2000), Adebayo *et al*. (2002) and Kehinde *et al.* (2006) who reported that feed cost accounts for about 70% of the total cost of production. Ogundipe (2002), Onimisi (2004), and Sekoni *et al*. (2008) earlier observed that high cost of poultry feed results in general increase in the cost of production. Tijani *et al*. (2012) also reported that feed costs and hired labour accounts for 80.65% and 5.25% of the total costs and returns associated with table egg production.

The sudden increase observed in total cost per bird with 7.5% LBP was similar to the findings of Vantsawa (2007) who reported an increased cost per bird in growing pullets fed 10% *dusa* (Maize offal) compared to the cost of other diets containing *dusa* .

LBP can be used in feed formulation when maize is scarce. The observed trend in the gross marginal profit is normal and is an indication of the possibility of making more profit when the total cost was low. The gross marginal profit was significantly higher at 30% level of LBP inclusion than for other diets. Therefore it is concluded that LBP could be used as alternative feedstuff in time of scarcity of other conventional feed resources. Ogundipe (2002) and Sekoni *et al.* (2008) had earlier reported that the only solution to the high cost of poultry feed is to incorporate non- conventional feed ingredients for which there was little or no competition from humans. Similarly, Orheruata and Otoikhian (2007) indicated that the two major concerns of poultry farmers are the total cost of production and the final returns after sales.

5.7 Subsequent Response of Pullets (20 – 42 weeks) Fed Graded Levels of Dietary Locust Bean Pulp during the Grower Phase

The observed trend in the percentage change in weight of the birds was an indication that the birds were able to recover from any nutrient deficiency suffered during the growing phase. This agreed with the report of Ogundipe *et al.* (1992) who reported that birds fed previously on poor diet were able to recover and attain normal physiological maturity. The observation in this study also agreed with the findings of Sekoni (1997) who reported that any feeding regime targeted at slowing down the growth and physiological development of the growing pullets will eventually lead to better physiological development. Abeke (2005) also reported a higher percent change in body weight for hens fed higher levels of lablab bean meal in their grower phase. Aduku (1992) and Olomu (1995) gave a similar report that birds that were starved of feed for some time, either on restricted feeding regimes and fed on poor diet resulting from low nutrient level tend to eat more and recover body nutrient losses faster than those on normal conventional diets.

The trend observed for age of the birds versus egg weight at first egg and at peak of egg production is an indication that the egg weight increased with the age of the birds. This observation is in agreement with the findings of Ezieshi *et al.* (2003), the authors reported that egg weight increased with hen day egg production. Hosseini *et al.* (2007) also reported that egg weight increased with the age of the hen. The result obtained in this study also agreed with the findings of Udeh (2010) who reported that a high correlation existed between egg weight and the age of the birds.

From the contrast analysis, the LBP had no negative effect on the age of the bird at first egg neither on the age which the birds reached peak of egg production. The observed linear increase in egg weight may not necessarily be due to the effect of the graded levels of LBP but due to the age of the birds.

The observed increase feed intake with increased in the level of LBP may be due to the low metabolizable energy value (2344 kcal ME/kg diet) of LBP compared to maize (3432 kcal ME/kg diet). This result is in agreement with the report by Steve (2000), who reported that birds ate more of low energy diets. Olomu and Offiong (1983) had earlier reported that low metabolizable energy diet resulted in increase feed intake. The gradual reduction observed in feed efficiency with increased level of LBP in the grower ration is contrary to the findings of Robinson *et al.* (2000a), who reported that birds on high energy diets produced fewer eggs per unit feed intake. However, Lumpkins *et al.* (2005) reported that low energy diets supported egg production. The results obtained in this study also agreed with the findings of Abeke (2005). The author reported gradual reduction in feed efficiency of the laying hens as the level of lablab increased in the diet fed during grower phase. The positive linear trend observed for water intake and water to feed ratio of the birds agreed with the report of Aduku (2004) that poultry consume two to three times amount of water per unit of dry feed consumed. The presence of alkaloids (19.72%) in the LBP used for the study might have induced the birds to drink more water as the LBP increased in the grower diets fed during the grower phase. It was also possible that the LBP fed during the growing phase had carry over effect on the water intake pattern by increasing thirst in the laying birds. This observation is in agreement with the findings of Bailey *et al*. (1999). Who had earlier reported that feeding rations with high levels of ergot sclerotia (an alkaloid) for an extended time resulted in loss of appetite, increased thirst and diarhorea in chickens.

The observed low cost in the feed cost per crate of egg at 22.5 and 30% LBP is an indication of reduction in the cost of feed required to produce a crate of egg. It was more costly to produce a crate of egg with the control diet than when 7.5, 22.5 and 30% LBP were used during the growing phase.

The significant high feed cost per crate of egg observed when 15% of LBP was given during the growing phase was in agreement with the findings of Ogundipe *et al.* (1992) and Abeke (1997). These authors reported that feeding poor quality diets to save cost in growing pullet may result in loss of profit during the laying phase. Aduku (1992) also reported that delay in sexual maturity of growing pullets might result in an increased cost of production because the birds were fed for longer period of time to compensate for the delay caused by sub- optimal feeding during growth. The significant increased income above feed cost per crate of egg which was observed when 7.5, 22.5 and 30% LBP were included in the grower ration is an indication of cost savings and is contrary to the report by Abeke (2005) who reported a significant low income above feed expenses for the laying hens fed diets containing lablab seed.

5.8 Effect of Graded Levels of Dietary Locust Bean Pulp Meal on the Performance of Laying Hens (42-53weeks)

The significantly high final weight observed in the birds fed control diet may be due to the nutrient density of the diet. This is contrary to the report of Steve (2000), who reported that birds ate less of high density diets to meet their nutrient requirements. The reduced feed intake observed at 30% inclusion level of LBP was similar to the report by Bot *et al.* (2012) who reported a depression in feed intake of broilers when LBP was fed above 25% level. The general depression in feed intake observed on birds fed LBP diets compared to those on control diet may be due to the powdery nature of the LBP.

The observed decrease in the feed efficiency (egg/feed) as the level of LBP increased in the diets is an indication that LBP suppressed egg production. This observation is contrary to the findings of Robinson *et al.* (2000a), the authors reported that birds on low energy diet converted energy and protein to egg more efficiently than those on high energy diet. Summers (2000) also reported that diets with the lowest feed efficiency may not always be the most economical in terms of feed utilization. The result obtained in this study also agreed with the report of Lumpkins *et al.* (2005). They observed that low energy diets caused depression in egg production because hens were not fully meeting their caloric requirement.

The better feed efficiency observed on the birds fed control and 7.5% LBP diet may be due to the high energy level of the diets compared to other diets. This observation is contrary to the findings of Neoh *et al.* (2007) who gave a report that high level of energy in the diet of a laying bird had a depressive effect on egg production. Afrouziyeh *et al.* (2011) also reported that diets with higher concentration of energy were usually more efficiently used in terms of unit gain per feed consumed. Abeke (2005) also recorded a significant better feed efficiency for the layers fed diet without lablab seeds.

Daily water intake and water to feed ratio of the laying hens was similar to what was obtained during the growing phase where the least intake was recorded for the birds on the control diet. Water/feed ratio reported in this study was in line with the reports of Aduku (2004) who reported that poultry consumes two to three times amount of water per unit of dry feed consumed. It may also be due to the level of alkaloid (19.72%) present in the LBP used for this study which might have induced thirst in the birds and consequently diarhorea as was observed during the study on the birds fed 22.5 and 30% LBP diets. Bailey *et al.* (1999) had earlier reported that feeding rations with high levels of ergot sclerotia (an alkaloid) for an extended period can result in loss of appetite, increased thirst and diarhorea in chickens.

The egg weight was observed to increase as the level of LBP increased in the diets while the egg numbers decreased with increased LBP inclusion level. It is possible that increased LBP in the diets of the laying hens supported egg weight and the observed decreased egg number may be due to decreased metabolizable energy level of the diets at higher inclusion levels of LBP. The inverse relationship observed between egg number and egg weight in this study may also be due to genetic factors. This observation agreed with the report of Niknafs *et al.* (2012). These authors reported an inverse correlation between egg weight and egg numbers. The findings in this study is contrary to the reports by Onimisi (2010), he reported that both the egg weight and the egg number increased as the level of quality protein maize increased in the diet of laying hens. Fadugba (1989), in a study with industrial maize offal fed to laying hens also reported that egg production was not affected by increasing levels of industrial maize offal. Sekoni (1997) had earlier reported that total number of eggs obtained from laying hens fed 20% cassava peel meal diet was similar to those fed the control diet. The observed linear increase in feed cost per crate of egg as LBP level increased across the treatments had consequently resulted in linear decrease in income above feed cost and is an indication that inclusion of LBP in the diet of laying hens did not appreciably reduce feed cost per crate of egg, therefore it was concluded that inclusion of LBP in layer ration may not be economical. It may also be that the nutrients were efficiently utilized by the birds. Therefore, LBP may not be efficient in layers ration as a major source of energy, except alternative energy source is added to boost the energy level. Bot *et al.* (2013) gave a similar report of increased cost per gain as the level of LBP increased in broiler finisher ration. Damang (2007) had earlier reported that inclusion of locust bean seeds in broiler finisher diets resulted in high cost of productions.

5.9 Effect of Graded Levels of Dietary Locust Bean Pulp on the Egg Quality Parameters

The observed linear increase in egg weight as the level of the LBP increased in the diets was attributed to the positive effect of LBP on the egg size. This was in line with the findings of Vantsawa (2007) who reported that egg weight increased with increased level of maize offal in diets of laying hens and also agreed with the reports of Onimisi (2010), the author reported a linear increase in the egg weight of hens fed graded levels of quality protein maize. However, contrast analysis result showed that the linear increase in egg weight recorded was not due to the effect of LBP. It may be due to other factors such as genetic factor and age of the birds. This observation agreed with the reports by Udeh (2010) and Niknafs *et al* (2012). These authors reported that both genetic and non genetic factors were responsible for egg weight and egg numbers. Jacopo and Khalid (2010) also gave a similar report and they outlined some factors influencing egg size to include genetic factors, food availability, seasonal variation, maternal size and age of the birds.

There were no significant (P>0.05) differences in the shell thickness, shell index and shell percentage across the dietary treatments. This was an indication that the LBP had no detrimental effect on the egg shell formation. This observation tallied with the findings of Farooq *et al.* (2001) who reported that positive correlation exist between egg weight, shell weight and shell thickness The results also agreed with the reports of Bawa *et al.* (2011) who reported that shell thickness, shell index, shell percentage were not significantly affected by graded levels of dietary proteins in the diet of Japanese quails. Abeke (2005) had earlier reported that inclusion of lablab seed in the diet of laying hens had no significant effect on the Haugh unit value, shell thickness, shell percentage, shell index and yolk index. The values obtained for Egg shape index in this study were statistically similar across the dietary treatments.

Egg surface area was observed to be significantly better at 30% LBP, this may be due to the bigger egg weight recorded at this level. In addition, LBP had a significant positive effects on the yolk colour which was observed to increase from pale yellow to deep yellow colour with RYCF score ranging from (1.00 – 4.50) as the level of LBP increased in the diet of the hens. This is an indication that LBP contained xanthophylls and was in agreement with the reports of Donald (2010) who reported that the presence of xanthophylls in the diet determines the colour of the yolk. Roberts and Ball (2000) reported a higher value (6.4 – 6.9) when distillers dried grains were included in the ration of the laying hens.

5.10 Haematological Indices of Laying Hens Fed Graded Levels of Dietary Locust Bean Pulp

The observed quadratic trend in PCV values recorded in this study is an indication that the nutrients were efficiently utilized at 15%. The results obtained in this study falls within the normal range for chickens but were lower than the findings of Mitruka and Rawnsely (1977) who reported that the normal range for PCV in broiler finisher was 31- 33.5%. The PCV values obtained in this study also agreed with the findings of Patra *et al.* (2010) who reported a range of (22-35%) for PCV. However, the PCV values obtained in this study differed from values reported by Adeyemo and Longe (2007) in a study on the effects of graded levels of cotton seed cake on broilers. The authors reported a range of 26.17 – 31% for PCV. In addition, Oladele (2000) and Ojediran *et al.* (2012) had earlier reported that the PCV content of the chicken's blood were a factor of their nutrient intake. Aro and Akinmoyegun (2012) also reported that blood was used to access the body's ability to respond to nutritional challenges. The significantly better value obtained at 15% inclusion level of LBP is an indication that

15% is the optimum inclusion level. There were no significant differences in the haemoglobin (Hb), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and red blood cells (RBC) obtained in this study . This may be an indication of the good nature of the LBP and also agreed with the findings of Kuka and Kaankuka (2012) who reported that the normal range of RBC for domestic fowls is 2 - 4 x 10^6mm^3. The results obtained in this study also agreed with the findings of Patra *et al.* (2010) who reported a range of (7 – 13 g/dl) for haemoglobin. Total white blood count was observed to be similar across the treatments except at 30 % level of LBP inclusion in which total white blood count was significantly high, and was above the normal range (6.95 – 18.65 x 10^6/mm^3) reported for a healthy chicken by Kempert (2010). This may be due to the coccidiosis suffered by the birds in this treatment as a result of watery diarhorea which consequently led to constant wetness of litter material. Therefore, TWBC increased in order to fight the infection which further explains the good nature of LBP. This observation agreed with Guyton (1991) who reported that heterophils migrate faster from the bone marrow to the damaged tissue few hours after infection. However, Afolabi, *et al.* (2011) reported a range of 9.20 – 31.0 x 10^6/mm^3, Kuka and Kaankuka (2012) also reported a similar range of 9 - 31x 10^6/mm^3 for WBC.

Lymphocyte was significantly ($P<0.\ 05$) higher at 30%, the high values recorded in this study suggest the resistance of the birds to disease conditions. The values obtained in this study agreed with the reports of Afolabi *et al.* (2011) but disagreed with the report of Adeyemo and Longe (2007) who reported a lower value of 35 – 54% for birds fed cotton seed cake between 0-8 weeks of age. There were no significant differences observed in serum parameters. Total serum protein obtained in this study ranges from 6.57 to 7.53% and is closer to the findings of Kuka and

Kaankuka (2012). The authors indicated a range of 5 – 7% for serum protein of domestic fowls. The results also fall within the normal range (4.02 – 8.36g/dl) for chickens as reported by Mitruka and Rawnsely, 1977. The results also indicate that LBP is safe for use as feed ingredient. The similarity observed across the treatments for serum parameters suggest that LBP is safe for consumption and had no adverse effect on serum protein, cholesterol, glucose and albumin. Bot *et al.* (2013) also reported that LBP had no negative effect on serum chemistry and haematology of birds. Cholesterol level recorded in this study (4.13- 5.05mmol/L) was also within the normal range (3.23 – 5.17mmol/L) for birds as reported by Patra *et al.* (2010).

5.11 Effect of Graded Levels of Dietary Locust Bean Pulp on Nutrients Digestibility (52 Weeks)

The results of crude protein digestibility showed that the 7.5% LBP diet was more digestible. The decrease in percentage digestibility of crude fibre with increasing levels of LBP could be attributed to the increased fibre load in the diets. This observation agreed with the reports by Ukachukwu *et al.* (2011) who reported that high fibre level encourages bowel movement. Reports by Hartini *et al.* (2003) and Jokthan *et al.* (2006) also indicated that dietary crude fibre have the tendency of speeding up the rate of passage of feed through the intestinal tract and may depress the digestibility, absorption , availability and utilization of nutrients.

The high percentage digestibility of ash reported in this study may be attributed to the presence of minerals, indicating that LBP may be a potential source of minerals. This observation agreed with the reports of Gernah *et al.* (2007) who reported that LBP was a good source of minerals required by the body. However, wetness of the faecal sample was observed to be significantly high at higher inclusion levels of LBP in the diets, as a result of this the birds on diets 22.5 and 30% LBP were always bringing out wet, foul smelly faeces. This observation agreed with the findings of Kwari and Igwebuike (2002) who reported that broilers fed graded level of LBP passed out very sticky faeces which has offensive odour, the authors attributed the stickiness of the feaces to jelly characteristic of the pulp. Generally, except for the low digestibility of crude fibre, the result obtained in this study is an indication that LBP is safe for consumption by birds even at 30% inclusion level and had little or no negative effect on the nutrient utilization.

5.12 Discussion of Principal Component Analysis

The principal component (PC) analysis (appendix 2) showed that the first thirteen (15) principal components account for most of the variability in the (59) components measured (figure 4.33). The reason for the consistent plateau observed beyond the 15th PC may be due to the fact that some of the variables were either correlated with one another or they measure the same data. Beyond the 15th variables the level of importance depreciate as more components were been added. The thirteen PCs which indicated the age of the birds at various laying period (age at first egg, age at 50% lay and age at peak egg production), egg weight during these various stages, daily feed intake, daily water intake, water/feed ratio, feed efficiency (egg/feed), total feed cost per crate of egg, income above feed cost per crate of egg, hen housed egg production (HHP) and hen day egg production (HDP) at peak collectively explained 98.93% of the total variability. The first principal component (age at first egg, table 4.7) is the principal controlling factor during the entire laying phase (20-53weeks) since it accounts for the largest amount of variance with eigenvalue 12%.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

Five experiments were conducted to evaluate the nutritive value and metabolizable energy content of the locust bean pulp on performance of pullet chicks, growers and laying hens fed graded dietary levels of locust bean pulp.

The laboratory analysis showed that LBP has low crude protein content of 3.19% which is an indication that it cannot be used as a source of protein and the NFE value recorded in this study 66.39% is an indication that LBP could be a potential source of carbohydrate (energy) for poultry and other livestock. Vitamin C (542.40mg/100g) content of LBP suggests the potential of LBP in improving the performance of heat stressed birds.

Most of the anti – nutrients recorded in this study showed that LBP may not have detrimental effect on the birds if incorporated in poultry diets. Except for the alkaloid level (19.72%) which was high and therefore may have negative effects on the performance of the birds.

The first experiment was conducted to determine the metabolizable energy value of LBP, The apparent metabolizable energy (AME) recorded for the LBP was 2344 kcal ME/kg and was lower than that of maize which ranges between 3350 -3447 kcal ME/ kg, while the efficiency of utilization of the metabolizable energy of the LBP was 56.29%.

In the second experiment which was the starter phase (0-8weeks), the birds fed 22.5% LBP diet had better final weight and weight gain which is an indication that the birds can tolerate up to 22.5% of LBP diet. Higher feed intake observed in birds fed locust bean diets is an indication of the palatability and good aroma of the locust bean pulp. The observed increase in feed cost per bird in LBP diets is an indication that inclusion of locust bean pulp in the chicks diets did not bring down the cost of feed appreciably.

In the third experiment which was the grower phase (9-20weeks). The increased final weight and weight gain observed at 30% LBP inclusion suggests that LBP can be fed up to 30% in the diet of growing pullets. The observed higher daily feed intake recorded for birds fed LBP diets is an indication that the birds consumed more of the LBP diets than the control possibly because of its sweet taste. Significant increase observed in the water intake and water to feed ratio may be due to the powdery nature of the LBP. The cost/bird recorded was an indication that LBP could be incorporated up to 30% in grower ration to obtain a least cost diet.

In the fourth experiment (20- 42 weeks), which was conducted to evaluate the effect of LBP diet fed to growers on the subsequent egg laying performance of pullets. The results showed that the egg weight increases with the age of the birds. The observed increase in water intake of the birds with increase in level of LBP in the grower diet fed during the grower phase showed the carry over effect of the LBP fed during the growing phase. The significant increase in Income above feed cost per crate of egg which was observed at 7.5, 22.5 and 30% levels of LBP in the previous grower ration is an indication of cost savings.

In the fifth experiment which was the laying phase (42 – 53 weeks). The results showed that higher inclusion level of LBP had depressive effect on egg production and that the nutrient was not efficiently utilized by the birds. The egg weight was observed to increase as the level of LBP increased in the diets while the egg numbers decreased with increased in LBP inclusion level. LBP also had significant positive effect on yolk colour. The PCV values obtained in this study falls within the normal range for chickens and the similarities observed for haemoglobin (Hb), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), red blood cells (RBC) and serum parameters across the treatments is an indication that LBP has no negative effect on the bird and that LBP is safe in poultry ration. The decrease in percentage digestibility of crude fibre observed at higher inclusion levels of LBP could be attributed to the increased fibre load in the diets

6.2 Conclusion

In conclusion, the antinutritional contents of LBP recorded were relatively low to cause any detrimental effect on the birds except alkaloid which was higher than normal level that poultry can tolerate. The AME value obtained for the African LBP used in this study is 2344 kcal ME/kg. Locust bean pulp enhanced feed intake in chicks and growers due to its palatability and good aroma. It can be fed up to 30% in growers' diet without detrimental effect on the growth parameters and also to obtain a least cost ration. The locust bean pulp fed during the growing phase had carry over effect on the water intake pattern of the laying birds and also on the income above feed cost during the early laying phase (20- 42 weeks). Therefore, locust bean pulp can be fed to the growing pullets but once laying commence the nutrients levels of the layers ration should be upgraded because, inclusion of LBP in layer ration was not economical. It also has positive influence on the egg yolk colour and has no adverse effect on the haematological parameters. Except for the low digestibility of the crude fibre, locust bean pulp had no negative effect on nutrients digestibility therefore it was safe for consumption by the birds.

6.3 Recommendations

From the studies carried out, the following are the recommendations:

1. The optimum level of inclusion of LBP recommended in the diets of chicks was 22.5% but can be fed up to 30% in growers and pullets ration between 9-20 and 20-42weeks without negative effect on the growth performance, 7.5% was the optimum inclusion level recommended for laying hens to ensure optimum performance.
2. Further research is recommended to investigate on addition of enzyme to improve the efficiency of feed utilization.
3. LBP can be used as egg yolk colour enhancer in layer diets.
4. Extension services should be extended to the local farmers on careful processing of the locust bean pulp to reduce contaminants in form of pods, seed coat and the seed so as to reduce alkaloid level (anti-nutrients).

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APPENDIX 1

UNIT PRICE OF FEED INGREDIENTS DURING THE PERIOD OF THE STUDY

Table A1 Unit price of feed ingredients as of September, 2011

INGREDIENTS	UNIT PRICE (₦/kg)
Maize	70
Groundnut cake	85
Soyabean cake	110
Locust bean pulp	21
Fish meal	160
Wheat offal	45
Maize offal	38
Bone meal	40
Limestone	17
Methionine	1300
Lysine	680
Common salt	65
Vitamin premix chicks	450
Vitamin premix growers	380
Vitamin premix layer	400

APPENDIX 2

EIGEN VALUES OF THE CORRELATION MATRIX

	Description	Eigenvalue	Difference	Proportion	Cumulative
1	Age at 1st egg	11.9665	3.46178	0.2028	0.2028
2	Age at 50% lay	8.50468	0.38887	0.1441	0.347
3	Age at peak	8.1158	2.54983	0.1376	0.4845
4	1st egg weight	5.56597	0.81766	0.0943	0.5789
5	25% egg weight	4.74831	0.47668	0.0805	0.6593
6	Egg weight at peak	4.27163	0.47883	0.0724	0.7317
7	Daily feed intake	3.7928	0.6766	0.0643	0.796
8	Daily water intake	3.1162	0.61124	0.0528	0.8488
9	Water /feed	2.50496	0.60724	0.0425	0.8913
10	Feed efficiency	1.89773	0.16843	0.0322	0.9235
11	Total feed cost	1.72929	0.40476	0.0293	0.9528
12	Feed cost/crate of egg	1.32453	0.496	0.0224	0.9752
13	income above feed cost	0.82853	0.19544	0.014	0.9893
14	HHP at peak	0.6331	0.6331	0.0107	1
15	HDP at peak				
16	Initial weight (20-42weeks)				
17	Final Weight (20-42weeks)				
18	% weight change				

19 Final weight (42-53 weeks)

20 %weight change

21 Feed intake

22 Water intake

23 Water/feed

24 Feed efficiency(egg/feed)

25 Egg number

26 Feed /crate of egg

27 Feed cost/crate of egg

28 income above feed cost

29 Mortality

30 Egg weight

31 Shell Thickness

32 Shape index

33 Shell index

34 Specific gravity

35 Shell percentage

36 Egg surface area

37 Yolk index

38 Albumin index

39 Haugh

40 Cholesterol

41 Glucose

42 Albumin

43 PCV

44 Hb

45 Total protein

46 MCV

47 MCH

48 MCHC

49 Neutrophil

50 Lymphocyte

51 Eosinophil

52 Total white blood cell

53 Red blood cell

54 Dry matter

55 Crude protein

56 Crude fibre

57 Ether extract

58 Ash

59 NFE