GROWTH AND LAYING PERFORMANCE OF JAPANESE QUAILS (*Coturnix coturnix japonica*) ON DIETS CONTAINING PROCESSED PIGEON PEA (*Cajanus cajan*) SEED MEAL WITH OR WITHOUT ENZYME SUPPLEMENTATION

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA.
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DEPARTMENT OF ANIMAL SCIENCE
FACULTY OF AGRICULTURE
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MARCH, 2016

DECLARATION

I declare that the work in this thesis entitled "Growth and laying performance of Japanese quails (*Coturnix coturnix japonica*) on diets containing processed pigeon pea (*Cajanus cajan*) seed meal with or without enzyme supplementation" 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.

_____ _____

Afolabi Rotimi, AKINTUNDE Date

CERTIFICATION

This Thesis entiled "**GROWTH AND LAYING PERFORMANCE OF JAPANESE QUAILS (*Coturnix coturnix japonica*) ON DIETS CONTAINING PROCESSED PIGEON PEA (*Cajanus cajan*) SEED MEAL WITH OR WITHOUT ENZYME SUPPLEMENTATION"** by Afolabi Rotimi Akintunde 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

This work is dedicated to the Almighty God who had shown me this great mercy throughout the period of this work. Unto Him alone be all glory, honour and adoration forever.

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ABSTRACT

Four studies were conducted to evaluate the effect of differently processed pigeon pea (*Cajanus cajanus*) seed meal (PPSM) with or without enzyme (vegpro$^{(R)}$) supplementation on the growth and laying performance of Japanese quail (*Coturnix coturnix japonica*). The processing methods are soaking (for 24, 48 and 72 hours), fermentation for 72 hours, boiling for 60 minutes and roasting for 30 minutes. The proximate composition and levels of anti-nutritional factors in the raw and processed pigeon pea seeds (PPS) were evaluated. In experiments 1 and 3 (chick phases), a total of 720 (one- week old) quail chicks were used. These were allocated to eight dietary treatments, with three replicates of 30 birds each in a completely randomized design. The eight dietary treatments were made up of diet 1 containing 0 % PPSM serving as the control and seven other diets that contained 30 % of differently processed pigeon pea seed meal. All diets were isonitrogenous (25 % CP).In experiments 2 and 4 (laying phases), a total of 360 and 288 quail hens respectively were used. Six week old quails from experiment 1 and 3 were allocated to eight laying treatments of 22 % CP. Three replicates of 15 and 12 birds were allocated for experiment 2 and 4 respectively. Enzyme (Vegpro $^{(R)}$) was added at the level of 100 g/ton of feed except the control in experiments 2and 4. Marked reductions were observed in anti nutritional factors such as trypsin inhibitor, tannin, phytate, oxalate, saponins and cyanide with processing

methods.In experiment 1,the final weight, weight gain, feed to gain ratio and feed cost per kg gain of birds fed the control and those fed diet 6 (PPSM soaked for 24 hours and fermented for 72 hours) were significantly ($P<0.05$) higher than those of other treatments. The feed intake were significantly ($P<0.05$) higher in all birds fed the PPSM diets compared to control.Age at first egg and first egg weight of birds were also significantly ($P<0.05$) affected by the dietary treatments. There was significant ($P<0.05$) effect of the dietary treatments on all the haematological parameters measuredexcept albumin. In the second experiment (laying phase), birds fed the control diet, diet 2 (raw PPSM), diet 3 (PPSM soaked for 24 hours) and diet 7 (boiled PPSM) had significantly ($P<0.05$) higher final weight and percent change in body weight compared to other treatments. The feed intake of birds fed PPSM based diets were significantly ($P<0.05$) higher compared to those on the control group. Feed conversion ratio and egg weights were significantly ($P<0.05$) affected across treatments. Hen housed egg production (%), hen day egg production (%) and peak egg production of birds were also significantly ($P<0.05$) improved. However, there was no significant ($P>0.05$) difference in age at peak lay of birds, external and internal egg quality characteristics of birds across all treatments. In the third experiment,the final weight and weight gain were significantly ($P<0.05$) higher in birds fed diets T1 (control), T2, T3 and T7 compared to those in other treatment groups. However, the least feed intake, feed to gain ratio and feed cost per kg gain were recorded in birds fed diets T1 (control) and diet 4. Age at first egg and first egg weight were significantly ($P<0.05$) higher in birds fed PPSM diets with enzymes. The haematogical parameters,carcass parameters and organ weights differed ($P<0.05$) significantly except the carcass weight and dressing percentages across the treatments. In the fourth experiment,final weight and percent change in body weight of birds were significantly ($P<0.05$) different across treatments. Feed intake of birds fed PPSM diets with enzyme were

significantly (P<0.05) better than those in the control group. No significant (P>0.05) differenceswere observed in the hen housed egg production (%), hen day egg production (%), peak egg production (%), external and internal egg quality characteristics of birds across all treatments. Therefore, it was concluded that inclusion of PPSM soaked for 24 hours, fermented,boiled for 60 minutes and the raw PPSM enhanced growth and egg laying performance of quail birds. However, enzyme supplementation of PPSM in quail diets may not be necessary. .

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CHAPTER ONE

1.0 INTRODUCTION

Themajor obstacle to the expansion of the poultry industry in Nigeria and by extension Africa is that of acute shortage and high cost of feed ingredients. (Fasuyi, 2005). This problem has been attributed to stiff competition for feedstuffs between human, industry and livestock (Tewe and Bokanga, 2001; Amaefule and Nwagbara, 2004; Iyayi and Davies, 2005).

The problem of feed shortage arising from sky rocketing prices of conventional protein and energy feed ingredients (e.g groundnut cake, soybean, maize, sorghum etc) has negatively affected animal animal protein supply. This however has created a wide gap between the demand and supply of animal protein in Nigeria and many underdeveloped countries of the world. Thus, average animal protein intake of persons in most of these countries is far below the recommendations (Oyawoye, 2002).

Increasing demand and exorbitantcost of conventional protein sources like soybean, groundnut cake, fish meal e.t.c which are necessary for monogastric nutrition has madeit imperative for animal nutritionists to explore other non conventional protein sources in anattempt to improve and sustain livestock production.Pigeon pea (*Cajanus cajan*) is one of the feedstuff that could serve as a useful alternative tosoybean meal and groundnut cake in the diets of poultry birds. It is one of the most widelygrown agricultural legumes in tropical and subtropical countries (Singh and Diwakar, 1993; Purdue, 2006) and has very low human food and industrial usage (Amaefule and Obioha, 2001). It is a moderately yielding legume (300-3000 kg/ha legume dry seeds) on native farms where it serves as valuable soil improver and yields 5000-7000 kg/ha under improved cultivation for over 2-3

years period (Phillip, 1997; Ngoka, 1997). Inspite of its yield potential, its consumption is quite low possibly because of the availability of alternatives which are easier to cook (Kaura, 1985). Like most tropical legumes, the utilization of pigeon pea seeds in poultry feeding may be limited due to the presence of anti nutritional factors such as protease inhibitors (trypsin, chymotrypsin inhibitors), lecithin, tannins and non starch polysaccharides (NSP) (Grimaud, 1988; Ologhobo, 1992; D'Mello, 1992). However, remarkable improvement in the nutritive quality of legumes seeds have been achieved through various processing methods such as cooking, roasting, soaking and germination, fermentation, dehulling and chemical treatment which exerts beneficial effects by destroying the inherent anti nutritional factors (Ogundipe, 1980;Omeje, 1999; Kaankuka *et al*., 2000;Bawa *et al.*, 2003; Matthew, *et al.*, 2010).

In order to bridge the gap between the demand and supply of animal protein in Nigeria, attention of scientists and researchers has turned to the rearing of Japanese quails (Edache *et al*., 2005). Japanese quail (*Coturnix coturnix japonica*) was introduced to Nigeria in 1992 to expand the poultry subsector through meat and egg production (Ani, 2009). Quails which are fast growing poultry species are very economical to maintain as they require less floor space (Haruna *et al.*, 1997). They are small sized, early maturing, hardy and prolific (Robbins *et al*., 1991). They come to sexual maturity and egg production early between 5-6 weeks of age and attain market weight of 150-180 g at almost the same age. The meat and eggs are high quality protein with low body fat and cholesterol content making it a choice product for individuals proned to cardiovascular diseases (Haruna *et al*., 1997; Olubamiwa *et al*., 1999). They have less feed requirement of 20-25 g per day. In addition they are fairly disease resistant and with proper care quail hens can lay between 200 and 350 eggs in their

first year (Oluyemi and Roberts, 2000). Quail production requires good management, proper feeding, and availability of fresh clean water all the time and a good market outlet (Dafwang, 2006). The most popular quail species is *Coturnix coturnix* which include *Coturnix coturnix coturnix* (European quail),*Coturnix coturnix africana* (African quail) and*Coturnix coturnix japonica* (Japanese quail).

In the last few decades, inclusion of exogenous enzyme in the diets for monogastric animals had been found to exert significant beneficial effects on performance and production indices. Some of these enzymes include cellulase (β-glucanase), xylanases and associated enzymes, phytases, proteases, lipases and galactosidases. Proteases had been evaluated to enhance protein digestion, lipases to enhance lipid digestion, galactosidases to neutralize certain anti-nutritional factors in non-cereal feedstuffs, and amylase to assist in the digestion of starch in early weaned animals (Chesson, 2001). Recently, considerable interests had been shown in the use of phytase as a feed additive, as it does not only increase the availability of phosphate in plants but also reduces environmental pollution. Other commercial brands of exogenous enzymes which have been discovered to be greatly effective in the feed industry for better growth performance and economic efficiency of feed are Allzyme SSF, Vegpro (Allzyme® vegpro), Maxigrain, Nutrasexyla, Rovabio and Roxazyme G2G.

Vegpro® is an enzyme complex that improves the digestibility of feed. It contains an enzyme complement to aid pigs and poultry in digestion of vegetable protein feed ingredients such as soybean meal, pigeon pea seeds and other legume protein feeds. It improves digestibility of protein, amino acids, energy of vegetable protein ingredients. Major enzyme activities in vegpro include protease, cellulase, pentosanase, (xylanase), -

Galactosidase and amylase. The enzymes present work together in synergy to break down the different substrates resulting in a greater release of nutrients from the diets, thus improving growth and economic efficiency.

1.1 Justification

The use of the conventional protein feedstuffs had been the practice over the years. However, the high cost, dwindling production and competition for these feedstuffs by industrial, livestock and human consumption have limited their availability for use in non ruminant animals feeding. Hence, the relentless search for alternative sources of proteins and energy which are available, affordable, and less competitive and can replace the conventional feed ingredients like soybean, groundnut cake, maize etc. Pigeon pea is an unconventional protein source which is readily available and may be cost effective to livestock farmers and feed millers if effective processing methods to rid it of its anti nutritional factors could be developed. Enzyme supplementation of such feed ingredient will enhance and sustain production without compromising quality of the final product and profit.

This study was therefore designed to evaluate the effects of differently processed pigeon pea seeds (*Cajanus cajan*) on the growth and laying performance of Japanese quails and possible improvement through enzyme supplementation.

1.2 Objectives of the study

The objectives of this research were to determine:

1. the proximate and anti-nutritional composition of differently processed pigeon pea seeds.

2. the effects of dietary inclusion of differently processed pigeon pea seed meal (PPSM) on the growth and early laying performance, digestibility of feed nutrients, haematological parameters and carcass characteristics of quails.
3. the effects of dietary inclusion of differently processed PPSM on the egg production parameters of quail hens.
4. the effects of enzyme (Vegpro$^{(R)}$) supplementation of diets containing differently processed PPSM on the growth and early laying performance, carcass characteristics, haematological parameters, and digestibility of feed nutrients by quails.
5. the effects of enzyme (Vegpro$^{(R)}$) supplementation of diets containing differently processed PPSM on the egg production parameters of quail hens.
6. the cost benefit of using differently processed PPSM with and without enzyme supplementation in the diets of quails.

1.3 Research Hypotheses

a) Null hypotheses

(i) Differently processed pigeon pea seedshave no effect on the nutritive value and anti nutritional factors of pigeon pea seeds.

(ii) Differently processed pigeon pea seeds with or without enzyme supplementation have no effect on growth and early layingperformance, carcass characteristics, haematological parameters and nutrient digestibility in Japanese quails.

(iii) Differently processed pigeon pea seeds with or without enzyme supplementation haveno effect on the egg production and quality parameters of quail hens.

(iv) Differently processed pigeon pea seeds with or without enzyme supplementation have no cost benefit in quail production

b) Alternative hypotheses

(i) Differently processed pigeon pea seeds have effect on the nutritive value and anti nutritional factors of pigeon pea seeds.

(ii) Differently processed pigeon pea seeds with or without enzyme supplementation have effect on the growth and early laying performance, nutrients digestibility,hematological parameters and carcass characteristics in Japanese quails.

(iii) Differently processed pigeon pea seed with or without enzyme supplementationhave effect on the egg production and quality parameters of quail hens.

(iv)Differently processed pigeon pea seeds with or without enzyme supplementation have cost benefit in quail production.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Utilization of Non-Conventional Protein Sources in Monogastric Nutrition

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 feedstuffs are feed ingredients that are not usually common in the markets and are not traditional ingredients used for feeding poultry. (Madu *et al.*,2003). Non conventional feedstuffs according to Dafwang, (2006) offer the best alternative for the reduction of feed cost and of animal products in Nigeria. The importance of utilizing cheaper non conventional feedstuffs has been emphasized times and again. The effort to use these non conventional feedstuffs, if successful, may reduce the cost of feed production and subsequently that of animal production in general and may increase the production of the livestock sector of agriculture (Annongu and Joseph, 2008).

With this, the utilization of non conventional feedstuffs of plant origin has been limited as a result of the presence of anti nutritional factors such as alkanoids, glycosides, oxalic acids, phytates, protease inhibitors, haemaglutinin, saponin, momosine, cyanoglycosides, linamarine to mention a few despite their nutritive value and low cost implications (Sogbesan, *et al*., 2006). These antinutritional factors are those substances generated in natural food or feedstuffs by the normal metabolism of plant species and by different mechanisms (e.g inactivation of some nutrients, diminution of the digestive process, or metabolic utilization of feed) which exert effects contrary to optimum nutrition (Kumar, 1992). Some of these chemicals are known as “secondary metabolites” and have been

shown to be highly biologically active (Zank, 1991), hence the need for adequate processing to reduce the anti nutritional factors in plants used as human food and animal feeds have been reviewed (Soetan and Oyewole, 2009).

Few among these non conventional feedstuffs include locust bean seeds (*Parkia spp.*), sesame seed (*Sesanum indicum, linn*), bambara groundnut (*Voandzeia subterranean*), lablab (*Lablab pupureus*), mucuna beans popularly known as velevet beans or devil beans, sunflower seed and meal (*Helianthus annus*), moringa seeds and leaves (*Moringa oleifera*), and pigeon pea seeds (*Cajanus cajan*) and meal.

2.2 The Origin and Geographical Distribution of Pigeon Pea

Pigeon pea is an important grain legume commonly grown and consumed in tropical and subtropical regions of the world (Olomu, 2011). Pigeon pea commonly known as dhal, gandul, red gram, Congo pea, and no eye pea belong to the family leguminosae, tribe phaseoleae and subtribe cajaninae (ICRISAT, 2002). The actual centre of origin of pigeon pea is still a matter of controversy. The presence of several wild relatives, large diversities of crop gene pool, ample linguistic evidence, a few archeological remains and the wild diversities in daily cuisine attributes the origin to India (Vander Maesen, 1990). Several authors opined Eastern Africa as the centre of origin. The scarce but often cited archeological evidence of one seed in an ancient Egyptian tomb and the wild occurrence in Africa made many authors believe that pigeon pea is of African origin (Rachie and Roberts, 1974). Kay (1979) reported that this specie of grain legume was cultivated in the North Eastern part of Africa, Egypt as the center of origin. Purseglore (1988) also reported Africa as the centre of origin.

However, pigeon pea is now believed to be indigenous to India and spread to South East Asia and is now grown throughout the tropics especially in India and East Africa. Purseglore (1988) revealed that over 90 % of the world's production of pigeon pea is from India. Pigeon pea is also grown in certain regions like South- East Asia, Africa and America. Several amounts are found in Kenya, Uganda and Malawi, but few amounts in Dominican Republic and Puerto Rico in Central America. Traditionally,it is grown in North and Central Sudan as minor crop, and is locally known as Labby addasy and consumed as boiled dry grain particularly during the month of Ramandan (ICRISAT, 1993).

In Nigeria, pigeon pea is mostly found in Edo, Plateau, Benue and Ondo States(Oyenuga, 1968). The crop according to Oyenuga (1968) is perhaps the most widely grown agricultural legume in tropical and subtropical countries although less popular in Nigeria. It has also been reported that the crop is relatively low in demand in Nigeria as a food crop as it is eaten mostly when there is scarcity of common beans (Cowpea) during which the price of cowpea is relatively high (Amaefule and Nwagbara, 2004). Kaura (1985) reported that the crop in some Nigerian communities are used as backyard fences and not commonly used for consumption. The seeds of the crop have no industrial use so far. Thus the pressure placed on the seed from industrial sector and by man for food is far less than that of other conventional legume crops.

2.2.1 Nutrient and Proximate Composition of Pigeon pea

A wide variability exists in the chemical composition of pigeon pea seeds which according to Salunkhe *et al.* (1985) depends on the geographical location, cultivar and growth

conditions. Matthew*et al*. (2010) also reported the proximate composition of pigeon pea seeds as dry matter of 90.13 %, crude protein of 23 %, crude fibre of 8.37%, ether extract of 2.73 %, ash of 4.76 %and nitrogen free extract of 60.64 %.

2.2.1.1 Carbohydrate Content of Pigeon Pea

Carbohydrates can be divided into two types on the basis of their solubility. These are the soluble carbohydrates and the insoluble carbohydrates. The soluble carbohydrates which can also be referred to as Nitrogen free extract is about 60 % of the dry matter in the majority of the dry grain (Oyenuga, 1968). The insoluble constituent which is the crude fibre is mostly less than 10 % of the dry matter. With reference to pigeon pea, Smarth (1976) reported that the Nitrogen free extract in pigeon pea is about 57.3 %. This value is more than the 35 % reported for soybean (Weingartner, 1987), 52.72 % for cowpea (Oke, *et al.,* 1995) and comparable to the level in other under-utilized legumes.

2.2.1.2 Protein Content of Pigeon Pea

Pigeon pea contains protein with an amino acid profile similar to that of soybean (Singh *et al*., 1984). The protein content of pigeon pea is less than that of fish meal (63.11 %), Soybean (44 %), and groundnut cake (45 %) respectively (Aduku, 1993). The crude protein (CP) content of pigeon pea ranges from 17.90 to 30.00 % (Siegel and Faweett, 1976; Geervani, 1981; Salunkhe *et al.*, 1985; Obioha, 1992).

Grimaud (1988) reported crude protein of 22.1 % for pigeon pea while Oyenuga (1968) reported that the crude proteins of pigeon pea was 23.77 % for the Ibadan variety and 23.70 % for the variety from Trinidad. Apata and Ologhobo (1993) worked on the proximate composition of some raw Nigerian legumes including pigeon pea and obtained crude

protein values of 20.6 – 27.7 %. Olomu (1995) reported crude protein value of 21.90 % for pigeon pea which is in line with the above findings. Singh and Jambunathan (1982) reported a crude protein value of 26.00 % for three varieties of pigeon pea while Amaefule and Obioha (2001) reported a crude protein value of 24.53 % for raw pigeon pea.

2.2.1.3 Amino Acid Content of Pigeon Pea

The comparison of the amino acid content of pigeon pea and other plant protein sources is shown in Table 2.1. The amino acids present in pigeon pea are 1.51 % Arginine, 0.27 % cysteine, 0.34 % methionine, 0.77 % histidine, 0.11 % tryptophan and 1.13 % valine (Olomu, 1995). Methionine, lysine and phenylalanine are the prominent amino acids in pigeon pea (Olomu, 1995). Grimaud (1988) and Kay (1979) revealed that pigeon pea has a very low amount of sulphur containing amino acids. The seed is adequate in lysine but deficient in methionine, cysteine and tryptophan (Olomu, 2011). It is also rich in carotene and has a fair amount of phosphorus.

2.2.1.4 Fat Content of Pigeon Pea

In terms of oil content, grain legumes can be classified into two broad groups: the oil seeds and the non – oil pulses. For their edible oil, soybeans and groundnut are the two main grain legumes majorly grown for their edible oil. Soy oil from soybeans has the highest content of polyunsaturated fatty acid (Linoleic and Linolenic acid) and this makes it superior over other vegetable oil (Kay, 1979).The non–oil pulse includes cowpea, pigeon pea and bambara to mention but a few. Kay (1979) gave the breakdown of the composition of fat in pigeon pea as linoleic acid 51.4 %, linolenic acid 5.7 %. Amaefule and Obioha

(2001) reported a value of 1.84 % for fat in pigeon pea which is not too different from those of common beans,

Table 2.1: Nutrient Contents (as purchased) of Green Gram. Pigeon Pea, Chick Pea, Field Pea and Lentils

	Green gram	Pigeon Pea	Chick Pea	Field Pea	Lentils
Dry matter (%)	90.00	89.00	88.00	90.00	88.00
ME (Kcal/kg) – Poultry	N/A	N/A	N/A	2570	N/A
DE (Kcal/kg) – Pigs	2960	2845	2580	3392	3065
Food ME (Kcal/kg) – Man	3280	3310	3570	3392	3392
Crude Protein (%)	25.20	21.10	21.40	23.50	24.70
Crude Fat (%)	1.00	1.00	5.40	1.30	1.30
Crude Fibre (%)	4.60	7.50	6.40	6.00	3.90
Ash (%)	4.60	7.50	6.40	6.00	3.90
N-Free extract (%)	54.60	54.50	52.00	56.60	55.20
Calcium (%)	0.9	0.13	0.20	0.07	0.08
Total Phosphorus (%)	0.32	0.28	0.32	0.37	0.35
Iron (mg/100g)	6.30	5.40	-	5.70	7.90
Amino acids (%)					
Arginine	1.40	1.51	1.50	1.65	1.63
Cystine	0.16	0.27	0.21	0.25	0.18
Methionine	0.28	0.34	0.24	0.25	0.33
Histidine	0.76	0.77	0.53	0.68	0.56
Isoleucine	1.41	0.86	0.67	0.93	0.88
Leucine	2.25	1.71	1.29	1.71	1.64
Lysine	1.73	1.58	0.90	1.65	1.63
Phenylalanine	1.21	1.96	1.14	1.21	1.09
Threonine	0.80	0.77	0.54	1.00	0.81
Tryptophan	0.20	0.11	0.17	0.22	0.25
Valine	1.49	1.13	0.73	1.15	1.00
Vitamins (mg/100g)					
Thiamine (mg)	0.68	0.34	0.50	0.78	0.54
Riboflavin (mg)	0.21	0.11	0.04	0.21	0.21
Niacin (mg)	2.00	2.30	2.10	2.50	2.14

Note: All values refers to the edible shelled seed only
Source: Olomu (1995)

2 % (Olomu, 1995) and cowpea, 2.05 % (Oke *et al.*, 1995). The oil content of 1.5 % has been reported for pigeon pea seeds (Smarth, 1976), which is by far lower than that of groundnut (44.8 %; Balogun and Koch, 1979) and soybean (18 – 25 %; Huskey *et al.*, 1990). Singh *et al.*, (1984) reported 1.7– 2.2 % fat for pigeon pea while Apata and Ologhobo (1993) reported a range of 1.3 – 6.7%. However, Olomu (1995) reported a value of 1.00 % crude fat for pigeon pea.

2.2.1.5 Mineral Content of Pigeon Pea

For minerals, calcium and phosphours are focused on since both minerals are very essential in bone formation in animals. Kay (1979) gave the values for calcium and phosphorus to be 154 – 194 mg / 100g and 238 – 372 mg/100g respectively. Oyenuga (1968) gave the value of 129 mg / 100g and 280 mg/100g for calcium and phosphorus respectively. Olomu (1995) reported values of 0.13% calcium, 0.28 % phosphorus and 5.40 mg/100g iron for pigeon pea. Purdue (2006) reported that pigeon pea contains 161 mg Ca, 285 mg phosphorus and 15 mg iron.

2.2.1.6Vitamin Content of Pigeon Pea

Grain legumes are excellent sources of vitamin B. A typical example is thiamine in which Kay (1979) gave the amount of thiamine in pigeon pea to be 500 mg/100g of the edible portion of the grain. However, the author observed that Riboflavin is deficient in pigeon pea (150 mg/100g). Olomu (1995) reported values of 0.34 mg thiamine, 0.11 mg Riboflavin and 2.30 mg Niacin for pigeon pea. Purdue (2006) also reported 55ug beta-carotene equivalent, 0.72 mg thiamine, 0.14 mg riboflavin and 2.9 mg niacin.

2.2.1.7 Crude fibre Content of pigeon pea

Crude fibre is the constituent of plant structural carbohydrates such as cellulose, hemicellulose and lignin which are highly in -digestible materials. The insoluble constituent which is the crude fibre is mostly less than 10 % of dry matter (Oyenuga, 1968). However,the dietary fibre of legume origin plays an important role in water retention in the gastro intestinal tract, hence, they are needed in the development of the GIT physiologically. Nworgu and Ologhobo (2000) defined crude fibre as a mixture of largely indigestible substances of vegetable origin obtained as a residue of a precisely defined digestion procedure using acetic, nitric and trichloro-acetic acids. Generally, poultry require a certain amount of digestive fibre for proper development of gastro intestinal tract physiologically. The amount of fibre in diet 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 the report of Oyenuga (1968), the insoluble constituent of carbohydrate which is the crude fibre in pigeon pea is mostly < 10 % of the dry matter.

2.3 Importance and Uses of Pigeon pea

Pigeon pea ranked fifth among the edible grain legumes of the world in terms of importance. The total world production of dried seeds is estimated to be nearly 2 million tones. Of this figure, it was estimated that India alone produces over 1.75 million tons (about 92 %) of the total world production (Kay, 1979). Pigeon pea is a staple crop in Puerto Rico, Bahamas and is widely grown in Asia. It is a multipurpose crop and is mainly grown for its mature, dry seeds. It could satisfy needs for food, animal feed, wood, agriculture and medicine.

2.3.1 Pigeon pea as Human Food

The pigeon pea is a truly multipurpose crop. It is grown and mainly used for the matured dry seed which in India is often split for dhal (dry dehulled split seed cooked in water to a desired softness) to make a thick soup primarily for mixing with rice (Singh, 1987). In Puerto Rico, Trinidad and Tobago, the immature seed and pods of pigeon pea are processed as canned vegetables. It can also be consumed as dehulled split, whole canned, boiled, roasted or ground into flour to make a variety of desserts, snacks and main dishes. Faris *et al.* (1987) reported that in India, some South East Asian and African countries, developing pods of pigeon pea were harvested and their green seeds shelled and used as vegetable. The young green peas are very nutritious and are excellent substitutes for English pea when used for human consumption (Oyenuga, 1968).

In Nigeria, pigeon pea could be eaten fresh as green pods or sun-dried and processed into "akara", "moimoi" and soup. Some of the seeds could be roasted, cracked and boiled to hasten cooking (Kaura, 1985).

2.3.2 Pigeon Pea as Animal Feed

Pigeon pea plants and grains have been used as animal feed for centuries by farmers. (Pathak, 1970; Wallis *et al.,* 1986). In many areas, Hawai for example, pigeon pea is an important source of fodder in seasons when there is deficit of energy and protein for cattle (White man and Norton, 1981). This can be traced to the potential of pigeon pea to produce a very high biomass demonstrated by the 40 tons per hectare of dry matter obtained in one cutting of late maturing pigeon pea at Kanpur in Northern India (Singh and Kush, 1981).

Incorporation of pigeon pea seed meal as protein source in poultry ration up to 30 % of the whole ration, resulted in improved feed conversion efficiency, higher body weight and live

weight gain (Grimaud, 1988; Tangtaweewipat and Elliot, 1989; D'mello, 1992; Amaefule and Obioha, 1998). It is much less useful as feed for pigs than for poultry because they are more susceptible to the anti-nutritional factors in pigeon pea than poultry (Wallis *et al.,* 1988).

2.3.3 Pigeon Pea as Wood

The relatively thin branches of pigeon pea are good sources of fuel when burnt because of its high biomass production potential. These thin straight branches could also be used for tubuler wicker work lining for walls, baskets, temporary fencing and hut construction.

Pigeon pea can be used as a wind breaker to provide support and shades for crops such as young cocoa, vanilla kola and oil palm (Oyenuga, 1968). It can also produce pulp similar to those produced by hard wood which can be used for making good quality writing and printing papers (Akhtaruzzaman *et al.*, 1986).

2.3.4 Pigeon Pea in Agriculture

Pigeon pea can be grown as a cover crop and as green manure because it is able to fix atmospheric nitrogen. Its deep root system allows for optimum moisture and nutrient utilization. It sometimes grows on mountain slopes; utilizes poor soils and reduces soil erosion (Nene and Sheila, 1990).

2.3.5 Pigeon Pea in Medicine

The leaves, flowers, dry roots and seeds of pigeon pea are used in traditional medicine in various countries to treat a wide range of ailment of the skin, liver, lungs and kidneys (Morton, 1976).

2.4Anti – Nutritional Factors (ANFs) in Pigeon pea

The pigeon pea like other leguminous seeds contain metabolic inhibitors which tend to limit their use in poultry feeding, but the level of such inhibitors in the seed is low when compared to other leguminous seeds (Leaky and Wills, 1977; ICRISAT, 1992). Among the anti nutritional factors found in grain legumes, trypsin, chymotrypsin, amylase inhibitors, polyphenols (tannins) and oligosaccharides are very important in pigeon pea. These metabolic seeds inhibitors also known as ANFs limit the use of the seeds in monogastric animal feeding (Amaefule *et al*., 2005). The presence of cyanogens (D'Mello, 1995) and tannins (Salunkhe *et al*., 1985) in the seeds have been reported. Tannins have effect on both protein and carbohydrates. The presence of tannin decrease digestibility of starches by 9-17 percent (Desphande and Salunkhe, 1982) and inhibit amylases of several starches from performing their digestive functions, hence reduced availability of starch (Makkar *et al*., 1982). The dietary fibre was also reported to be reduced by dietary tannin. Udedibe and Carlini (2002) and Onwuka (2006) reported the presence of haemagglutinin in pigeon pea seeds. The other anti -nutritional factors contained in the seeds according to Onwuka (2006) are alkaloids and phytic acid (Akpojovwo and Onimawo, 2006; Sylvester *et al.*, 1993).

2.4.1Protease inhibitors

Protease inhibitors (trypsin and chymotrypsin inhibitors) are proteins of wide distribution in the plant kingdom, and they are common constituents of particularly legume seeds. Protease inhibitors especially trypsin, chymotrypsin and elastase are low molecular- weight proteins, capable of binding and inhibiting the normal catalytic functions of the digestive

enzymes, thereby interfering with the enzymic digestion of proteins into their basic amino acid components. They are readily denatured by heat, acids and alkali (Kakade *et al*., 1969). Trypsin and chymotrypsin are enzyme inhibitors as they inhibit the activities of the digestive enzymes within the system of the poultry. They are very high in raw soybean compared to raw pigeon pea (Jambunathan and Singh, 1980).Batterhams *et al*. (1986) affirmed that trypsin and chymotrypsin inhibitors are perhaps the most widely distributed of all ANFs. He further revealed that the concentrations of trypsin and chymotrypsin inhibitors vary and in many varieties they are so low as to have no detrimental effects as they pass unnoticed through the gastro intestinal tracts.

Hypertrophy of the pancreas is one of the primary physiological effects produced by trypsin inhibitor (Olomu, 2011). Hypertrophy of the pancreas is accompanied by a stimulation of its secretive activity and this results in an endogenous loss of the pancreatic enzymes, trypsin and chymotrypsin which are rich in sulphur amino acids. The result is increased deficiency of the sulphur amino acids and consequently depressed animal performance. The physiological responses of animals to the same level of trypsin and chymotrypsin inhibitors in different legumes may vary. Pigs for example can tolerate dietary levels of at least 4.7 and 4.5 mg^{-1} of trypsin and chymotrypsin inhibitors respectively from chick pea meals (Batterham *et al*., 1993). However, in one experiment, the growth of pigs fed diets containing pigeon pea meal which contained a lower level of these two protease inhibitors was severely depressed. The alternative explanation was that there may be other unidentified inhibiting factors in pigeon pea meal that have a greater effect than the trypsin and chymotrypsin inhibitors. However, it is important to know both

the levels of trypsin and chymotrypsin inhibitors in the different legumes and their threshold level for the safe use of each legume in practical situations.

Apart from pancreatic hypertrophy caused by trypsin and chymotrypsin inhibitors, other workers also observed that the presence of these ANFs in animal diets can lead to pancreatic enlargement, reduced digestibility, reduced absorption of amino acids and reduced availability of minerals (Liener and Kakade, 1980; Yavelov *et al*., 1983; Gatel and Grosjean, 1990). Both trypsin and chymotrypsin inhibitors interfere with normal protein digestion in the intestine as they primarily inactivate proteolytic enzymes i.e trypsin and chymotrypsin secreted by the pancreas through the formation of inhibitor – enzyme complex (Liener, 1994). Growth depression from feeding grain legumes is usually caused by more than one factor. Other growth inhibiting substances such as lectins, tannin and non starch polysaccharides in raw soybean and other legumes are probably responsible for the rest of the impairment of animal performance. According to Mc Donald *et al*. (1990), ruminants are less susceptible to the effects of ANFs when compared with monogastrics, hence trypsin inhibitors are not considered to be important in ruminants.

2.5Effect of Processing on the Nutritional Value of Grain Legumes

The acceptability and use of food grain legumes has been limited by the presence of relatively high concentrations of a number of anti nutritional factors and allergens (Liener and Kakade, 1980; Liener, 1980). However, to enhance palatability and high nutritive value, processing of grain legumes such as pigeon pea has become very crucial. Different processing methods or techniques have been used by researchers to improve the nutritional value of legumes such as pigeon pea (Liener and Kakade, 1980; Liener, 1980). These

processing methods include soaking, cooking, fermentation, physical treatment (heat treatment and mechanical treatment) and chemical treatment.By processing, carbohydrate contents of legumes can be rendered more susceptible to enzyme degradation (Ologhobo, 1981).

2.5.1 Effect of Physical Treatment on the Nutritional Value of Grain Legumes

Physical treatment as a method of processing legume grains can be grouped into heat treatments and mechanical treatment. These are the most widely used methods for the reduction of negative effects induced by anti-nutritional factors (Ekpenyong and Borchers (1980).

2.5.1.1 Effect of Heat Treatment on the Nutritional Value of Grain Legumes

Heat treatment is the most widely used method for reducing anti nutritional factors. Heat treatment which is based on heat denaturation of the proteinaceous inhibitors, is a good method of decreasing the activity of lectins, trypsin, and chymotrypsin inhibitors (Hanovar *et al.*, 1962; Kadam *et al*.,1987; Van der Poel, 1990; Estevez *et al*., 1991). Faris and Singh (1990) reported that anti-nutritional factors in pigeon pea and other legumes like soybean which inhibit the activities of protease enzymes can be removed by heating. Several heat treatments can be applied to reduce the" heat- labile" trypsin and lectin activity. Some of the methods used to inactivate theses anti-nutritional factors include steam heating at various pressures (Smith and Circle, 1978), roasting with dry heat (Maldo and Rasario, 1989), extrusion and microwave heating (Marty and Chavez, 1993).

The most common way by which food legumes are processed is by subjecting them to heat process though this depends on the variety of grains. Thus autoclaving appears to be the

best suitable heat treatment for legumes as established by Ekpenyong and Borchers (1980). It was in this view that Kaankuka e*t al.* (1996) and Iyayi and Egharevba (1998) reported that the processing of legume grains by cooking or roasting reduced their anti-nutritional factors to a threshold level. Heat treatment is the most widely used method, however excessive heating reduces the availability of some amino acids (Amos *et al.*, 1975; Dhurandhar and Chang, 1990).Vijayakumari *et al.*, (1995) also investigated the effect of hydrothermal treatments on certain anti-nutritional compounds in the seeds of lablab and concluded that autoclaving seemed to be the most efficient method of improving in-vitro protein digestibility and eliminating the anti-nutrients such as phyto-haemagglutinin, hydrogen cyanide and oligosaccharides that were inherent in the seeds.

Cooking is another processing method. Some level of anti-nutritional factors in pigeon pea can be destroyed by cooking (Jambunathan and Singh, 1980). Balogun *et al.* (2001) reported 30 minutes cooking time for soybeans as adequate for its inclusion in rations for weanling and growing pigs. Most legume protein are globular molecules which are completely folded in the raw bean and they show little susceptibility to proteinases until their internal structure is disrupted (Pukushima, 1979). This suggests that heat treatment is therefore required to alter the chemicall structure of the proteins in raw beans and make them more susceptible for enzyme digestion. Cooking of beans in water, with or without pressure increases their protein quality (Bressani, 1993). Jorgensen *et al.*(1984) reported that heat treatment destroys most of the inhibitory properties and renders the sulphur amino acids more available in raw beans. Cooking induces loses of vitamins (25-30%) and minerals (0.15%) (Augustin *et al*., 1981; Bressani, 1993; Bressani *et al*., 1998). Bawa *et al.* (2003) showed that cooking of lablab seeds at 100^0C for 45 minutes significantly decreased

trypsin inhibitor activity (TIA) from 593.87 mg / 100 g to 132.00 mg/100g; phytic acid from 5.65mg/100g to 1.19mg/100g; tannin from 0.22 mg/100g to 0.10 mg/100g and cyanide from 1.58 mg/100g to 0.45 mg/100g; which corresponded to 77.8,98.9, 34.6 and 71.5 percent reduction in TIA, phytic acid, tannin, and cyanide levels respectively. Ogundipe *et al.* (2003) reported that lablab seeds cooked for 30 minutes gave the best result compared to when lablab seeds were cooked for 60 minutes and used for feeding trials on pullet chicks. Kaankuka *et al.*, (1996) and (2000) observed that time and temperature were important in the processing of full fat soyabeans. Apparent digestibility and retention of dietary dry matter nitrogen and ether extract by weaner pigs increased with increased duration of cooking. However, trypsin inhibitor activity level and percentage tannin decreased non – significantly with increased duration of cooking.

The effect of heat depends on the temperature and duration of processing (Van der Poel *et al.*, 1990; Ichihara *et al.*, 1994; Quin *et al.*, 1996; Wu *et al.*, 1996). Excessive heat treatment can result in the reduction of protein solubility and may destroy certain amino acids (Metebe, 1989; Dhurandhar and Chang, 1990, Van Barneveld *et al.*, 1993). It is therefore expedient to find the appropriate condition of heating which can maximize the destruction of the anti-nutritional factor and minimize damage to the feed protein.Processing of legumes by roasting reduced their anti nutritional factors to a threshold level. Roasting with dry heat is a method of treatment of legume grains. From the reports of Udedibe (1995) and Olupona *et al.* (1998), heat treatment alone was enough to significantly destroy all the anti-nutritional factors especially glucosides.

2.5.1.2 Mechanical Treatment

Dehulling

Dehulling is simply the process of removing the seed coat (hull) of legume grains. This plays a significant role in processing and utilization of legume grains. Desphande and Salunkhe *et al.* (1985) observed that dehulling improved the digestibility of the proteins, lowered the tannin content and reduced the crude fibre and calcium content of pigeon pea seeds. Dehulling of cooked pigeon pea seeds also increased the biological value, percent true protein and net protein utilization of seeds but led to considerable loss of protein, iron and other dietary nutrients.(ICRISAT, 1987; 1991). Amaefule and Obioha (2001) fed dehulled and boiled pigeon pea to broilers and observed that dehulling of boiled pigeon pea seeds was a better processing method than boiling alone. There was a higher nutrient utilization of boiled dehulled seeds than the raw seeds. Kaankuka *et al.* (1996) and Kaankuka *et al.*(2000) also reported a higher nutrient utilization of dehulled boiled soybean seeds than raw seeds.

Weight gain, feed- to- gain ratio, apparent protein digestibility (APD) and apparent metabolizable energy (AME) were improved when growing chickens were fed dehulled high – tannin peas compared with those fed on untreated pea diet (Brenes *et al.*, 1993). The improvement might have occurred not only because of the reduction of tannin content but also because of the reduction of fibre content associated with the removal of the testa.

The nutritional implication of dehulling pigeon pea seeds is also apparent since the high crude fibre content of the seed coat may affect nutrient utilization considering that about 98% of the fibre content of the seed is in the seed coat (Salunkhe*et al*., 1985).

2.5.2Effect of Soaking

Ologhobo (1989) reported that soaking in water for 96 hours and germination are the most effective method of reducing phytic acid and oxalic acid in soybeans. Nwokolo and Orji (1985) also established that soaking in water and cooking can also improve the nutritional status of grain legumes.

2.5.3Effect of Fermentation

Fermentation is a common and well established practice of eliminating cyanogenic glucosides in cassava prior to preparation of cassava for human or livestock nutrition. Most unprocessed legume seeds contain oligosaccharides and glucosides that impart bitter taste and consequently depressed feed intake in animals fed raw legume seeds.

Faris and Singh (1990) reported that the nutritive value of legume based fermented foods were higher than their raw components. Liener (1981) reported the destruction of trypsin inhibitor during fermentation. Fermentation therefore improves digestibility and utilization of protein and starch in pigeon pea. It also increases the levels of soluble nitrogen and soluble sugars in pigeon pea.

2.5.4Effect of Germination

Germination followed by cooking could reduce the levels of oligosaccharides in pigeon pea by 70% (Iyengar and Kulkarni, 1977). A considerable reduction in the levels of anti-nutritional factors has been caused by the germination of Mucuna and phaseolus seeds (Iyayi and Egharevba, 1998; Lee and Karannanithy, 1990).

Soaking followed by germination considerably reduces the activity of trypsin inhibitor in pigeon pea. Salunkhe (1982) documented that germination can reduce or eliminate

appreciable amounts of phytic acids in pigeon pea. Phytic acid levels were more effectively reduced by germination than by heating (Iyayi and Egharevba, 1998).

Germination can reduce or eliminate appreciable amounts of phytic acid in pigeon pea, thus improving the bioavailability of minerals (Salunkhe, 1982). Iyayi and Egharevba, (1998) observed an increase in the protein content of germinated seeds over the raw and heated seeds.

2.5.5Effect of Chemical Treatments on the Nutritional Value of grain Legumes

The inactivation of trypsin inhibitors, chymotrypsin inhibitors and lectins of raw soybean by incubation with microbial proteases (Huo *et al.,* 1993) and extensive hydrolysis of raffinose – family oligosaccharides of ground cowpeas by microbial α – galactosidase have been demonstrated. The result of this experiment has opened up possibility to employ enzymes to enhance the quality of grain legumes.

Bryden *et al.*(1994) reported that adding a feed enzyme, "Lupinase" (β – galactanase and minor α-galactosidase) to Lupin diet increased the apparent metabolizable energy (AME) value by 10.7%. Changing the structures of protease inhibitors and other anti-nutritional factors render them inactive.Farran *et al.* (2001) fed treated and untreated vetch seeds to broilers and layers. Vetch seeds were soaked in 1% $NaHCO_3$ or acetic acid solution, which reduced the α-cyanoalanine level in the seeds, thereby improving the performance of the birds. These treatments or processing techniques are potential methods for improving the nutritional status of grain legumes.

2.6Status of Quail Production in Nigeria

The poultry industry in the tropical areas especially Nigeria is not as diversified as in the temperate (Oluyemi and Roberts, 2000; Basil, 2011). In the tropics, the emphasis is on egg production and only on one species of poultry, the domestic fowl, whereas economic and nutritional benefits can be derived from keeping other species such as quail, some strains of which are fast growing, resistant to many diseases of the domestic fowl and can produce as many as 300 eggs per year. These can be used to increase the consumption of poultry products in the tropics.

Japanese quails as an important animal protein source have caught the attention of scientists and researchers in the recent times (Edache *et al.,* 2005). Japanese quail (*Coturnix coturnix japonica*) was introduced to Nigeria in 1992 to expand the poultry sub-sector and help supplement the domestic chicken production through meat and eggs (Ani, 2009). Of recent in Nigeria, quails production gained wider recognition and acceptance because of its high egg and meat quality, less capital investment requirement, relatively short turn-over cycle, less demand of land space, labour and management (Badejo, 1983). Quail (*Coturnix coturnix japonica*) is a small migratory bird which is native to Asia and Europe. It belongs to the species galli-forms. They have a short generation interval, mature early (35 days) and lay between 200 – 300 eggs annually (Selim and Ibrahim, 2004).

In most countries eggs and meat production for Japanese quails are combined in a single enterprise with a low capital outlay and to start generating income quickly (Sundaram, 1989). In spite of the contribution of the Japanese quail to the protein intake of the masses, the farming is still at its infancy in Nigeria. The awareness about these highly productive birds is still at the low level in most part of the country. Hence, the need to intensify efforts in developing the great deal of potentialities in this bird species as part of valuable assets to the poultry industry in Nigeria. Owing to the huge base of production potential of Japanese quails, there are many derivable benefits from rearing these unique set of birds. At present, quail have been acclimatized and adapted in places like Kano, Benue, Lagos, Oyo, Yobe, Enugu, Akwa ibom, Kaduna, Kebbi, Borno, Abuja, Niger Kwara, Jigawa, and Plateau states.

2.6.1 Benefits of Quail Farming

According to Cooper (1989), quail has the potential to serve as an excellent and cheap source of animal protein. Other unique characteristics and advantages of quail over other species of poultry include early attainment of sexual maturity, short generation interval (Anon, 1991) and fast growth rate attaining market weight of 150 – 180g between 5-6 weeks of age. They also have high rate of lay with the ability to produce 250 – 280 eggs per year. Additionally, quail requires less floor space because of their smaller body size, about 8 – 10 adult quails can be reared in a space meant for one adult chicken (Haruna *et al*., 1997). They have less feed requirement as adult quail require only 20 – 25 g of feed per day. In terms of egg production the total feed per kg eggs produced is 2.4 compared to 3.3 in chicken. Quail has shorter incubation period of 16 – 18 days compared to the 21 days for chicken and 28 days for ducks, guinea fowls or turkeys, thus 18 – 19 hatches of quail eggs can be made in a year compared to 11 – 12 for ducks, turkey or guinea fowl eggs. Quail meat and eggs are renowned for their high quality protein, high biological value and low caloric value (low cholesterol) thus making it a choice product for hypertensive – prone individuals (Haruna *et al*., 1997 and Olubamiwa *et al*., 1999). They are highly resistant to notorious poultry diseases like Gumboro disease and moderately resistant to others. Apart from the above listed benefits, quail production can be started with very little capital. They make excellent materials for biological research because of their size and fast generation. The quail has potentials in biomedical research especially if the genes responsible for resistance to common poultry disease could be identified and isolated for transfer to domestic chicken. There are also possibilities of using its eggs and tissues for production of biological. Though, not proven scientifically, in many parts of the world, quail meat and

eggs were claimed to be useful in increasing man's libido, used in curing or preventing hypertension, diabetes, asthma, tuberculosis among others. Quail by products are also useful for agro industries, though its role in this sector is relatively new in Nigeria. By - products of quails such as droppings, feathers, offal and egg shells have uses in feed manufacturing, fertilizer production, textiles and fashion designing. Their droppings are high in nitrogen thus forming good compost manure for plants and vegetables.

2.7The Importance of Enzymes in Poultry Diets

Enzymes are protein catalysts that aid chemical reactions in biological systems. They are made up of long chains of amino acids with highly complex molecular structures. They play a key role in digestive processes of the animal. Enzymes have been used to degrade different structural carbohydrates found in cereals, particularly those that are not digested by avian and mammalian enzymes, and those that are highly viscous and have high water-binding capacity. Various companies have recently developed enzyme sources to improve the nutritional value of corn/soyabean meal-based diets for poultry. These enzymes carry out their activity by improving nutrient utilization especially the energy component and the reduction of anti-nutritional factors in soybean meal. Commercially available enzymes include fibre-degrading enzymes, as well as protease, amylase and /or α-galactosidase activity.The range of feedstuffs that can be improved through the use of enzymes include: rice offal, maize offal, brewers' dried grain, wheat offal and legumes (Classen and Cooper, 1998).

Although enzymes are produced either by the animal itself or by the microbes that are naturally present in the digestive tract, specific activities necessary to break down some other compounds in feed are not found or are at low levels in the digestive tract. Therefore

exogenous enzymes are added to the diet to break down these compounds. Enzymes used as feed additives are now produced through commercial fermentation processes. Specific enzymes that appear to be beneficial for non-ruminant animals are the xylanases, or more specifically the endoxylanases for wheat, triticale, rye and the β-glucanase or cellulases for barley and oats. Some commercial enzymes, such as maxigrain and Allzymes contain a spectrum of different enzymes including xylanases and β-glucanases and therefore can be used effectively with most of the cereals.

The use of enzymes in non-ruminant feeds has been reviewed by Campbell and Bedford (1992). These workers reported that some factors need to be considered when using enzymes. These factors include the following:

1. The enzyme supplement must contain the proper spectrum and adequate amount (activities) of enzyme so that anti-nutritive effects of target substrate will be neutralized i.e β-galactosidase for barley and oats, xylanase for wheat, rye, β-galactosidase and amylase for corn, and phytase for release of phytate phosphorus.
2. Different cereals contain different amounts of the enzyme sensitive anti-nutritional factors. Therefore, the response to enzyme treatment may vary within a given cereal (i.e. barley, corn and probably wheat).
3. The enzymes must not be inactivated by processing or by low pH or by the digestive enzyme in the gastro intestinal tract.
4. Results are affected by class and age of poultry. The responses in swine are usually less dramatic than those of poultry and have not less dramatic than those of poultry and have not been clearly established. Class and age of poultry affect results.

Classen and Cooper (1998) categorized the use of feed enzymes into four areas:

1 Removal of anti nutritional factors (ANFs)

2 Increasing the digestibility of existing nutrients

3 Increasing digestibility of Non-Starch Polysaccharides (NSP)

4 Supplementation of the activities of the host endogenous enzymes

There are various categories of enzyme preparation with varying degrees of substrate specificity. These include xylanase, protease, phytase, polysaccharidase, glucanase, amylase, cellulase, pectinase, arabinase, lipase and hemicellulase. Enzymes can be added to feeds as multi enzyme products that contain a variety of different activities or specific enzyme products that are responsible for a single type of enzymatic activity based on a particular dietary substrate.Other beneficial effects of enzymes are: increased body weight gain, improved feed efficiency, decreased occurrence of sticky droppings, lowered feed cost per kg live weight gain, improved metabolizable energy contents of diets, increased digestibility of feeds, reduction of anti-nutritional factors (Pettersson and Aman, 1987;Allen *et al.,* 1996; Aboosadi, 1998; Oluyemi and Roberts, 2000; Atteh, 2004).

Based on performance, other commercial brand of exogenous enzymes which have been discovered to be greatly effective in the feed industry for better growth performance and economic efficiency are: Allzymes, maxigrain, nutrase xyla and Roxazyme G2G and Rovabio.

2.7.1Benefits of Using Enzymes in Poultry Diets

2.7.1.1 Increasing the feeding value of feedstuffs

Many scientists have demonstrated performance benefits of enzymes when added to barley (Classen *et al.,* 1985; Elwinger and Saterby, 1987; Broz and Frigg, 1990; Brenes *et al*.,

1993;Marquardt *et al.*, 1994), wheat (Classen *et al.*, 1995; Bedford and Morgan, 1996; Hughes and Zviedrans, 1999), and more recently maize based diets (Wyatt *et al*., 1997, Steenfeldt *et al*., 1998).

Phytases are routinely utilized particularly in environmentally sensitive areas of the World due to their ability to increase the phosphorous availability from vegetable ingredients (Jongbloed *et al*., 1997; Kornegay *et al*., 1997; Kemme *et al*., 1999). Bedford (2003) reported that the use of enzyme enables the feed compounder to minimize feed costs through reduced usage of expensive ingredients. The author reported that phytase releases phytate phosphorous which, when accounted for, replaces inorganic phosphate sources and at the same time reduces formulation costs.

2.7.1.2 Reducing variation in nutrient quality of ingredients

The response to the use of enzymes is greatest on the poorest quality raw materials (Classen *et al.*, 1995; Scott *et al*., 1998a and b; Bedford *et al*., 1998). As a result, variations in subsequent bird performance are reduced allowing for a more uniform flock and also less variation in productivity from flock to flock

2.7.1.3 Increasing precision and flexibility of least cost feed formulation

The nutritive value of cereal grains for poultry varies greatly and no suitable assays are currently available for rapid in-mill testing. Enzymes also allow the use of a wide range of ingredients without compromising bird performance and hence provide great flexibility in least-cost feed formulation (Choct, 1997)

2.7.1.4 Increasing nutrients digestibility and decreased faecal output

Dry matter digestibility (DMD) of feed stuffs by animal range from 50% - 80%, the remainder of the dry matter is lost via the excreta. In recent years enzymes have been used

in monogastric diets to increase nutrient digestibility and to decrease nutrient waste in the excreta. The effect however depends on the type of diet and the type of animal. Enzymes have been demonstrated to increase the digestibility of poorly digested cereals to a much greater extent than well-digested cereals (Classen *et al*., 1995; Scott *et al*., 1998a and b).

2.7.1.5 Reducing the incidence of wet litter (faecal moisture)

A reduction in the moisture content of poultry faeces is often noted when glucanases are included in the diet (Choct, 1997). Enzymes have been used to degrade different structural carbohydrates found in cereals particularly those that are not digested by avian and mammalian enzymes, and those that are highly viscous and have high water binding capacity.

2.7.2 Commercial Enzyme Vegpro (R)

It has been demonstrated that supplementation of poultry diets with enzymes frequently exerts beneficial effects in enhancing production efficiency and increasing the effectiveness of nutrient utilization (Maquardt *et al.,* 1994, Akintunde *et al.,* 2013). Among several commercial brands of enzymes like Allzyme SSF, Maxigrain, Nutrasexyla, Roxazyme G2G, Rovabio, Vegpro(R)has been found to be very effective in improving the digestibility of nutrients, growth and economic efficiency. It is a combination of naturally – occuring enzymes protease, cellulase, pentosanase (Xylanase), α - Galactosidase and amylase routinely used in poultry and pig feeds to improve the nutritive value of plant – based feeds (Campbell and Bedford, 1992).

In feed, the enzymes in the complex work synergistically to break down the different substrates. As a result, more nutrients are released and made available to the animal, thus improving growth and economic efficiency.

Vegpro® used for the study was produced by Altech Biotechnology Centres (Altech Inc. Nicholasville and Kentucky, USA). It is recommended at 100 grams/tones of feed for pig or poultry. Major enzyme activities in Allzyme SSF include: Protease, cellulase, Pentosanase (xylanase), α - galactosidase and Amylase.

The following benefits of using the enzyme have been identified:

Improved weight gain, feed conversion ratio (FCR) and feed: gain ratio, digestion and release of nutrients from diet, metabolizable energy of feed, and it allows more flexibility in the use of raw materials, which result in more cost effective rations

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

These studies were conducted at the poultry unit of the Department of Animal Science Teaching and Research Farm, Ahmadu Bello University – Samaru – Zaria; Kaduna State. It is located within the Northern Guinea Savanna zone of Nigeria on Latitude 11^0 12^1N and Longitude 7^0 23^1E, 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 maximum temperature ranges between 14^0C to 24^0C during the cold season while the mean maximum daily temperature is from 19^0C to 36^0C during the hot season. The relative humidity varies between19 to 35% during the hot season, and 63 to 80% in the wet season as reported by Ovimaps, (2012).

3.2Source of Pigeon Pea Seeds

The Pigeon pea seeds used for this study were purchased from Samaru Market in Sabon Gari Local Government Area of Kaduna State, Nigeria.

3.3 Processing of Pigeon Pea Seeds

Four processing methods of pigeon pea seeds employed were:

3.3.1 Raw pigeon pea sample

Thirty kilograms (30 kg) of the raw sample of well stored pigeon pea seeds were milled using hammer mill, bagged and kept in the store.

3.3.2 Soaking in water for different hours

Thirty kilogram (30 kg) pigeon pea seeds were poured into 75 litres of cold clean water for different hours; 24, 48 and 72 hours at room temperature. The water was drainedafter each soaking duration and the seeds were sun dried for 4 days on a concrete floor. Seeds were then milled and bagged.

3.3.3 Fermentation

Thirty kilogram (30 kg) pigeon peas seeds were soaked in 75 litres of water for 24 hours at room temperature. The water was allowed to drain and the seeds bagged and put into an air – tight polythene bag and allowed to ferment for 3 days (72 hours). After 72 hours, the seeds were then sun dried on a concrete floor for 4 days.

3.3.4 Boiling for 60 minutes

The 75 litres of waterwas allowed to boil at a temperature of 100^0C using fire wood as the source of heat. The 30 kg of pigeon pea seeds were then poured into the boiling water, covered and then allowed to boil again for 60 minutes. Then, cooked sample immediately werepoured inside a cold water, drained and dried on a concrete floor for 4 days.

3.3.5 Roasting

Thirty kilogram (30 kg) of raw pigeon pea seeds were roasted in a silver pot on a big tripod stand with fire wood supplying a steady flame. The seeds were constantly stirred with a laddle so as to have a uniform roast and prevent the seeds from burning. The roasting was done for 30 minutes.

3.4Proximate and Chemical Composition of Pigeon Pea Seeds (PPS)

The proximate composition (dry matter, crude protein, crude fibre, ether extract, ash and nitrogen free extract) of the samples of Pigeon Pea Seeds (PPS) were determined using the standard methods described by AOAC, (1990) in the Biochemical Laboratory, Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria. To determine the dry mater (DM) content, weighed samples were put into an oven at 105^0C for 16 hours. The DM was then determined based on weight loss. Macro Kjeldah method was used in determining the nitrogen (N) content of the seed sample and the crude protein was calculated as N × 6.25. The ash content was determined as residue remaining after incinerating the sample at 600^0C for 3 hours in a muffle furnace.

3.5Determination of the Anti - Nutritional Factors of Pigeon Pea Seeds (PPS)

The presence of anti – nutritional factors such as trypsin inhibitor, tannin, phytate, oxalate, saponin and Hydrocyanide were detected quantitatively by the standard methods described at the Biochemical Laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria.

3.5.1Determination of Tannins

Tannin was determined using the standard method described by Earp *et al.* (1981). An oven dried sample (0.5g)was weighed into 100 cm^3 conical flask. 50 cm^3 of distilled water was added and allowed to boil gently for 1 hour on a hot plate. The solution was filtered while warm into a 50 cm^3 ml volumetric flask. The filter paper washings were added into the solution and made to volume. When cooled, 0.3 cm^3 aliquot of tannic acid was taken into a range of 0.5,1.0, 1.5, 2.0, 2.5 and 3.0 cm^3 corresponding to 0.05, 0.15, 0.2 , 0.25 and

0.3 mg. 3.0 cm^3 of the sample was pipette into a 50 cm^3 volumetric flask. To both standards and sample, water was added until half full. 2.5 cm^3 of Folin – Denis reagent was added to each flask followed by the addition of 10 ml 17 % (w/v) sodium carbonate solution and diluted to 50 cm^3 marks and mixed. These were allowed to stand in water bath at 25^0C for five minutes. The optical density (absorbance) readings were taken at 760 nm wavelength using water as reference.

3.5.2 Determination of Phytate

Phytatewas determined using the procedure described by Sutardi and Buckle (1985). Ground sample (4.0 g) was soaked in 100 cm^3 of 2% hydrochloric acid for 5 hours and filtered. 25 cm^3 of the filtrate was taken into a conical flask and 5 cm^3 of 0.3 % ammonium thiocyanate solution was added. The mixture was titrated with a standard solution of iron (III) chloride until a brownish – yellow colour persists for 5 minutes. Three replicate determinations were performed.

1 cm^3 of 0.025 M $FeCl_3$ = 6.601 mg phytate.

3.5.3 Determination of Trypsin inhibitor

Trypsin inhibitor was determined by spectrophotometric method and N-O-Bensoyl-DL Arginine, P- Nitroamilide (BAPA) was used as a standard as described by Kakade *et al.* (1974). Exactly 1g of the sample was dispersed in 50 ml of 0.5M NaOH solution, stirred for 30 minutes and configured at 3600 rpm and then filtered. 2 milliliters of standard trypsin was added to10 ml of aliquot in a test tube and was allowed to stand for 5 minutes. The absorbance of the aliquot was then measured in a spectrophotometer at 410nm. The blank analysis was also carried out simultaneously. One trypsin unit inhibition is equal to an increase of 0.01 absorbance unit from the blank.

3.5.4Determination of Saponins

The method of El-Difrawi and Hudson (1979) was used to determine the saponin content of PPS sample. Ground sample (10 g) was taken into a 100 cm^3 of 20 % aqueous ethanol in water and agitated with a magnetic stirrer for 12 h at 55 ^{0}C. The solution was filtered using Whatman No1 filter paper and the residue was re-extracted with 300 cm^3 of 20% aqueous ethanol. The extracts were combined and reduced to about 40 cm^3 under vacuum using a rotator evaporator. The extract and 20 cm^3 diethyl ether were transferred into a 250 cm^3 separatory funnel and shaken vigorously. The aqueous layer was discarded. The process of purification was discontinued until a colourless aqueous extract was obtained. The pH of the remaining aqueous solution was adjusted to 4.5 by adding 4 g of sodium chloride and the solution then shaken successfully with butanol. The butanolic extract was washed twice with 10 cm^3 of 5 % (W/V) sodium chloride and evaporated to dryness in a fume cupboard to give the saponin, which was weighed and expressed as a percentage.

3.5.5Determination of Oxalate

Oxalate was determined using the method described by Onwuka (1996). The total oxalic acid of the powdered samples was determined by weighing 2g into a 250 ml flask. Then 190 ml distilled water and 10 ml of 6M hydrochloric acid were added. The mixture was heated for 1 hour 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 10 ml 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 PPS sample was calculated using the formula below:

1ml of potassium permanganate = 2.24mg oxalate

3.5.6Determination of Cyanide

Alkaline titration method of AOAC (1990) was used to determine the cyanide content of PPS. Exactly 10 g of ground sample was soaked in a mixture of 200 cm^3 of distilled water and10 ml of othophosphoric acid. The mixture was left for 12 hours to release all bounded hydrocyanic acid. A drop of anti foaming agent (Paraffin) and anti bumping agent were added and the solution distilled until 150 cm^3 of the distillate was collected. 20 cm^3 of the distillate was taken into a conical $_{flask}$ and diluted with 40 cm^3 of distilled water. 8.0 cm^3 of 6.0 M ammonium hydroxide (NH_4OH) and 2 cm^3 of 5 % (W/V) potassium iodide (KI) were added. The mixture was titrated with 0.02 M silver nitrate solution using a micro burette until a faint but permanent turbidity was obtained.(1 ml 0.02 M $AgNO_3$= 1.08 mg HCN).

3.6 Experiment1: Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal on Growth and Early laying Performance of Quails Chicks (2-6 weeks).

3.6.1Design and Management of Experimental Birds

A total of seven hundred and twenty (720) one – week old Japanese quail chicks purchased from National Veterinary Research Institute (NVRI) Vom, Jos were used. Ninety birds were randomly assigned to each of the dietary treatments which had 30 chicks per replicate in a completely randomized design. The birds were raised in 75cm long × 75cm wide × 60cm high cages. Kerosene stoves were used to provide additional heat while electricity bulb were installed in each pen to provide light and heat during the brooding period; feed and water were provided *adlibitum,*drugs were administered as necessary and all other routine management practices were observed. The experiment lasted for 4 weeks. The birds were weighed at the beginning of the experiment and their average initial weights were taken. The chicks were subsequently weighed every week to determine the weight gained. Feed supplied and the left over were also weighed weekly to determine the weekly feed intake. Average weight, feed intake, weight gain, feed: gain ratio, and percentage mortality (when it occured) were computed.Analysis of the cost benefit of using pigeon pea seed meal in the diets of quails were carried out. The cost /per kg of feed and cost of feed /kg gains were computed for each dietary treatment.

3.6.2Experimental Diets

Eight experimental diets were formulated. Each diet contained 25% crude protein based on the standard requirement of quail birds (NRC, 1994) as shown in Table 3.1. Milled pigeon pea seeds processed by different methods as described earlier were incorporated into the

Table 3.1: Composition of Quail Starter Diets Containing Differently Processed Pigeon Pea Seed Meal (2-6 weeks)

	Treatments							
Ingredients	**1 Control**	**2 Raw PPSM**	**3 Soaked PPSM (24hrs)**	**4 Soaked PPSM (48hrs)**	**5 Soaked PPSM (72hrs)**	**6 Soaked+ Fermentation**	**7 Boiled PPSM (60mins)**	**8 Roasted PPSM (30mins)**
Maize	47.97	30.29	30.29	30.29	30.29	30.29	30.29	30.29
SBM	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
PPSM	0.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
GNC	37.53	25.21	25.21	25.21	25.21	25.21	25.21	25.21
Bone	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Common Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Vit. Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total (%)	100	100	100	100	100	100	100	100
Determined Analysis								
M.E (Kcals/Kg)	2933	2976	2971	2965	2881	2927	2975	2955
Crude Protein (%)	25.12	25.88	26.13	26.68	24.87	24.68	25.06	24.50
Crude Fibre (%)	5.73	5.64	5.00	5.45	6.70	6.00	5.94	6.25
Ether Extract (%)	4.54	4.16	3.92	4.00	4.34	3.85	3.77	4.08
Calculated Analysis								
Calcium (%)	1.39	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Phosphorus (%)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Lysine (%)	1.22	1.43	1.43	1.43	1.43	1.43	1.43	1.43
Methionine (%)	0.74	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Cysteine (%)	0.41	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Feed cost/kg (₦)	80.20	89.53	89.53	89.53	89.53	89.53	96.20	96.20

*Biomix chick premix provided per kg of diet: Vit A. 10,000 I.U; Vit D_3 32,000 I.U; Vit E 23,000 mg; Vit K 2,000mg; Vit. $B_1$1,800 mg; Vit. B_2 5,000mg; Pantothenic acid 7,500mg; Vit.B_{12}150mg; Folic acid 750mg;

Biotin 100mg; Choline chloride; 300,000mg; Cobalt 3,000mg; Iodine 1,000mg; Iron 20,000mg; Manganese 40,000mg; Selenium 200mg; Zinc 30,000mg; Antioxidant 1250mg.
SBM = Soybeanmeal, PPSM = Pigeon Pea Seed Meal, ME = Metabolizable Energy
GNC = Groundnut cake

dietarytreatments at 30% of diet. Diet 1 formulated with defatted soya bean meal and the groundnut cake without the pigeon pea seed meal as the main vegetable protein source served as the control. Diet 2 was formulated with the raw pigeon pea seed meal, while diet 3, 4, and 5 were formulated with pigeon pea seeds soaked for 24, 48 and 72 hours respectively. Diet 6 was formulated with pigeon pea seeds soaked and fermented for 3 days. Diet 7 contained pigeon pea seeds boiled for 60 minutes while diet 8 contained pigeon pea seeds roasted for 30 minutes.

3.6.3 Digestibility Trial

During the fifth week of the experiment, the birds were weighed and a total of 72 birds at five weeks old were used for this study. Nine birds were selected from each treatment with three birds per pen and had the average weight of the birds housed in cages for faecal collection which lasted for 7 days. The birds were housed in metabolic cages during a two days adjustment period before faecal collection. At the end of two days, the birds were fasted for 24 hours after which the experimental diets were fed. Five hundred grammes of the experimental diets were supplied to the birds in each cage daily for five days. The total faecal output for each pen was bulked together. Samples of the diets and faecal droppings from birds were taken to the Biochemical Laboratory, Departmentof Animal Science Ahmadu Bello University, Zaria for proximate analysis according to the standard method described by AOAC (1990).

3.6.4 Haematological and Serum Biochemical Study

At the end of the chick experiment(6^{th} week), 1.0ml of blood samples were collected from the jugular veins of the three birds in each replicate (with a total of 9 birds per treatment)

into sterile, universal bottles containing Ethylene Diamine Tetra Acetic (EDTA) an anti coagulant. The blood samples were analyzed at the Clinical Pathology Laboratory, Faculty of Veterinary Medicine Ahmadu Bello University, Zaria. The haematological and serum biochemical parameters measured were packed cell volume (PCV), haemoglobin (Hb), red blood cells (RBC), white blood cells count (WBC), creatinine, cholesterol, albumin, urea and total protein concentrations. MCV, MCH and MCHC were calculated for each sample.

3.6.5 Carcass Evaluation

At the end of the first experiment (6 weeks of age), the birds were sexed and three male quails were selected from each pen based on the average weight of the group for carcass evaluation. The carcass evaluation was done after the termination of the experiment. The birds were fasted overnight prior to slaughtering and slaughtered by severing the jugular veins while allowing the blood to drain. Thereafter, they were de-feathered and eviscerated. The carcass prime cuts were weighed and expressed as a percentage of carcass weight while the organs weights were expressed as a percentage of live weight. Primal cuts measured were thigh, breast,back, drum stick, wing, head and neck while the organ weights measured were liver, gizzard, heart and small intestine.

3.6.6Statistical Analysis

All data obtained in this study were subjected to analysis of variance using the general linear model procedure of Statistical Analysis System (SAS, 2008). Significant differences among treatment means were separated using Tukey test of the same statistical package.

3.7 Experiment 2: Effects of Feeding Diets containing Differently Processed pigeon Pea Seeds Meal on Laying Performance of Japanese Quail and Economic Benefit (7 – 26 weeks)

3.7.1Design and Management of Experimental Birds

Birds were sexed at the end of Experiment 1(5 weeks). A total of three hundred and sixty (360) laying quails were selected and used for Experiment 2. Forty five (45) birds were randomly assigned to each of the dietary treatments having 15 birds per replicate in a completely randomized design. Experimental diets and water were administered *ad libitum.* The experimental diets were fed for twenty weeks. Body weights of birds in the replicate groups were taken at the beginning and fortnightly till the end of the study and percent change in body weight were calculated. Egg production was recorded daily and pooled weekly to calculate hen - day production (HDP) and hen – housed production (HHP). Other egg laying performance parameters measured were average initial weight of the birds, the final weight, daily feed intake, feed cost/kg egg, average weight of eggs, total number of egg production per bird, age at peak and percent egg production at peak. Analysis of the cost benefit of using pigeon pea seed meal in the diet of quails was carried out. The cost/kg feed, cost per dozen eggs, cost per crate of eggs and income above feed cost were calculated for each dietary treatment.

3.7.2Experimental Diets

Milled pigeon pea seeds processed by different methods as described in section 3.3 were incorporated into the dietary treatments at 30% inclusion level. Eight experimental diets were formulated. Each diet contained 22 % crude protein based on the standard requirement of quail birds (NRC, 1994) as shown in Table 3.2.All formulations are as expressed in experiment 1 except that the metabolizable energy and crude protein were adjusted to meet the requirement of laying hens.

Table 3.2: Composition of Quail Layer Diets Containing Differently Processed Pigeon Pea Seed Meal (7-26 weeks)

Ingredients	Treatments							
	1 Control	**2 Raw PPSM**	**3 Soaked PPSM (24hrs)**	**4 Soaked PPSM (48 hrs)**	**5 Soaked PPSM 72hrs**	**6 Soaked + Fermented PPSM**	**7 Boiled PPSM (60mins)**	**8 Roasted PPSM (30mins)**
Maize	51.70	34.37	34.37	34.37	34.37	34.37	34.37	34.37
SBM	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
PPSM	0.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
GNC	30.40	17.73	17.73	17.73	17.73	17.73	17.73	17.73
Bone	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Limestone	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Common Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Lysine	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vit. Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100	100
Determined Analysis								
ME (Kcals/kg)	2981	2989	2968	2977	2981	2976	2985	2982
Crude protein (%)	21.44	21.75	22.13	22.06	22.56	22.88	22.63	22.61
Crude Fibre (%)	6.57	6.67	7.41	6.72	7.32	7.32	7.34	7.96
EtherExtract (%)	5.26	5.45	4.92	4.88	4.69	4.41	4.35	4.22
Calculated Analysis								
Calcium (%)	2.70	2.71	2.71	2.71	2.71	2.71	2.71	2.71
Phosporus (%)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Lysine (%)	1.10	1.28	1.28	1.28	1.28	1.28	1.28	1.28
Methionine (%)	0.66	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Cysteine (%)	0.36	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Feed cost/kg (₦)	75.18	76.41	76.41	76.41	76.41	76.41	83.08	83.08

*Biomix layer premix provided per kg of diet: Vit A. 12,000 I.U; Vit D_3 1,500 I.U; Vit E 10,000mg; Vit K_3 1,000mg; Vit.B_1 1500mg; Vit. B_2 4,500mg; Niacin 15,000mg; Pantothenic acid 4,500mg;Folic acid 1,000mg; Vit.B_6 3,000mg,Vit. B_{12}15.00mg; Vit.C 45,000mg; Biotin 100mg; Choline chloride 300,000mg; Cobalt 20,000mg;Iodine 1000mg; Iron 20,000mg; Copper 3,000mg; Manganese 40,000mg; Selenium 200mg; Zinc 30,000mg; Antioxidant 1250mg.

SBM = Soybeanmeal, PPSM = Pigeon Pea Seed Meal, ME = Metabolizable Energy, GNC = Groundnut cake

3.7.3Digestibility Trial

During the fifteenth week of the experiment, the birds were weighed and a total of 72 birds were used for this study.Nine birds were selected based on average group weight from each treatment with three birds per pen for digestibility study and faecal collection which lasted for 7days. Digestibility was carried out as described in experiment 1.

3.7.4Egg Quality

Eggs were collected twice daily (morning, 9.00a.m and evening, 4.00 p.m), counted, weighed and recorded per replicate. Three freshly laid eggs representing the average weight of eggs per replicate were used weekly to determine the egg quality parameters throughout the twenty weeks. Egg weights were recorded after which they were carefully broken into a flat plate to assess the internal and external egg quality traits. The shell was washed with distilled 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 (FEJ 1500 A series) citizen scale to the nearest 0.01 g. Egg length and diameter were measured with Vernier caliper and egg shape index was 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 the egg freshness, based on the thickness of the albumen was calculated from the measured height of the albumen and weight of the egg using the following formula proposed by Haugh (1937).

$HU = 100 \log_{10} (h - 1.7W^{0.37} + 7.6)$, where HU = Haugh Unit, H = Observed height of the albumen in mm, W = Weight of egg in grammes.

3.7.5 Statistical Analysis

All data obtained in this study were subjected to analysis of variance using the general linear model procedure of Statistical Analysis System (SAS, 2008). Significant differences among treatment means were separated using Tukey test of the same statistical package.

3.8 Experiment 3: Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (vegpro) Supplementation on Growth and Early Laying Performance of Quails Chicks (2-6 weeks).

3.8.1Design and Management of Experimental Birds

A total of seven hundred and twenty (720) one – week old Japanese quail chicks purchased from National Veterinary Research Institute (NVRI) Vom, Jos were used. Ninety birds were randomly assigned to each of the dietary treatments which had 30 chicks per replicate in a completely randomized design. The birds were raised in 75cm long × 75cm wide × 60cm high cages.The experiment lasted for 4 weeks. The birds were weighed at the beginning of the experiment and their average initial weights were taken.The chicks were subsequently weighed every week to determine the weight gain. Feed supplied and the left over were also weighed weekly to determine the weekly feed intake. Average final weight, feed intake, weight gain, feed: gain ratio, and percentage mortality were computed. Analysis of the cost benefit of using pigeon pea seed meal supplemented with enzyme in the diet of quails was carried out. The cost /per kg of feed and cost of feed /kg gains were computed for each dietary treatment.Other management procedures were strictly followed as described in experiment 1.

3.8.2Experimental Diets

Eight experimental diets were formulated. Each diet contained 25% crude protein based on the standard requirement of quail birds(NRC, 1994) as shown in Table 3.3. Milled pigeon pea seeds processed by different methods as described in section 3.3 were incorporated into the dietary treatments at 30 % of diet. Enzyme (Vegpro$^{(R)}$) was supplemented in the diets at the level of 100g/ton of feed asrecommended by the manufacturer.

Table 3.3: Composition of Quail Starter Diets Containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation (2-6 weeks)

Ingredients	Treatments							
	1 Control	2 Raw PPSM +Vegpro	3 SoakPPM (24hrs) +Vegpro	4 Soaked PPSM (48hrs) +Vegpro	5 Soaked PPSM (48hrs) +Vegpro	6 Soaked + Fermentation+ Vegpro	7 Boiled PPSM (60 mins)+ Vegpro	8 Roasted PPSM (30 mins)+vegpro
Maize	47.97	30.29	30.29	30.29	30.29	30.29	30.29	30.29
SBM	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
PPSM	0.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
GNC	37.53	25.21	25.21	25.21	25.21	25.21	25.21	25.21
Bone	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Common Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Vit. Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total (%)	100	100	100	100	100	100	100	100
Enzyme	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Determined Analysis								
M.E (Kcals/Kg)	2933	2976	2971	2965	2881	2927	2975	2955
Crude protein ((%)	25.12	25.88	26.13	26.68	24.87	24.68	25.06	24.50
Crude Fibre (%)	5.73	5.64	5.00	5.45	6.70	6.00	5.94	6.25
Ether Extract (%)	4.54	4.16	3.92	4.00	4.34	3.85	3.77	4.08
Calculated Analysis								
Calcium (%)	1.39	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Phosphorus (%)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Lysine (%)	1.22	1.43	1.43	1.43	1.43	1.43	1.43	1.43
Methionine (%)	0.74	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Cysteine (%)	0.41	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Feed cost/kg (~~₦~~)	80.20	90.69	90.69	90.69	90.69	90.69	97.36	97.36

*Biomix chick premix provided per kg of diet: Vit A. 10,000 I.U; Vit D_3 32,000 I.U; Vit E 23,000 mg; Vit K 2,000mg; Vit. $B_1$1,800 mg; Vit. B_2 5,000mg; Pantothenic acid 7,500mg; Vit.B_{12}150mg; Folic acid 750mg; Biotin 100mg; Choline chloride; 300,000mg; Cobalt 3,000mg; Iodine 1,000mg; Iron 20,000mg; Manganese 40,000mg; Selenium 200mg; Zinc 30,000mg; Antioxidant 1250mg.

SBM = Soybeanmeal, PPSM = Pigeon Pea Seed Meal, ME = Metabolizable Energy

GNC = Groundnut cake

The enzymes were first thoroughly mixed with a little quantity of the required ration. The quantity of the rations was gradually increased until all were thoroughly mixed with the enzyme. Diet 1 was formulated with soybean seed meal and the groundnut cake as the main vegetable protein source served as the control. Diet 2 containedthe raw pigeon pea seeds, while diets 3, 4, and 5 contained pigeon pea seeds soaked for 24, 48 and 72 hours respectively. Diet 6 contained pigeon pea seeds soaked and fermented for 3 days. Diet 7 contained pigeon pea seeds boiled for 60 minutes while diet 8 contained pigeon pea seeds roasted for 30 minutes. All the diets were supplemented with enzymes except the control.

3.8.3 Digestibility Trial

During the fifth week of the experiment, the birds were weighed and a total of 72 birds were used for this study.Nine birds were selected based on average group weight from each treatment with three birds per pen for digestibility study and faecal collection which lasted for 7 days. Digestibility was carried out as described in experiment 1.

3.8.4 Haematological and Serum Biochemical Study

At the end of the experiment (6^{th} week), 1.0ml of blood samples were collected from the jugular veins of the three birds in each replicate (with a total of 9 birds per treatment) into sterile, universal bottles containing Ethylene Diamine Tetra Acetic (EDTA)an anti coagulant. The blood samples were analyzed at the Clinical Pathology Laboratory, Faculty ofVeterinary Medicine Ahmadu Bello University, Zaria. The haematological and serum biochemical parameters measured were packed cell volume (PCV), haemoglobin (Hb), red blood cells (RBC), white blood cells count (WBC), creatinine, cholesterol, albumin, urea and total protein concentrations. MCV, MCH and MCHC were calculated for each sample.

3.8.5 Carcass Evaluation

At the end of the experiment (6 weeks of age), the birds were sexed and three male quails were selected from each pen based on the average weight of the group for carcass evaluation. The birds were fasted overnight prior to slaughtering and slaughtered by severing the jugular veins while allowing the blood to drain. Thereafter, they were de-feathered and eviscerated. The carcass prime cuts were weighed and expressed as a percentage of carcass weight while the organs weights were expressed as a percentage of live weight. Primal cuts measured were thigh, breast,back, drum stick, wing, head and neck while the organ weights measured were liver, gizzard, heart and small intestine.

3.8.6 Statistical Analysis

All data obtained in this study were subjected to analysis of variance using the general linear model procedure of Statistical Analysis System (SAS, 2008). Significant differences among treatment means were separated using Tukey test of the same statistical package.

3.9 Experiment 4: Effects of Feeding Diets containing Differently Processed Pigeon Pea Seeds Meal with Enzyme (Vegpro) Supplementation on Laying Performance of QuailHens and Economic Benefit (7 – 26 weeks)

3.9.1Design and Management of Experimental Birds

Birds were sexed at the end of experiment 3 (6weeks). A total of two hundred and eighty eight (288) laying quails were used. Thirty six (36) birds were randomly assigned to each of the dietary treatments having 12 birds per replicate in a completely randomized design. Experimental diets and water were provided*ad libitum*. Other management procedures were strictly followed as described in experiment 2.

3.9.2 Experimental Diets

Eight experimental diets were formulated. Each diet contained 22 % crude protein based on the standard requirement of quail birds(NRC, 1994) as shown in Table 3.4. Milled pigeon pea seeds processed by different methods as described in section 3.3 were incorporated into the dietary treatments at 30% inclusion level. Enzyme(vegpro) was supplemented in the diets at the level of 100g/ton of feed as recommended by the manufacturer. The enzyme was first thoroughly mixed with a little quantity of the required ration before mixing into the total diets.The quantity of the rations was gradually increased until all were thoroughly mixed with the enzyme. Diet 1 was formulated with soybean seed meal and the groundnut cake as the main vegetable protein source served as the control. Diet 2 was formulated with the raw pigeon pea seed meal, while diets 3, 4, and 5 were formulated with pigeon pea seeds soaked for 24 hours, 48 hours and 72 hours respectively. Diet 6 was formulated with pigeon pea seeds soaked and fermented for 3 days. Diet 7 contained pigeon pea seeds boiled for 60 minutes while diet 8 contained pigeon pea seeds roasted for 30 minutes. All the diets were supplemented with enzymes except the control.

Table 3.4: Composition of Quail Layer Diets Containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation (7-26 weeks)

Ingredients	Treatments							
	1 Control	2 Raw PPSM + Vegpro	3 Soaked PPSM (24hrs)+ Vegpro	4 Soaked PPSM (48hrs) + Vegpro	5 Soaked PPSM (72hrs) +Vegpro	6 Soaked + Fermentation+ Vegpro	7 Boiled PPSM (60 mins)+ Vegpro	8 Roasted PPSM (30mins) + Vegpro
Maize	51.70	34.37	34.37	34.37	34.37	34.37	34.37	34.37
SBM	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
PPSM	0.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
GNC	30.40	17.73	17.73	17.73	17.73	17.73	17.73	17.73
Bone	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Limestone	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Common Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Lysine	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vit. Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100	100
Enzymes	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Determined Analysis								
ME (Kcal/kg)	2981	2989	2968	2977	2981	2976	2985	2982
CrudeProtein (%)	21.44	21.75	22.13	22.06	22.56	22.88	22.63	22.61
Crude Fibre (%)	6.57	6.67	7.41	6.72	7.32	7.32	7.34	7.96
EtherExtract (%)	6.67	6.25	6.36	6.78	6.50	6.45	6.35	5.74
Calculated Analysis								
Calcium (%)	2.70	2.71	2.71	2.71	2.71	2.71	2.71	2.71
Phosphorus (%)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Lysine (%)	1.10	1.28	1.28	1.28	1.28	1.28	1.28	1.28
Methionine (%)	0.66	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Cysteine (%)	0.36	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Feed cost/kg (₦)	75.18	78.74	78.74	78.74	78.74	78.74	85.41	85.41

*Biomix layer premix provided per kg of diet: Vit A. 12,000 I.U; Vit D_3 1,500 I.U; Vit E 10,000mg; Vit K_3 1,000mg; Vit.B_1 1500mg; Vit. B_2 4,500mg; Niacin 15,000mg; Pantothenic acid 4,500mg;Folic acid 1,000mg; Vit.B_6 3,000mg,Vit. B_{12}15.00mg; Vit.C 45,000mg; Biotin 100mg; Choline chloride 300,000mg; Cobalt 20,000mg; Iodine 1000mg; Iron 20,000mg; Copper 3,000mg; Manganese 40,000mg; Selenium 200mg; Zinc 30,000mg; Antioxidant 1250mg.

SBM = Soybeanmeal, PPSM = Pigeon Pea Seed Meal, ME = Metabolizable Energy, GNC = Groundnut cake

3.9.3Digestibility Trial

During the fifteenth week of the experiment, the birds were weighed and a total of 72 birds were used for this study.Nine birds were selected based on average group weight from each treatment with three birds per pen for digestibility study and faecal collection which lasted for 7 days. Digestibility was carried out as described in experiment 1.

3.9.4Egg Quality Study

This was carried out as explained in Experiment 2.

3.9.5 Statistical Analysis

All data obtained in this study were subjected to analysis of variance using the general linear model procedure of Statistical Analysis System (SAS, 2008). Significant differences among treatment means were separated using Tukey test of the same statistical package.

CHAPTER FOUR

4.0 RESULTS

4.1 Effects of Different Processing Methods on Proximate Composition of Pigeon Pea SeedMeal (PPSM)

The effects of different processing methods on proximate composition of pigeon pea seed meal are presented in Table 4.1. The results obtained showed that different processing methods had significant ($P<0.05$) effect on the proximate composition of pigeon pea seeds (PPS). There was no significant ($P>0.05$) difference in the dry matter content of raw pigeon pea seeds and that of the processed seeds. The crude protein (CP) content ranged between 21.25 % for raw seeds to 24.75 % for fermented PPS. There was significant ($P<0.05$) increase in the CP content of fermented PPS (24.75 %) followed by other processed seeds and these were significantly ($P<0.05$) higher than the CP value obtained for the raw PPS. The crude fibre (CF) of pigeon pea seeds were significantly ($P<0.05$) affected by the different processing methods. Boiling for 60 minutes, roasting for 30 minutes were similar and had significantly ($P<0.05$) reduced the crude fibre content of pigeon pea seeds from 7.32 % in raw PPS to 5.83 and 5.47 % in boiled and roasted PPS respectively. These values were significantly lower and better compared to those obtained for other processing methods. The ether extract content was significantly ($P<0.05$) higher in raw seeds (1.89 %) compared to ether extract content of other processed PPS. The ash content was also significantly ($P<0.05$) affected by processing as values obtained for raw PPS (4.87%) was higher than that obtained in the processed seeds. The nitrogen free extract (NFE) obtained for raw pigeon pea seeds was significantly ($P<0.05$) higher compared to values obtained for all the processed seeds which were similar.

Table 4.1: Proximate Composition of Differently Processed Pigeon Pea Seed Meal (PPSM)

Parameters (%)	Processing Methods							SEM
	Raw	Soaking (hours)			Fermentation (72 hrs)	Boiling(60mins)	Roasted (30mins)	
		24	48	72				
Dry matter	90.26	90.08	89.36	87.48	88.21	87.80	90.15	10.09
Crude protein	21.25^{c}	22.63^{bc}	23.44^{b}	23.8^{b}	24.75^{a}	23.88^{b}	24.25^{b}	0.24
Crude fibre	7.32^{a}	7.14^{a}	7.03^{a}	6.82^{b}	6.45^{b}	5.83^{c}	5.47^{c}	0.20
E.E	1.89^{a}	1.82^{b}	1.79^{bc}	1.78^{bc}	1.75^{c}	1.72^{d}	1.66^{e}	0.01
Ash	4.87^{a}	4.11^{b}	4.09^{b}	4.00^{b}	3.67^{bc}	3.96^{b}	4.06^{b}	0.06
NFE	68.67^{a}	64.30^{b}	63.69^{b}	63.50^{b}	63.38^{b}	64.61^{b}	64.56^{b}	0.33

abcde: means within the same row with different superscripts differ significantly ($P<0.05$), SEM: Standard error means, EE: Ether extract NFE: Nitrogen free extract

4.2 Effect of Different Processing Methods on Anti – nutritional Factors of Pigeon Pea Seeds

The results of the effect of different processing methods of pigeon pea seeds on the levels of some anti nutritional factors (ANFs) are presented in Table 4.2. From the result obtained in this study, trypsin inhibitor, tannins, phytic acid, oxalate, saponins and hydrogen cyanide were identified. The result also showed that the percent reduction of all the anti nutritional factors followed a declining pattern from roasting of PPS which had highest significant reduction of ANFs followed by boiling for 60 minutes, fermentation for 3 days, soaking for 72 hours, soaking for 48 hours and soaking for 24 hours which had the least significant ($P<0.05$) reduction of all the ANFs.

Roasting of PPS for 30 minutes significantly ($P<0.05$) reduced the content of trypsin inhibitor from 2.86 mg/100g in raw PPS to 1.68 mg/100g representing 41.26 % destruction of trypsin inhibitor activity (TIA), tannin from 1.32 mg/ 100g in raw PPS to 0.55 mg/100g representing 77% destruction of tannin, phytate from 1.83 mg/100 g in raw PPS to 1.03 mg/100 g representing 80 % destruction of phytate, oxalate from 0.77 mg/100g in raw PPS to 0.38 mg/100g representing 50.65 % destruction of oxalate, saponin from 1.63 mg/100g in raw PPS to 0.89 mg/100 g representing 45.39 % destruction of saponin and hydrogen cyanide from 2.88 mg/100 g in raw PPS to 1.58 mg/100g representing 45.14 % destruction of cyanide.

The least significant reduction of all the anti nutritional factors was observed in soaking of PPS for 24 hours. Highest reduction of phytate (80%) was observed in roasted PPS followed by those processed by fermentation and these were significantly ($P<0.05$) higher compared to values obtained in other processing methods. It was generally observed that heat treatment through roasting and boiling significantly

Table 4.2: The Effect of Processing Methods on the Levels and Reduction Percentages of Anti nutritional Factors of Pigeon Pea Seeds.

	Processing methods							
	Raw	Soaking (hrs)			Fermentation	Boiled (60mins)	Roasted (30mins)	
Anti Nutritional Factors		24	48	72	(72hrs)			SEM
Trypsin inhibitor (mg/100g)	2.86	2.76	2.58	2.47	2.22	2.10	1.68	
% reduction		3.49^{f}	9.79^{e}	13.63^{d}	22.37^{c}	26.57^{b}	41.26^{a}	0.07
Tannins (mg/100g)	1.32	1.27	1.21	1.08	0.84	0.76	0.55	
% reduction		3.78^{f}	8.33^{e}	18.18^{d}	36.36^{c}	42.42^{b}	77.00^{a}	0.13
Phytate (mg/100g)	1.83	1.78	1.69	1.52	1.29	1.18	1.03	
% reduction		2.73^{f}	7.65^{e}	16.94^{d}	54.00^{b}	35.52^{c}	80.00^{a}	0.25
Oxalate (mg/100g)	0.77	0.73	0.68	0.57	0.49	0.46	0.38	
% reduction		5.19^{f}	11.69^{e}	25.97^{d}	36.36^{c}	40.26^{b}	50.65^{a}	0.10
Saponins (mg/100g)	1.63	1.55	1.48	1.42	1.21	1.16	0.89	
% reduction		4.90^{f}	9.20^{e}	12.88^{d}	25.76^{c}	28.83^{b}	45.39^{a}	0.05
HCN (mg/100g)	2.88	2.83	2.27	2.60	2.31	1.86	1.58	
% reduction		1.73^{f}	4.86^{e}	9.72^{d}	19.79^{c}	35.41^{b}	45.14^{a}	0.02

abcdef: Means within the same row with different superscripts differ significantly ($p<0.05$),
SEM: Standard error of means,
HCN: Hydrogen cyanide

reduced anti nutritional factors. In addition, fermentation also resulted in significantly (P<0.05) higher reduction of the levels of all the anti nutritional factors compared to soaking of pigeon pea seeds for various durations such as 24 , 48 and 72 hours respectively.

4.3 Experiment 1: Effect of Diets containing Differently Processed Pigeon pea Seed Meal on the Growth and Early Laying Performance of Quail (2-6 weeks)

The performance quail chicks fed diets containing differently processed pigeon pea seeds meal (PPSM) is shown in Table 4.3. The result showed that there were significant (P<0.05) differences in all the parameters measured.The final body weight and weight gain followed the same trend and were significantly (p<0.05) higher for birds fed the control diet when compared with those fed pigeon pea seeds soaked for 48 and 72 hours and those boiled for 60 minutes. In terms of daily weight gain of birds fed processed pigeon pea seeds, those fed diet 6 containing soaked and fermented PPSM for 72 hours, and roasted PPSM were significantly (P<0.05) better compared to other PPSM based diets. The total feed intake were significantly (P<0.05) higher in birds fed diets containing soaked PPSM for 72 hours (T5), boiled PPSM (T7) and roasted PPSM (T8) compared to those on the control diet (T1) but similar to those containing raw PPSM (T2), soaked PPSM for 24 hours (T3), soaked PPSM for 48 hours (T4) and the fermented PPSM (T6).The lowest value for feed to gain ratio (2.54) recorded in the control group was similar to those fed diet 6 containing fermented PPSM (3.09) and these were significantly (P<0.05) better compared to those of other treatments. The result also showed that the feed cost per kg gain in birds fed the control diet (₦204.21) followed by those on diet 6 containing fermented PPSM (₦ 277.27) were significantly (P<0.05) better compared to other treatments. The highest feed cost per gain (₦ 350.79) was recorded in birds fed diet 7 containing boiled PPSM.

Table 4.3: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal on Growth and Early Laying Performance of Quail Chicks (2- 6 weeks).

Parameters	TREATMENTS								
	1 (Control)	2 Raw PPSM	3 Soaked PPSM (24hrs)	4 Soaked PPSM (48hrs)	5 Soaked PPSM (72hrs)	6 Soaked + Fermentation	7 Boiled PPPSM (60mins)	8 Roasted PPSM (30mins)	SEM
Initial Weight (g/bird)	21.70	21.70	21.70	21.70	21.70	21.70	21.70	21.70	0.00
Final Body Weight (g/bird)	138.33^{a}	133.33^{abc}	131.00^{abc}	127.33^{bc}	128.33^{bc}	136.33^{ab}	126.33^{c}	131.00^{abc}	1.99
Total Weight Gain (g/bird)	116.63^{a}	111.30^{abc}	109.30^{abc}	105.63^{bc}	106.63^{bc}	114.63^{ab}	104.63^{c}	109.30^{abc}	1.99
Daily Weight Gain (g/bird/day)	4.16^{a}	3.97^{abc}	3.89^{abc}	3.77^{bc}	3.81^{bc}	4.09^{ab}	3.73^{c}	3.89^{abc}	0.07
Total Feed Intake (g/bird)	296.67^{b}	361.11^{ab}	353.34^{ab}	353.33^{ab}	371.11^{a}	354.44^{ab}	381.11^{a}	371.11^{a}	8.32
Daily Feed Intake (g/bird/day)	10.59^{b}	12.89^{ab}	12.62^{ab}	12.62^{ab}	13.25^{a}	12.65^{ab}	13.61^{a}	12.82^{ab}	0.29
Feed/Gain Ratio	2.54^{a}	3.25^{b}	3.24^{b}	3.35^{b}	3.48^{b}	3.09^{ab}	3.64^{c}	3.29^{b}	0.08
Feed Cost (₦)/kg Gain	204.21^{a}	290.82^{bc}	289.96^{bc}	299.59^{bc}	311.68^{cd}	277.27^{ab}	350.79^{d}	316.32^{cd}	7.33
Age at First Egg (days)	39.00^{a}	41.00^{b}	42.00^{b}	42.00^{b}	42.00^{b}	41.00^{b}	39.00^{a}	42.33^{b}	0.89
First Egg Weight (g)	7.36^{a}	7.03^{a}	7.50^{a}	7.53^{a}	6.73^{b}	7.73^{a}	7.43^{a}	7.10^{a}	0.38
Mortality (%)	4.45^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.78

abcd: Means within the same row with different superscripts are significantly different ($P<0.05$), SEM = Standard Error of Means,

PPSM: Pigeon Pea Seed Meal

Age at first egg was similar for birds fed the control diet and diet 7 containing boiled PPSM (39.00). Birds on the two diets came into lay earlier than others ($P<0.05$).

First egg weight was comparable($P>0.05$) among birds fed the dietary treatments except those on diet 5 containing soaked PPSM for 72 hours which were significantly ($P<0.05$) lower (6.73g).

4.3.1 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal on the Carcass Characteristics of Quail Birds

The result of the carcass characteristics of quail birds fed diets containing differently processed pigeon pea seed is presented in Table 4.4. The result showed that processing methods of PPS had significant ($P<0.05$) effect on all the parameters measured. The live weight of birds fed the control diet (T1) was significantly ($P<0.05$) higher (157.33 g) when compared to those on diet 4 but similar to those of other treatments. The dressed weight of birds fed diets T1, T2, T3 and T6 were similar ($P>0.05$) but significantly ($P<0.05$) higher compared to those in other treatment groups. The carcass weights of birds fed the control diet (T1) and T2 (raw PPS) were similar to those on T5 (soaked PPS for 72 hours) and T6 (soaked and fermented PPS) but significantly ($P<0.05$) higher than those fed other diets. Dressing percentages of birds fed the control diet, diet 2 (raw PPS) diet 3 (soaked PPS for 24 hours) and diet 6 (soaked and fermented PPS) were significantly ($P<0.05$) higher compared to those in other treatment groups.The result also showed that the percent weights of most of the cut parts were significantly ($P<0.05$) different across all the treatments. The percent weights of breast, thigh and neck of birds were significantly ($P<0.05$) lower for birds fed diet T1 (control) and diet T2 containing raw PPSM compared to those of other treatments which were similar. The percent weight of back in birds fed

diet T4 (soaked PPSM for 48 hours) was significantly ($P<0.05$) lowercompared to those of other treatments.

Table 4.4: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal on the Carcass Characteristics of Quail Birds

Parameters	TREATMENTS								
	1 (Control)	2 Raw PPSM	3 Soaked PPSM (24hrs)	4 Soaked PPSM (48hrs)	5 Soaked PPSM (72hrs)	6 Soaked + Fermentation	7 Boiled PPPSM (60min)	8 Roasted PPSM	SEM
Live Weight (g)	157.33^{a}	146.77^{ab}	146.67^{ab}	137.77^{b}	145.57^{ab}	148.97^{ab}	144.43^{ab}	142.30^{ab}	3.19
Dressed Weight (g)	105.43^{a}	97.00^{a}	96.00^{a}	83.00^{b}	83.00^{b}	96.00^{a}	81.67^{b}	81.43^{b}	5.06
Carcass Weight (g)	84.80^{a}	84.67^{a}	73.43^{b}	71.53^{b}	75.33^{ab}	77.33^{ab}	72.00^{b}	73.67^{b}	1.71
Dressing (%)	67.01^{a}	66.09^{a}	65.45^{a}	60.25^{b}	57.01^{b}	64.44^{a}	56.55^{b}	57.22^{b}	1.95
Major Cuts Expressed as Percentages of Carcass Weight and Organs as Percentage of Live weight (%)									
Breast	25.76^{b}	25.52^{b}	27.35^{a}	27.85^{a}	28.90^{a}	26.87^{a}	28.25^{a}	29.14^{a}	1.63
Back	23.88^{a}	23.30^{a}	24.28^{a}	20.68^{b}	22.43^{a}	23.12^{a}	25.05^{a}	25.74^{a}	2.16
Thigh	10.81^{b}	9.72^{b}	11.69^{ab}	11.35^{ab}	12.82^{ab}	12.39^{ab}	13.37^{a}	11.60^{ab}	0.69
Drumstick	8.45^{a}	7.37^{b}	7.45^{b}	7.60^{b}	7.68^{b}	9.19^{a}	9.54^{a}	8.30^{a}	0.68
Wing	7.59^{bc}	6.71^{c}	9.52^{ab}	7.30^{bc}	7.51^{bc}	7.64^{bc}	10.33^{a}	9.05^{ab}	0.29
Head	6.46^{b}	5.49^{b}	6.82^{a}	6.83^{a}	6.06^{b}	6.34^{b}	7.31^{a}	7.69^{a}	0.55
Neck	4.06^{b}	3.83^{b}	5.75^{a}	5.74^{a}	4.58^{ab}	4.59^{ab}	5.53^{a}	5.58^{a}	0.29
Heart	0.78^{a}	0.75^{a}	0.75^{a}	0.88^{a}	0.61^{b}	0.67^{ab}	0.74^{ab}	0.63^{ab}	0.10
Gizzard	1.49^{b}	1.70^{b}	1.59^{b}	1.69^{b}	1.75^{b}	1.71^{b}	1.78^{b}	2.19^{a}	0.19
Small Intestine	2.84^{a}	3.02^{a}	2.88^{a}	3.07^{a}	2.52^{ab}	1.64^{b}	2.65^{ab}	2.96^{a}	0.11
Liver	2.12^{b}	2.27^{b}	2.42^{a}	2.66^{a}	2.45^{a}	2.24^{b}	2.29^{b}	2.57^{a}	0.13

abcd: Means with different superscripts on the same row are significantly different ($P<0.05$), SEM = Standard Error of Means, PPSM = Pigeon Pea Seed Meal

Percent weights of drumstick of birds fed diet T1 (Control), T6 (soaked and fermented PPSM), T7 (boiled PPSM) and T8 (roasted PPSM) were significantly (P<0.05) higher compared to those of other treatments.

Percent wings of birds fed diets T3, T7 and T8 were similar but significantly (P<0.05) higher compared to those fedother treatments. The percent weights of head were similar in birds fed diets T3, T4, T7 and T8 but significantly (P<0.05) higher compared to those of other treatments.

For the organ weights, percent weights of heartwere similar in birds across all the treatments except those fed diet 5 (soaked PPSM for 72 hours) which were significantly (P<0.05) lower. The percent weights of gizzard of birds fed T8 was significantly (P<0.05) higher ccompared to those in other treatment groups. The percent weight of liver of birds fed diets T3, T4, T5 and T8 were similar and significantly (P<0.05) higher compared to those of other treatment. The percent weights of small intestine were similar in birds across the treatments except those on diet 6 which was significantly (P<0.05) lower.

4.3.2 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seeds on HaematologicalParameters and Serum Biochemisry of Japanese Quail

The haematological and serum biochemical profiles obtained for Japanese quail chicks fed differently processed pigeon pea seed meal (PPSM) are presented in Table 4.5. Significant(P<0.05) effects of the dietary treatments on the haematological and serum biochemical parameters of birds were observed except in albumin concentration (g/dl).

The Packed cell volume (PCV), Haemoglobin (Hb) and Red blood cells (RBC) were comparable (P>0.05) among birds fed diets T1 – T5 except those on diet 6 containing fermented PPSM, diet 7 containing boiled PPSM and diet 8 containing roasted PPSM which

Table 4.5: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal on Haematological Parametersand Serum Biochemistry of Japanese Quail Chicks

Parameters	TREATMENTS								
	1 (Control)	2 Raw PPSM	3 Soaked PPSM (24hrs)	4 Soaked PPSM (48hrs)	5 Soaked PPSM (72hrs)	6 Soaked + Fermentation	7 Boiled PPPSM (60mins)	8 Roasted PPSM (30mins)	SEM
PCV (%)	49.37^{a}	51.17^{a}	50.00^{a}	51.60^{a}	52.17^{a}	41.00^{b}	44.72^{b}	47.11^{b}	3.55
Hb (g/dl)	16.40^{a}	16.92^{a}	16.63^{a}	17.17^{a}	17.35^{a}	13.63^{b}	14.83^{b}	15.64^{b}	1.20
RBC (x 6 x 10^{6}/mm^{3})	8.27^{a}	8.50^{a}	8.30^{a}	8.57^{a}	8.83^{a}	6.80^{b}	7.41^{b}	8.05^{b}	0.61
WBC (x 10^{3}/mm^{3})	7.30^{a}	7.50^{a}	9.23^{a}	6.12^{b}	6.93^{a}	8.29^{a}	6.89^{a}	8.58^{a}	1.53
MCV (%)	53.76^{b}	60.17^{a}	60.24^{a}	60.22^{a}	59.20^{a}	60.31^{a}	60.35^{a}	58.47^{a}	2.09
MCH (pg)	19.87^{a}	19.88^{a}	20.03^{a}	20.03^{a}	19.69^{a}	20.05^{a}	20.00^{a}	19.41^{b}	0.25
MCHC (%)	33.24^{a}	33.04^{b}	33.26^{a}	33.26^{a}	33.25^{a}	33.25^{a}	33.15^{a}	33.20^{a}	0.09
Serum Biochemistry									
Lymphocytes (%)	87.33^{b}	88.49^{a}	88.67^{a}	92.17^{a}	88.50^{a}	87.78^{a}	90.45^{a}	90.11^{a}	2.01
Neutrophil (%)	12.33^{a}	11.28^{a}	10.83^{a}	7.83^{b}	11.17^{a}	12.00^{a}	9.11^{a}	9.66^{a}	1.90
Total Protein (g/dl)	7.70^{a}	6.57^{b}	5.90^{b}	6.01^{b}	6.10^{b}	5.68^{b}	5.88^{b}	5.62^{b}	0.50
Cholesterol (mg/dl)	4.42^{b}	5.23^{ab}	5.02^{ab}	4.32^{b}	5.82^{a}	4.47^{b}	4.49^{b}	4.19^{b}	0.37
Albumin (g/dl)	34.00	34.33	33.22	34.56	32.89	35.56	30.56	31.99	3.22
Urea (mg/dl)	4.44^{b}	5.31^{b}	5.06^{b}	5.91^{b}	5.06^{b}	4.98^{b}	7.56^{a}	4.53^{b}	0.92
Creatinine (mg/dl)	66.78^{b}	72.00^{b}	67.19^{b}	69.55^{b}	60.45^{b}	66.67^{b}	89.11^{a}	57.45^{b}	8.61

abc: Means with different superscripts on the same row are significantly different (P<0.05), PPSM : Pigeon Pea Seed Meal, SEM = Standard Error of Means, PCV = Packed Cell Volume, HB = Haemoglobin, RBC = Red Blood Cells,WBC = White Blood Cells, MCV = Mean Corpuscular Volume, MCH = Mean Corpuscular Haemoglobin, MCHC = Mean Corpuscular Haemoglobin Concentration

were significantly (P<0.05) lower.The WBC and Neutrophils were significantly (P<0.05) lower in birds fed diet 4 containing PPSM soaked for 48 hours compared to other treatments. The MCV and Lymphocytes were also significantly (P<0.05) lower in birds fed the control diet compared to those on PPSM diets.The MCH was significantly (P<0.05) lower in birds fed diet 8 (roasted PPSM) while MCHC was significantly (P<0.05) lower in birds fed diet 2 (raw PPSM) compared to other treatments. The total protein was significantly (P<0.05) higher in the control group compared to all other treatments.Urea and Creatinine were also significantly (P<0.05) higher in birds fed diet7 (boiled PPSM) compared to other treatments. Cholesterol levels in birds fed diet 5 (soaked PPSM for 72 hours) was similar to those in diet 2 (raw PPSM) and diet 3 (soaked PPSM for 24 hours) but significantly (P<0.05) higher compared to those in other treatments. There was no significant (P>0.05) difference in the albumin of birds across all the treatments.

4.3.3 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal on Digestibility of Nutrients by Quail Chicks

The result of the effects of diets containing differently processed pigeon pea seeds meal on nutrients digestibility by quail chicks is presented in Table 4.6. Dietary treatments had significant (P<0.05) effect on all the parameters measured. It was observed that percentage digestibility of dry matter, crude protein,ash and nitrogen free extract by birds across the treatments followed the same trend. These were significantly (P<0.05) higher for birds on the control diet (T1) compared to those on PPSM based dietary treatments. Crude fibre digestibility by birds on the control diet was similar to those on diets T2, T5, T7and T8 and these were significantly (P<0.05) higher compared to those on other diets. However, birds on the control diet, diet 2 and diet 5 had significantly (P<0.05) higher ether extract digestibility compared to those on other dietary treatments.

Table 4.6: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal on Nutrients Digestibility by Quail Chicks

Parameters	TREATMENTS								
	1 (Control)	**2 Raw PPSM**	**3 Soaked PPSM (24hrs)**	**4 Soaked PPSM (48hrs)**	**5 Soaked PPSM (72hrs)**	**6 Soaked + Fermentation**	**7 Boiled PPPSM (60mins)**	**8 Roasted PPSM (30mins)**	**SEM**
Dry Matter	82.88[a]	77.90[b]	74.76[b]	72.73[b]	77.63[b]	72.26[b]	77.58[b]	74.47[b]	3.16
Crude Protein	92.29[a]	89.72[b]	88.68[b]	88.27[b]	89.64[b]	86.96[b]	89.36[b]	87.66[b]	1.42
Crude Fibre	88.61[a]	84.87[ab]	78.96[b]	79.38[b]	84.66[ab]	78.71[b]	84.29[ab]	82.15[ab]	2.69
Ether Extract	91.90[a]	90.91[a]	86.67[b]	87.15[b]	91.55[a]	83.39[b]	87.18[b]	87.25[b]	2.22
Ash	86.67[a]	81.59[b]	82.48[b]	78.92[b]	83.36[b]	79.36[b]	80.45[b]	77.64[b]	2.39
NFE	75.88[a]	69.28[b]	64.84[b]	62.28[b]	68.50[b]	62.85[b]	70.22[b]	65.47[b]	4.41

ab = Means within the same row with different superscripts are significantly different (P<0.05), SEM = Standard Error of Means,

PPSM = Pigeon Pea Seed Meal

4.4 Experiment 2: Effects of Differently Processed Pigeon Pea Seeds Meal on Laying Performance of Japanese Quailsand Economic Benefits(7 – 26 weeks)

The effect of dietary treatments on the performance of laying quails is presented in Table 4.7. The results showed that differently processed pigeon pea seeds meal had significant (P<0.05) effect on all the performance parameters measured across the dietary treatments except age at peak lay of birds. The final weight and percent change in body weight followed similar trend. The values obtained for birds on the control diet were significantly (P<0.05) higher compared to those on other treatments but similar to those on diets T2 containing raw PPSM, T3 containing PPSM soaked for 24 hours and T7 containing PPSM boiled for 60 minutes. However, significantly (P<0.05) higher feed intake were recorded for birds fed differently processed PPSM especially those on diet 8 compared to those in the control group, diet 4 containing PPSM soaked for 48 hours, and diet 6containing fermented PPSM. Birds on the control diet (2.77) and diet 4 (2.92) had significantly (P<0.05) the lowest feed conversion ratio (FCR) compared to those on other treatments but similar to those on diets 2, 3 and 6. The poorest FCR were recorded for birds on diets T5, T7 and T8.

Feed consumed per dozen eggs and crate of eggs were significantly (P<0.05) lower for birds on diet 4 (₦27.62 and ₦119.68) and the control diet (₦28.97 and ₦125.55) compared to those on other treatments. Income above feed cost was also significantly (P<0.05) higher for birds on diet 4 containing soaked PPSM for 48 hours (₦280.32) and those in the control diet (₦274.55) compared to those on treatments 7 and 8.

Table 4.7: Effects of Diets containing Differently Processed Pigeon Pea Seeds Meal on Laying Performance of Quail and Economic Benefits(7 – 26 weeks)

Parameters	TREATMENTS								
	1 (Control)	2 Raw PPSM	3 Soaked PPSM (24hrs)	4 Soaked PPSM (48hrs)	5 Soaked PPSM (72hrs)	6 Soaked + Fermentation	7 Boiled PPPSM (60mins)	8 Roasted PPSM (30mins)	SEM
Initial Weight (g/bird)	158.00	158.00	158.00	158.00	158.00	158.00	158.00	158.00	0.00
Final Weight (g/bird)	209.67^{a}	195.05^{ab}	195.55^{ab}	187.43^{b}	190.60^{b}	187.52^{b}	199.39^{ab}	189.82^{b}	5.32
Change in body Weight (%)	24.53^{a}	18.97^{ab}	19.04^{ab}	15.67^{b}	17.10^{b}	15.67^{b}	20.27^{ab}	16.74^{b}	2.14
Total Feed Intake (g/bird)	3656.70^{c}	4786.70^{ab}	4796.70^{ab}	3953.30^{c}	4450.00^{ab}	4263.30^{bc}	4783.30^{ab}	5150.00^{a}	161
Daily Feed Intake (g/bird/day)	25.04^{c}	32.78^{ab}	32.83^{ab}	27.07^{c}	33.81^{ab}	29.20^{bc}	32.76^{ab}	35.27^{a}	1.54
FCR (Total Feed in kg/total egg no)	2.77^{a}	3.39^{ab}	3.30^{ab}	2.92^{a}	3.58^{b}	3.15^{ab}	3.49^{b}	3.73^{b}	0.15
Age at Peak lay (day)	52.00	58.33	52.00	54.00	54.00	58.33	54.67	52.00	3.58
Average Egg Weight (g)	9.30^{bc}	9.65^{ab}	9.82^{a}	9.23^{c}	9.40^{bc}	9.27^{bc}	9.37^{bc}	9.41^{bc}	0.07
Hen House Egg Production (%)	62.69^{cd}	75.83^{a}	75.64^{a}	73.27^{ab}	67.92^{bcd}	70.42^{abc}	67.04^{bcd}	71.77^{abc}	1.15
Hen day Egg Production (%)	78.29^{a}	78.85^{a}	80.48^{a}	77.46^{b}	81.65^{a}	76.27^{b}	81.10^{a}	76.32^{b}	1.60
Peak Egg Production (%)	75.55^{c}	88.89^{a}	84.45^{ab}	84.45^{ab}	80.00^{bc}	86.67^{ab}	80.00^{bc}	86.67^{ab}	1.52
Kg Feed/Dozen eggs	0.38^{a}	0.41^{abc}	0.42^{abc}	0.36^{a}	0.44^{abc}	0.40^{abc}	0.47^{bc}	0.48^{c}	0.02
Feed cost ₦ /Dozen egg	28.97^{a}	31.93^{bc}	32.47^{bc}	27.62^{a}	33.75^{bc}	30.87^{ab}	39.10^{c}	40.25^{c}	1.44
Feed cost/Crate of eggs	125.50^{a}	138.39^{bc}	140.71^{bc}	119.68^{a}	146.26^{bc}	133.80^{bc}	169.44^{c}	174.44^{c}	6.24
Income above feed cost (₦) at ₦ 10/egg	274.44^{a}	261.60^{ab}	259.29^{ab}	280.32^{a}	253.73^{ab}	266.19^{ab}	230.55^{b}	225.55^{b}	6.24
Mortality (%)	8.89^{c}	2.21^{a}	2.96^{a}	3.70^{ab}	9.63^{c}	5.18^{bc}	8.89^{c}	4.44^{bc}	1.05

abcd = Means with different superscripts on the same row are significantly different (P<0.05), PPSM : Pigeon Pea Seed Meal, SEM = Standard Error of Means

Dietary treatments had no significant (P>0.05) effect on age at peak lay (days) of birds across the treatments**.** However, average egg weights of birds fed diet 3 for 24hours (9.82 g) was similar to those fed diet 2 (9.65 g) but were significantly (P<0.05) higher compared to those of other treatments. Percent hen housed egg production was similar for birds on diet 2 containing raw PPSM and diet 3 containing soaked PPSM for 24 hours and were significantly (P<0.05) higher compared to those on other treatments but similar to those on diets 4, 6 and 8. Birds on diets 1 (control), 2, 3, 5and 7 also had higher (P<0.05) percent hen day egg production compared to those of other treatments. Percent peak egg production for birds fed diet 2 was similar to those on treatments 3, 4, 6 and 8 but significantly (P<0.05) higher than those on the control diet (T1), diet 5 and diet 7. Mortality was significantly (P<0.05) different across the dietary treatments.

4.4.1 The Economic Benefits of Feeding Diets containing Differently Processed Pigeon Pea Seeds to Laying Quails (7 – 26 weeks)

The results presented in Table 4.7 indicates that the inclusion of differently processed pigeon pea seeds (PPSM) in the diets of laying quails resulted in a significantly (P<0.05) lower Kg feed per dozen eggs for birds on the control diet and diet 4 for 48 hours compared to those on other dietary treatments. Feed cost per dozen eggs and feed cost per crate of eggs were similar and significantly (P<0.05) lower for birds fed diet 4 (₦27.62) and (₦119.68) respectively and the control diet (₦28.97) and (₦125.50) respectively compared to those on other PPSM diets. Hence, higher income above cost of feed was recorded in birds fed diet 4 (₦280.32) and the control diet (₦274.44) and these were significantly (P<0.05) better compared to those of treatments 7 and 8

4.4.2 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seeds Meal on External andInternal Egg Quality Characteristics of Laying Quails (7-26 weeks)

The results of the effect of the dietary treatments on external and internal egg quality parameters of laying quails are presented in Table 4.8. The results showed that all the external egg quality parameters evaluated such as egg weight, egg height, egg diameter, egg shape index and egg shell thickness of birds showed no significant (P>0.05) differences across the dietary treatments.

The results also showed that all the internal egg quality parameters evaluated such as albumen height, albumen diameter, albumen weight, yolk height, yolk diameter, yolk weight, yolk index and Haugh unitmeasured in this study showed no significant (P>0.05) differences across the dietary treatments. The albumen quality across the dietary treatments was indicated by the Haugh unit values.

Table 4.8: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal on External and internal Egg quality Characteristics of Japanese quail (7 – 26 weeks)

Parameters	TREATMENTS								
	1 Control	2 Raw PPSM	3 Soaked PPSM (24hrs)	4 Soaked PPSM (48hrs)	5 Soaked PPSM (72hrs)	6 Soaked + Fermentation	7 Boiled PPPSM (60mins)	8 Roasted PPSM (30mins)	SEM
EXTERNAL QUALITY									
Egg Weight (g)	9.30	9.65	9.82	9.37	9.40	9.40	9.70	9.41	0.80
Egg Height (mm)	30.23	30.52	30.49	30.36	30.54	30.47	30.60	30.31	0.65
Egg Diameter (mm)	22.61	22.77	22.81	22.52	22.40	22.63	22.64	22.38	0.43
Egg Shape Index	0.75	0.75	0.75	0.74	0.73	0.74	0.74	0.73	0.02
Egg Shell Weight (g)	0.99	1.02	1.00	1.01	1.00	1.01	1.02	0.99	0.02
Egg Shell Thickness (mm)	0.25	0.25	0.25	0.25	0.25	0.30	0.25	0.25	0.07
INTERNAL QUALITY									
Albumen Height (mm)	2.77	2.89	2.77	2.92	2.92	3.18	2.84	2.89	0.45
Albumen Diameter (mm)	32.40	32.11	33.96	32.59	31.52	32.55	33.02	33.96	1.88
Albumen Weight (g)	4.90	5.09	5.14	5.10	4.98	4.79	5.22	4.99	5.58
Yolk Height (mm)	9.84	9.46	9.14	9.04	9.19	9.36	9.57	9.52	1.36
Yolk Diameter (mm)	2.21	2.17	2.19	2.19	2.21	2.22	2.20	2.17	0.06
Yolk Weight (g)	3.42	3.56	3.68	3.25	3.43	3.60	3.51	3.44	0.41
Yolk Index	0.44	0.43	0.41	0.41	0.41	0.42	0.43	0.43	0.06
Haugh Unit	77.74	77.44	77.29	77.57	77.46	77.63	77.30	77.42	0.89

abc: Means with different superscripts on the same row are significantly different (P<0.05), SEM = Standard Error of Means, PPSM = Pigeon Pea Seed Meal.

4.4.3 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal on Digestibility of Nutrients by Laying Quails (7 – 26 weeks)

The result of the effect of diets containing differently processed pigeon pea seed meal on nutrients digestibility is presented in Table 4.9. The result showed that the dietary treatments had significant ($P<0.05$) effect on all the parameters measured. Percentage digestibility of dry matter and crude protein followed the same trend. These were similar for birds fed diets T1 (control), T3 (soaked PPSM for 24 hours), T4 (soaked PPSM for 48 hours), T5 (soaked PPSM for 72 hours), T6 (fermented PPSM) and T7 (boiled PPSM) and significantly ($p<0.05$) higher compared to diets T2 (raw PPSM) and T8 (roasted PPSM). Thepercent crude fibre (CF), ash and nitrogen free extract (NFE) digestibilities also followed the same trend.These were similar for birds fed diets 3 and 7 and these were significantly ($P<0.05$) higher compared to the values for other treatments. However, percentage ether extract (E.E) digestibility was similar for birds on diets T1, T2, T3, T4, T5, T6 and T7 and these were significantly ($P<0.05$) higher compared to those on diet 8 containing roasted PPSM.

Table 4.9: Effect of Diets containing Differently Processed Pigeon Pea Seed Meal on Nutrients Digestibility by Laying Quail (7 – 26 weeks).

Parameters	TREATMENTS								
	1 (Control)	**2 Raw PPSM**	**3 Soaked PPSM (24hrs)**	**4 Soaked PPSM (48hrs)**	**5 Soaked PPSM (72hrs)**	**6 Soaked + Fermentation**	**7 Boiled PPPSM (60mins)**	**8 Roasted PPSM (30mins)**	**SEM**
Dry Matter	81.60[a]	78.62[b]	86.20[a]	81.46[a]	80.07[a]	80.62[a]	84.42[a]	77.02[b]	2.52
Crude Protein	88.46[a]	86.30[b]	90.89[a]	88.16[a]	87.92[a]	88.10[a]	89.53[a]	85.72[b]	1.63
Crude Fibre	86.78[b]	85.12[b]	89.49[a]	85.97[b]	84.61[b]	86.93[b]	90.45[a]	85.24[b]	1.84
Ether Extract	84.81[ab]	83.31[ab]	87.80[a]	83.40[ab]	82.24[ab]	84.24[ab]	86.65[ab]	81.59[b]	2.13
Ash	85.81[b]	83.92[b]	88.83[a]	85.09[b]	84.40[b]	85.30[b]	87.76[a]	83.37[b]	2.00
NFE	75.73[b]	71.57[b]	82.41[a]	76.86[b]	74.42[b]	74.02[b]	80.09[a]	70.35[b]	3.28

abcd: Means with different superscripts on the same row are significantly different ($P < 0.05$), SEM = Standard Error of Means, PPSM = Pigeon Pea Seed Meal, NFE = Nitrogen Free Extract

4.5 Experiment 3: Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Growth and Early LayingPerformance of Quail Chicks (2 - 6 weeks)

The performance of the quail chicks fed diets containing differently processed pigeon pea seeds meal with enzyme supplementation is presented in Table 4.10 The result showed that there were significant ($P<0.05$) differences in all the parameters measured. The final body weight and weight gain followed the same trend. Birds fed diets T1 (control), diets T2, T3 and T7 supplemented with enzymes were similar and had significantly ($P<0.05$) higher final weight and weight gain compared to those on other dietary treatments. Feed intake was similar for birds fed diets T2 (raw PPSM), T3 (soaked PPSM for 24 hours),T5 (soaked PPSM for 72 hours), T6 (fermented PPSM), T7 (boiled PPSM) and T8 (roasted PPSM) supplemented with enzyme but significantly ($P<0.05$) higher than those on diets T1 (control) and T4 (soaked PPSM for 48 hours with enzyme). Birds on diets T1 (control) and T4 (soaked PPSM for 48 hours with enzyme) had lower feed to gain ratio and feed cost per kg gain which were similar and significantly ($P<0.05$) better compared to those on other dietary treatments.

Age at first egg (days) was similar among birds across the dietary treatments except those on diet T5 (soaked PPSM for 72 hours with enzyme) which were significantly ($P<0.05$) lower. However, first egg weight was similar (8.33 g) for birds on diet 2 (raw PPSM with enzyme) and diet 3 (soaked PPSM for 24 hours with enzyme) and these were comparable to those on other dietary treatments but significantly ($P<0.05$) higher than those on diet T1 (control). Generally, it was observed that birds on differently processed pigeon pea seed meal with enzyme supplementation had significantly ($P<0.05$) higher first egg weight

compared to the control group. Mortality was significantly ($P<0.05$) different across all the dietary treatments.

Table 4.10: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Growth and Early Laying Performance of Quail Chicks (2 – 6 weeks)

Parameters	TREATMENTS								
	1 (Control)	**2 RPPSM + Vegpro**	**3 SPPSM (24hrs) + Vegpro**	**4 SPPSM (48hrs) + Vegpro**	**5 SPPSM (72hrs) + Vegpro**	**6 S+FPPSM + Vegpro**	**7 BPPSM (60mins)+ Vegpro**	**8 RPPSM (30mins) + Vegpro**	**SEM**
Initial Weight (g/bird)	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	0.00
Final Body Weight (g/bird)	134.83^{a}	130.67^{a}	129.43^{a}	128.43^{b}	127.80^{b}	127.37^{b}	130.33^{a}	127.47^{b}	3.16
Total Weight Gain (g/bird)	111.83^{a}	107.67^{a}	106.43^{a}	105.43^{b}	104.80^{b}	104.37^{b}	107.33^{a}	104.47^{b}	3.12
Daily Weight Gain (g/bird/day)	3.99^{a}	3.85^{a}	3.80^{a}	3.77^{b}	3.74^{b}	3.72^{b}	3.83^{a}	3.73^{b}	0.10
Total Feed Intake (g/bird)	328.55^{b}	386.90^{a}	401.43^{a}	336.78^{b}	404.00^{a}	388.73^{a}	385.94^{a}	392.45^{a}	27.45
Daily Feed Intake (g/bird/day)	11.73^{b}	13.82^{a}	14.33^{a}	12.03^{b}	14.43^{a}	13.88^{a}	13.78^{a}	14.01^{a}	0.97
Feed Gain Ratio	2.94^{a}	3.59^{b}	3.77^{b}	3.18^{a}	3.86^{b}	3.72^{b}	3.60^{b}	3.75^{b}	0.26
Feed Cost (₦)/Kg Gain	235.81^{a}	325.79^{b}	341.76^{b}	289.16^{ab}	350.19^{b}	336.97^{b}	350.53^{b}	368.80^{b}	24.93
Age at First Egg (days)	33.00^{a}	33.00^{a}	32.67^{a}	33.00^{a}	34.67^{b}	32.67^{a}	33.33^{a}	33.33^{a}	0.72
First Egg Weight (g)	6.67^{b}	8.33^{a}	8.33^{a}	7.60^{ab}	7.83^{ab}	7.83^{ab}	7.33^{ab}	6.93^{ab}	0.44
Mortality (%)	1.11^{ab}	2.22^{b}	2.22^{b}	2.22^{b}	0.00^{a}	2.22^{b}	1.11^{ab}	1.11^{ab}	0.42

ab = Mean within the same row with different superscripts are significantly different (P<0.05), SEM = Standard Error of Means

4.5.1 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (vegpro) Supplementation on the Carcass Characteristics of Quail Birds

The result of the carcass characteristics of quail birds fed diets containing differently processed pigeon pea seed meal with enzyme supplementation is presented in Table 4.11 The result showed that enzyme supplementation of pigeon pea seeds processed by different methods had significant ($P<0.05$) effect on most of the parameters measured except carcass weight and dressing percentage. Live weights were similar in birds fed diets T1(control), T2 (raw PPSM with enzyme), T3 (soaked PPSM for 24 hours with enzyme), T4 (soaked PPSM for 48 hours with enzyme) and T7 (boiled PPSM with enzyme) and these were significantly ($P<0.05$) higher compared to those on other treatments. Birds fed the control diet had significantly ($P<0.05$) higher dressed weight compared to those on other dietary treatments. Carcass weight and dressing percentages of birds were not significantly ($P>0.05$) different across the treatments.

The percent breast weights were similar for birds fed diets T2 (raw PPSM with enzyme), T4 (soaked PPSM for 48 hours with enzyme), T6 (fermented PPSM with enzyme) and T7 (boiled PPSM with enzyme) and these were significantly ($P<0.05$) higher compared to those on other treatments. Percent weights of back were similar for birds fed the control diet (T1) diet 2 (raw PPSM with enzyme), diet 3(soaked PPSM for 24 hours with enzyme) and diet 5(soaked PPSM for 72 hours with enzyme) and significantly ($P<0.05$) higher compared to other treatment groups. Percent weights of thigh for birds fed diet 5 (soaked PPSM for 72 hours with enzyme) were significantly ($P<0.05$) higher compared to those in other treatment groups. Percent weights of drum stick in birds fed diet 1 (control), diet 5(soaked PPSM for

Table 4.11: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Carcass Characteristics of Quails

TREATMENTS									
Parameters	**1 (Control)**	**2 RPPSM + Vegpro**	**3 SPPSM (24hrs) + Vegpro**	**4 SPPSM (48hrs) + Vegpro**	**5 SPPSM (72hrs) + Vegpro**	**6 SFPPSM + Vegpro**	**7 BPPSM (60mins) + Vegpro**	**8 RPPSM (30mins)+ Vegpro**	**SEM**
Live Weight (g)	134.60^{a}	130.69^{a}	129.44^{a}	128.46^{a}	127.78^{b}	127.38^{b}	131.01^{a}	127.47^{b}	3.16
Dressed Weight (g)	116.00^{a}	108.78^{b}	107.59^{b}	106.33^{b}	105.69^{b}	105.00^{b}	109.11^{b}	105.11^{b}	2.28
Carcass Weight (g)	82.00	81.76	81.69	81.67	81.30	80.33	81.78	80.78	2.12
Dressing (%)	86.18	83.24	83.11	82.77	82.71	82.43	82.04	82.45	3.16
Major Cuts Expressed as Percentages of Carcass Weight and Organs as Percentage of Live weight (%)									
Breast (%)	30.59^{b}	32.31^{a}	30.60^{b}	33.19^{a}	31.02^{b}	33.33^{a}	34.23^{a}	30.95^{b}	0.91
Back (%)	29.27^{a}	27.74^{a}	27.60^{a}	26.38^{b}	27.47^{a}	25.72^{b}	25.12^{b}	25.03^{b}	0.95
Thigh (%)	14.23^{b}	14.65^{b}	14.82^{b}	14.41^{b}	15.99^{a}	14.66^{b}	14.02^{b}	14.57^{b}	0.43
Drumstick (%)	9.35^{a}	8.84^{b}	8.70^{b}	8.56^{b}	9.70^{a}	8.30^{b}	9.23^{a}	8.93^{b}	0..35
Wing (%)	9.34^{a}	9.52^{a}	9.65^{a}	9.39^{a}	10.38^{a}	9.82^{a}	10.30^{a}	8.22^{b}	0.46
Head (%)	8.13^{a}	7.75^{b}	7.88^{b}	7.62^{b}	7.92^{b}	7.88^{b}	7.89^{b}	7.15^{b}	0.40
Neck (%)	5.69^{ab}	5.98^{ab}	5.71^{ab}	5.17^{ab}	6.28^{a}	5.25^{ab}	5.33^{ab}	4.00^{b}	0.45
Heart (%)	0.57^{b}	0.59^{b}	0.85^{a}	0.60^{b}	0.69^{b}	0.61^{b}	0.60^{b}	0.61^{b}	0.10
Gizzard (%)	2.72^{b}	3.49^{a}	3.44^{a}	3.03^{ab}	3.39^{ab}	3.39^{ab}	3.15^{ab}	2.61^{b}	0.19
Liver (%)	1.65^{a}	1.36^{b}	1.72^{a}	1.56^{b}	2.01^{a}	1.49^{b}	1.52^{b}	1.66^{a}	0.21
Small Intestine (%)	3.05^{b}	3.57^{a}	3.51^{a}	3.55^{a}	3.80^{a}	3.67^{a}	3.49^{a}	3.67^{a}	0.35

ab = Means with different superscripts on the same row are significantly different (P<0.05), SEM = Standard Error of Means, RPPSM = Raw Pigeon Pea Seed Meal, SPPSM = Soaked Pigeon Pea Seed Meal, SFPPSM = Soaked + Fermented Pigeon Pea Seed Meal, BPPSM = Boiled Pigeon Pea Seed Meal, RPPSM = Roasted Pigeon Pea Seed Meal

72 hours with enzyme) and diet 7 (boiled PPSM with enzyme) were significantly (P<0.05) higher compared to those on other treatments. The percent weights of wing in birds fed diet 8 was significantly (P<0.05) lower compared to those in other treatment group. Percent weight of head in birds fed the control diet was significantly (P<0.05) higher compared to those of other treatments.However,percent weight of neck in birds fed diet T5 (soaked PPSM for 72 hours with enzyme) was significantly (P<0.05) higher compared to those in diet T8 containing roasted PPSM with enzyme but similar to those in other treatments.

The percent weight of heart in birds fed diet T3 (soaked PPSM for 24 hours with enzyme) was significantly (P<0.05) higher compared to those on other dietary treatments. Percent gizzard weights of birds fed diets T2 (raw PPSM with enzyme) and T3 (soaked PPSM for 24 hours with enzyme) were similar and comparable to those on diets T4 – T7 but were significantly (P<0.05) higher compared to those on T1 (control) and T8 (roasted PPSM with enzyme). The percent weights of liver in birds fed diets T1, T3(soaked PPSM for 24 hours with enzyme), T5(soaked PPSM for 72 hours with enzyme) and T8 (roasted PPSM) were significantly (P<0.05) higher compared to those in other treatment groups. Percent weight of small intestine of birds in the control group was significantly (P<0.05) lower compared to those fed PPSM diets.

4.5.2 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Haematological Parameters and Serum Biochemistry of Japanese Quails

The results of the haematological parameters and serum biochemistry obtained for Japanese quail chicks fed diets containing differently processed pigeon pea seed meal supplemented with enzyme (vegpro) are presented in Table 4.12The results showed that enzyme

Table 4.12: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Haematological Parameters and Serum Biochemistry of Japanese Quails

Parameters	TREATMENTS								
	1 (Control)	**2 RPPSM + Vegpro**	**3 SPPSM (24hrs) + Vegpro**	**4 SPPSM (48hrs) + Vegpro**	**5 SPPSM (72hrs) + Vegpro**	**6 SFPPSM + Vegpro**	**7 BPPSM (60mins)+ Vegpro**	**8 RPPSM (30mins) + Vegpro**	**SEM**
PCV (%)	51.42[a]	51.45[a]	49.44[a]	51.00[a]	49.67[a]	52.44[a]	48.22[b]	45.89[b]	1.96
Hb (g/dl)	17.11[a]	17.12[a]	16.46[a]	16.97[a]	16.51[a]	17.36[a]	16.04[b]	15.26[b]	0.66
RBC (x 6 x 10^6/mm^3)	8.50[a]	8.59 [a]	8.29[a]	8.48[a]	8.37[a]	8.90[a]	7.99[b]	7.70[b]	0.32
WBC (x 10^3/mm^3)	6.82[b]	8.12[a]	11.79[a]	8.27[a]	5.82[b]	10.51[a]	7.01[a]	5.57[b]	2.42
MCV (%)	60.50[a]	60.50[a]	59.66[a]	60.15[a]	59.25[b]	58.90[b]	60.49[a]	59.79[a]	0.43
MCH (pg)	20.12[a]	20.14[a]	19.86[a]	20.01[a]	19.78[a]	19.49[b]	20.13[a]	19.95[a]	0.14
MCHC (%)	33.26[b]	51.81[a]	33.28[b]	33.26[b]	33.24[b]	50.75[a]	33.27[b]	33.32[b]	9 .00
Serum Biochemistry									
Lymphocytes (%)	90.55[a]	93.56[a]	94.89[a]	87.10[b]	94.67[a]	90.89[a]	91.22[a]	93.11[a]	2.20
Neutrophil (%)	9.22[a]	6.44[b]	4.67[b]	10.03[a]	5.11[b]	7.55[a]	8.22[a]	5.77[b]	1.54
Total Protein (g/dl)	4.51[b]	5.93[b]	7.12[a]	4.58[b]	5.89[b]	5.95[b]	6.51[b]	6.42[b]	0.94
Cholesterol (mg/dl)	4.30[b]	5.59[b]	4.67[b]	5.92[b]	4.47[b]	5.95[b]	7.16[a]	5.39[b]	0.96
Albumin (g/dl)	30.89[ab]	33.33[ab]	37.33[a]	32.78[ab]	37.22[a]	30.00[ab]	25.00[b]	26.11[b]	2.91
Urea (mg/dl)	2.49[a]	1.75[b]	1.93[b]	2.22 [a]	2.21[a]	2.26[a]	2.17[a]	2.03[a]	0.30
Creatinine (mg/dl)	40.44[ab]	41.44[ab]	33.67[b]	35.89[b]	36.33[b]	45.45[a]	46.89[a]	49.45[a]	3.21

ab = Means with different superscripts on the same row are significantly (P<0.05) different, SEM = Standard Error of Means, PPSM = Pigeon Pea Seed Meal, RPPSM = Raw Pigeon Seed Meal, SPPSM = Soaked Pig
on Pea Seed meal, SFPPSM = Soaked + Fermented Pigeon Pea Seed Meal, BPPSM = Boiled Pigeon Pea Seed Meal, PCV = Packed Cell Volume, HB = Haemoglobin, RBC = Red Blood Cells,WBC = White Blood Cells, MCV = Mean Corpuscular Volume, MCH = Mean Corpuscular Haemoglobin, MCHC = Mean Corpuscular Haemoglobin Concentration

supplementation had significant (P<0.05) effect on all the parameters evaluated across the dietary treatments. The packed cell volume (PCV), haemoglobin (Hb) and red blood cells (RBC) of birds fed diets T1, T2, T3, T4, T5 and T6 were similar across the treatments and these were significantly (P<0.05) higher compared to those of diets T7 (boiled PPSM with enzymes) and T8 (roasted PPSM with enzyme). White blood cells (WBC) of birds fed diets T2 (raw PPSM with enzyme), T3(soaked PPSM for 24 hours with enzyme), T4 (soaked PPSM for 48 hours with enzyme), T6 (fermented PPSM with enzyme) and T7 (boiled PPSM with enzyme) were similar but significantly (P<0.05) higher than those on diets T1 (control), T5 (soaked PPSM for 72 hours with enzyme) and T8 (roasted PPSM with enzyme). Mean corpuscular volume (MCV) were similar for birds fed diets T1, T2, T3, T4, T7 and T8 and these were significantly (P<0.05) higher compared to those on T5 (soaked PPSM for 72 hours with enzyme) and T6 (Fermented PPSM with enzyme). The Mean corpuscular haemoglobin (MCH) was significantly (P<0.05) lower in birds fed diet 6 (fermented PPSM with enzyme) compared toother other treatment groups.

Mean corpuscular haemoglobin concentration (MCHC) of birds fed diets T2 (raw PPSM with enzyme) and T6 (Fermented PPSM with enzyme) were similar and significantly (P<0.05) higher compared to those of other treatments.The lymphocytes were significantly (P<0.05) lower in birds fed soaked PPSM for 48 hours with enzyme (T4) compared to all other treatments. The neutrophils was similar among birds fed diets T1 (control), T4 (soaked PPSM for 48 hours with enzyme), T6 (fermented PPSM with enzyme) and T7 (boiled PPSM with enzyme) and these were significantly (P<0.05) higher compared to those on other dietary treatments. However, the total protein was significantly (P<0.05) higher in birds fed soaked PPSM for 24 hours with enzyme (T3) compared to those in other

treatment groups. The cholesterol was significantly (P<0.05) higher in birds fed boiled PPSM with enzyme (T7) compared to all other treatments. Serum albumin was similar in birds fed diets T3 and T5 and these were comparable to those on diets T1, T2, T4 and T6 but significantly (P<0.05) higher than those in other treatments. The urea concentration were similar in birds fed diets T2 (raw PPSM with enzyme) and T3 (soaked PPSM for 24 hours with enzyme) and were significantly (P<0.05) lower compared to those in other treatment groups. The creatinine were similar in birds fed diets T6 – T8 and were comparable to those on T1 (control) and T2 (raw PPSM with enzyme) but significantly (P<0.05) higher compared to other treatments.

4.5.3 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed meal with Enzyme (Vegpro) Supplementation on Nutrients Digestibility by Quails

The result of the effect of diets containing differently processed pigeon pea seed meal (PPSM) with enzyme supplementation on nutrients digestibility is presented in Table 4.13 The result showed that enzyme supplementation of PPSM had significant (P<0.05) effect on nutrient digestibility by quails. Percentage dry matter digestibility by birds fed diets T7 (boiled PPSM with enzyme) and T8 (roasted PPSM with enzyme) were similar and comparable to those of other dietary treatments but were significantly (P<0.05) higher than those on diet T3 (soaked PPSM for 24 hours with enzyme).

Percentage crude protein digestibility by birds on diets T4, T5, T6, T7 and T8 were similar to those on diet T1 (control) but significantly (P<0.05) higher than those on diets T2 (raw PPSM with enzyme) and T3 (soaked PPSM for 24 hours with enzyme). Percentage crude fibre digestibility by birds on diet T7 (boiled PPSM with enzyme) was similar to those on diets T1 (control), T4 (soaked PPSM for 48 hours with enzyme), T5 (soaked PPSM for 72

hours with enzyme), T6 (fermented PPSM with enzyme) and T8 (roasted PPSM with enzyme) and were comparable to those on diet 2 (raw PPSM with enzyme) but were

Table 4.13: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Nutrients Digestibility by Quail

Parameters	TREATMENTS								
	1 (Control)	**2 RPPSM + Vegpro**	**3 SPPSM (24hrs) + Vegpro**	**4 SPPSM (48hrs) + Vegpro**	**5 SPPSM (72hrs) + Vegpro**	**6 SFPPSM + Vegpro**	**7 BPPSM (60mins)+ Vegpro**	**8 RPPSM (30mins)+ Vegpro**	**SEM**
Dry Matter	70.98^{ab}	67.29^{ab}	61.94^{b}	67.72^{ab}	69.58^{ab}	65.13^{ab}	73.22^{a}	71.43^{a}	3.42
Crude Protein	81.32^{a}	79.94^{b}	77.62^{b}	81.17^{a}	81.17^{a}	80.88^{a}	83.69^{a}	83.76^{a}	2.02
Crude Fibre	78.30^{a}	71.23^{ab}	61.49^{b}	72.76^{a}	75.52^{a}	78.58^{a}	81.38^{a}	78.01^{a}	3.02
Ether Extract	89.02^{a}	88.06^{a}	78.41^{b}	87.97^{a}	89.05^{a}	85.25^{a}	87.28^{a}	86.34^{a}	1.60
Ash	80.63^{a}	79.75^{a}	72.90^{b}	78.11^{a}	81.01^{a}	78.97^{a}	79.86^{a}	80.71^{a}	2.38
NFE	59.19^{a}	53.13^{a}	49.37^{b}	55.13^{a}	56.03^{a}	49.30^{b}	61.13^{a}	59.00^{a}	4.81

ab = Mean within the same row with different superscripts are significantly ($P < 0.05$) different, SEM = Standard Error of Means, RPPSM = Raw Pigeon Seed Meal, SPPSM = Soaked Pigeon Pea Seed meal, SFPPSM = Soaked + Fermented Pigeon Pea Seed Meal, BPPSM = Boiled Pigeon Pea Seed Meal

significantly (P<0.05) higher than those on diet 3 containing soaked PPSM for 24 hours with enzyme.

Percentage ether extract and ash digestibility by birds followed the same trend as these were similar for birds across the dietary treatments except those on diet T3 which were significantly (P<0.05) lower. However, percentage nitrogen free extract (NFE) digestibility was similar among birds fed diets T1 (control), T2 (raw PPSM with enzyme), T4 (soaked PPSM for 48 hours with enzyme), T5 (soaked PPSM for 72 hours with enzyme), T7 (boiled PPSM with enzyme) and T8 (roasted PPSM with enzyme) but significantly (P<0.05) higher compared to those on diets T3 (soaked PPSM for 24 hours with enzyme) and T6 (fermented PPSM with enzyme).

4.6 Experiment 4: Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Laying Performance of Quails and Economic Benefits(7- 26 weeks)

The effect of diets containing differently processed pigeon pea seeds meal with enzyme supplementation on performance of laying quails is presented in Table 4.14 The result showed that dietary treatments had significant (P<0.05) effects on all the parameters measured except hen housed egg production (%), hen day egg production (%) and peak egg production (%). Final body weight and percent change in body weight followed the same trend. The final weight and percent change in body weight of birds on diet 2 containing raw PPSM with enzyme was similar to those on T1, T3 and T7 but significantly (P<0.05) higher when compared to those on other treatments. Feed intake of birds fed T2, T5 andT6 were similar and comparable to those on other PPSM based diets but significantly (P<0.05) higher than those in the control group. Feed conversion ratio of birds fed diet T1 (control) was

similar to those on diets T3 (soaked PPSM for 24 hours with enzyme) and T4 (soaked PPSM for 48

Table 4.14: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Laying Performance of Quail Hens and Economic Benefits (7 – 26 weeks)

Parameters	TREATMENTS								
	1 (Control)	2 RPPSM + Vegpro	3 SPPSM (24hrs) + Vegpro	4 SPPSM (48hrs) + Vegpro	5 SPPSM (72hrs) + Vegpro	6 S +FPPSM + Vegpro	7 BPPPSM (60mins) + Vegpro	8 RPPSM (30min) Vegpro	SEM
Initial Weight (g/bird)	158.33	158.33	158.33	158.33	158.33	158.33	158.33	158.33	0.00
Final Weight (g/bird)	187.88^{a}	188.39^{a}	183.20^{a}	175.76^{b}	177.78^{b}	175.42^{b}	182.40^{a}	179.54^{b}	4.29
Change in body Weight (%)	15.41^{a}	15.90^{a}	13.51^{a}	9.87^{b}	10.90^{b}	9.62^{b}	13.12^{a}	11.78^{b}	2.05
Total Feed Intake (g/bird)	4166.67^{b}	4880.00^{ab}	4516.67^{ab}	4506.67^{ab}	4970.00^{a}	5100.00^{a}	4723.33^{ab}	4653.33^{ab}	249.0
Daily Feed Intake (g/bird/day)	29.14^{b}	34.12^{a}	31.58^{ab}	31.51^{ab}	34.75^{a}	35.66^{a}	33.03^{ab}	32.54^{ab}	1.74
FCR (kg feed/kg eggs)	3.19^{a}	3.56^{b}	3.38^{a}	3.47^{a}	3.76^{b}	3.77^{b}	3.60^{b}	3.50^{b}	0.15
Age at Peak lay (day)	54.00^{a}	53.67^{a}	53.00^{a}	52.33^{a}	56.33^{a}	50.67^{a}	47.33^{b}	52.33^{a}	4.30
Average Egg Weight (g)	9.13^{ab}	9.57^{a}	9.32^{ab}	9.07^{b}	9.18^{ab}	9.45^{a}	9.15^{ab}	9.13^{ab}	0.08
Hen Housed Egg Production (%)	75.07	82.12	75.42	75.41	84.07	75.67	77.77	77.35	4.62
Hen day Egg Production (%)	81.06	83.43	82.39	79.76	84.07	80.01	80.14	83.07	3.12
Peak Egg Production (%)	91.67	97.22	88.89	94.45	94.45	91.67	91.67	94.45	4.39
Kg Feed/Egg	0.45^{b}	0.48^{b}	0.47^{b}	0.47^{b}	0.48^{b}	0.54^{a}	0.49^{b}	0.48^{b}	0.02
Feed cost ((₦)/Dozen egg	34.16^{a}	37.97^{ab}	37.50^{ab}	37.01^{ab}	37.75^{ab}	43.94^{b}	41.90^{b}	41.27^{b}	1.50
Feed cost (₦)/Crate of eggs	148.05^{a}	163.79^{ab}	162.51^{ab}	160.39^{ab}	163.57^{ab}	190.40^{b}	181.60^{b}	178.86^{b}	6.53
Inc above feed cost ((₦)	251.95^{a}	236.21^{ab}	237.48^{ab}	239.61^{ab}	236.43^{ab}	209.59^{b}	218.39^{b}	221.40^{b}	6.53
Mortality (%)	5.55^{b}	0.92^{ab}	0.54^{ab}	2.77^{ab}	0.00^{a}	3.70^{ab}	2.77^{ab}	4.62^{b}	1.29

ab= Means with different superscripts on the same row are significantly different ($P < 0.05$), SEM = Standard Error of Means, RPPSM: Raw Pigeon Pea Seed Meal, SPPSM = Soaked Pigeon Pea Seed meal, SFPPSM = Soaked + Fermented Pigeon Pea Seed Meal, BPPSM = Boiled Pigeon Pea Seed Meal, RPPSM = Roasted Pigeon Pea Seed Meal

hours with enzyme) and these were significantly (P<0.05) better compared to those on other treatments.

Age at peak lay (day) of birds fed diet 7 (boiled PPSM with enzyme) was significantly (P<0.05) lower compared to those on other dietary treatments. Average egg weights of birds on diet 2 containing raw PPSM with enzyme and T6 (fermented PPSM with enzyme) were comparable to those in other treatment groups but significantly (P<0.05) higher than those on diet T4 (soaked PPSM for 48 hours with enzyme). Percent hen housed egg production, percent hen day production and percent peak egg production did not differ significantly (P>0.05) across the treatments. However, feed cost per dozen eggs and crate of eggs for birds on diets T6 (fermented PPSM with enzyme), T7 (boiled PPSM with enzyme) andT8 (roasted PPSM with enzyme) were significantly (P<0.05) higher compared to those on other dietary treatments. Birds on the control diet had significantly (P<0.05) higher income above feed cost (₦251.95**)** compared to those on diets T6, T7 and T8 but similar to those on diets T2, T3, T4 and T5. Significant (P<0.05) differences in mortality was observed among birds across the treatments.

4.6.1 The Economics of Feeding Diets containing Differently Processed Pigeon Pea Seeds Supplemented with Enzyme (Vegpro) to Laying Quails (7 – 26 weeks)

The results presented in Table 4.14 indicates that the inclusion of differently processed pigeon pea seed meal (PPSM) in the diets of laying quails resulted in a significantly (P<0.05) higher Kg feed per egg for birds on diet 6 (0.54 kg) containing fermented PPSM compared to other dietary treatments. Feed cost per dozen eggs, feed cost per crate of eggs of birds fed the control diet were comparable to those on diets T2 (raw PPSM with enzyme), T3 (soaked PPSM for 24 hours with enzyme), T4 (soaked PPSM for 48 hours with enzyme) and T5 ((soaked PPSM for 72 hours with enzyme)) but significantly

(P<0.05) lower than those on diets T6, T7 and T8. This may be due to the cost of processing of PPSM by boiling and roasting. Consequently, income above feed cost of birds fed the control diet (₦ 251.95) was comparable to those on diets T2, T3, T4 and T5 but significantly (P<0.05) higher and better than those on diets T6, T7 and T8. These results implied that the control diet was comparably cost effective and profit rewarding with raw PPSM and those soaked with enzymes for various durations in quail diets.

4.6.2 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) on External and Internal Egg Quality Characteristics of Laying Quails (7 - 26 weeks)

The results of the effect of diets containing differently processed pigeon pea seed meal supplemented with enzyme on external and internal egg quality characteristics are presented in Table 4.15. The results showed that enzyme supplementation of differently processed PPSM had no significant (P>0.05) effect on all the external egg quality parameters evaluated. Similarly, no significant (P>0.05) difference was also observed for all the internal egg quality parameters measured across the dietary treatments.

4.6.3 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) on Nutrients Digestibility by Laying Quails (7- 26 weeks)

The result of the effect of diets containing differently processed pigeon pea seeds meal with enzyme supplementation on nutrient digestibility by quail birds is presented in Table 4.16. Significant (P<0.05) effects of dietary treatments on nutrient digestibility by birds were observed in all the parameters measured. Percentage digestibility of dry matter by birds fed diet 7 containing boiled PPSM with enzyme supplementation was comparable to those on other dietary treatments but significantly (P<0.05) higher compared to those on diets T2

Table 4.15: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on External and Internal Egg Quality Characteristics of Japanese Quail (7 – 26 weeks)

Parameters	TREATMENTS								
	1 (Control)	2 RPPSM + Vegpro	3 SPPSM (24hrs) + Vegpro	4 SPPSM (48hrs) + Vegpro	5 SPPSM (72hrs) + Vegpro	6 SFPPSM + Vegpro	7 BPPSM (60min)+ Vegpro	8 RPPSM (30mins) + Vegpro	SEM
EXTERNAL QUALITY									
Egg Weight (g)	9.13	9.57	9.32	9.07	9.18	9.43	9.15	9.13	0.37
Egg Height (mm)	30.79	31.55	31.49	30.98	31.07	31.57	30.95	30.92	0.71
Egg Diameter (mm)	23.33	23.87	23.51	22.97	23.30	23.40	23.25	23.19	0.68
Egg Shape Index	0.76	0.76	0.75	0.74	0.75	0.74	0.75	0.75	0.02
Egg Shell Weight (g)	1.00	1.03	1.00	0.99	1.00	1.02	1.00	1.03	1.47
Egg Shell Thickness (mm)	0.26	0.26	0.25	0.25	0.25	0.26	0.25	0.25	0.01
INTERNAL QUALITY									
Albumen Height (mm)	3.03	3.09	3.04	2.99	3.04	4.78	2.95	3.05	3.79
Albumen Diameter (mm)	31.96	32.86	32.40	32.38	32.25	32.52	32.34	32.19	1.40
Albumen Weight (g)	5.09	5.47	5.29	5.17	5.17	5.28	5.14	5.07	0.37
Yolk Height (mm)	9.53	9.60	9.66	9.50	9.50	9.73	9.55	9.34	0.70
Yolk Diameter (mm)	22.55	22.89	23.00	22.42	22.38	22.56	22.57	22.64	0.68
Yolk Weight (g)	3.08	3.22	3.18	3.09	3.14	3.23	3.14	3.14	0.29
Yolk Index	0.42	0.42	0.42	0.42	0.42	0.43	0.42	0.41	0.03
Haugh Unit	83.07	83.05	82.94	82.83	83.09	84.94	82.51	83.22	3.05

SEM = Standard Error of Means, RPPSM = Raw Pigeon Seed Meal, SPPSM = Soaked Pigeon Pea Seed meal, SFPPSM = Soaked and Fermented Pigeon Pea Seed Meal, BPPSM = Boiled Pigeon Pea Seed Meal, Roasted = Roasted Pigeon Pea Seed Meal

Table 4.16: Effects of Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Nutrients Digestibility by Laying Quails (7 – 26 weeks).

TREATMENTS Parameters	1 (Control)	2 RPPSM + Vegpro	3 SPPSM (24hrs) + Vegpro	4 SPPSM (48hrs) + Vegpro	5 SPPSM (72hrs) + Vegpro	6 S+FPPSM + Vegpro	7 BPPPSM (60mins) + Vegpro	8 RPPSM (30mins) + Vegpro	SEM
Dry Matter	68.88^{ab}	63.53^{b}	61.00^{b}	63.03^{b}	67.39^{ab}	67.91^{ab}	73.15^{a}	64.35^{b}	2.84
Crude Protein	83.29^{a}	78.84^{b}	77.89^{b}	79.11^{b}	82.84^{a}	83.87^{a}	85.80^{a}	80.92^{ab}	1.62
Crude Fibre	77.02^{bc}	72.39^{c}	78.27^{bc}	73.25^{c}	80.23^{ab}	77.19^{bc}	85.09^{a}	78.09^{bc}	1.92
Ether Extract	88.19^{ab}	88.24^{ab}	84.63^{b}	87.51^{ab}	87.98^{ab}	86.19^{ab}	93.05^{a}	87.40^{ab}	1.09
Ash	65.50^{a}	54.20^{b}	56.28^{b}	60.55^{ab}	64.94^{ab}	65.10^{ab}	71.83^{a}	57.68^{b}	3.36
NFE	59.19^{a}	53.07^{b}	48.74^{b}	51.80^{b}	56.72^{ab}	57.08^{ab}	64.22^{a}	53.37^{b}	3.71

NFE = Nitrogen Free Extract, abc = Means with different superscripts on the same row are significantly different (P<0.05), SEM = Standard Error of Means, RPPSM = Raw Pigeon Pea Seed Meal, SPPSM = Soaked Pigeon Pea Seed meal, SFPPSM = Soaked + Fermented Pigeon Pea Seed Meal, BBPSM = Boiled Pigeon Pea Seed Meal

(raw PPSM with enzyme), T3 (soaked PPSM for 24 hours with enzyme), T4 (soaked PPSM for 48 hours with enzyme)) and T8 (roasted PPSM with enzyme)**.** Percentage crude protein digestibility by birds fed diet 7 (containing boiled PPSM with enzyme) was similar to those on diets T1, T5, T6 and T8 but significantly ($P<0.05$) higher than those on diets T2, T3 and T4.

Percent crude fibre digestibility by birds fed diet 7 was also similar to those on T5 (containing soaked PPSM for 24 hours with enzyme) but significantly ($P<0.05$) higher compared to those on other treatments.Percent ether extract digestibility by birds fed diet 7 wassignificantly ($P<0.05$) higher than those on diet T3 (containing soaked PPSM for 24 hours with enzyme) but comparable to those on other dietary treatments. Percent ash digestibility by birds fed diet 7 was significantly ($P<0.05$) higher compared to those on diets T2, T3 and T8 but similar to those of other dietary treatments. However, percent digestibility of nitrogen free extract (NFE) by birds on diet 7 was significantly ($P<0.05$) higher than those on diet 2 (containing raw PPSM with enzyme), diet 3 (containing soaked PPSM for 24 hours with enzyme) and diet 4 (containing PPSM soaked for 48 hours with enzyme) but similar to those on other treatments.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Proximate and Chemical Composition of Pigeon Pea Seeds (PPS)

The percentage dry matter of raw pigeon pea seeds (90.26 %) was similar to those reported by Olomu (1995), Amaefule and Obioha (2001) and Matthew *et al.* (2010). The non-significant difference obtained in raw and the processed seeds suggested that processing methods employed had similar effect on the dry matter content of PPS. The percent crude protein value obtained for PPS in this study ranged between 21.25 % and 24.75 % for the raw seeds and the fermented seeds respectively. These values fell within the range of 17.90 to 30 % as reported by Siegel and Faweet (1976). Apata and Ologhobo (1993) also reported a range of 20.60to 27.70 % CP for raw pigeon pea. Furthermore, the CP obtained in this study also fell within the range 24 -30 % of plant protein sources as reported by Aduku (1992) and 23.50 % reported by Matthew *et al.* (2010). The higher crude fibre value of 7.32 % obtained in the raw PPS compared to values obtained in the processed seeds was an indication that processing reduced effectively the crude fibre content of PPS, especially boiling for 60 minutes and roasting for 30 minutes.

This result agrees with the findings of Aleto and Ojo (1989) who reported that cooking, roasting and auto claving generally reduced CF levels in legume seeds. The value of ether extract (1.89 %) obtained in this study for the raw pigeon pea seeds was higher than 1.50 % reported by Smarth (1976) but was within the range of 1.30 – 6.70 % reported by Apata and Ologhobo (1993). The values of ether extract obtained in processed PPS were significantly lower than that of the raw seeds. The significant decrease in the oil content of all the processed seeds caused by the processing methods could be due to leaching of the

oil into the water through soaking or boiling water or through volatilization of fats during roasting. The ash content in raw PPS was significantly affected by the processing methods. Total ash content decreased significantly from raw PPS down to all the processed PPS. Fermentation and boiling of pigeon pea seeds resulted in significant reduction of ash content compared to other processing methods. This may imply that some minerals especially soluble inorganic salts in the processed PPS got leached into the water through soaking and boiling and others may have been reduced by heat especially the heat labile minerals. The significantly higher nitrogen free extract (NFE) obtained for raw pigeon pea seeds compared to those of processed seeds may be due to reduction in NFE content caused by processing.

5.2 Effect of Anti –Nutritional Factors of the Pigeon Pea Seeds (PPS)

In this study, different processing methods significantly reduced anti nutritional factors inherent in raw pigeon pea seeds (PPS).The observed results agreed with the report of earlier workers (Grimaud, 1988; Ologhobo, 1992; D' Mello, 1992) who reported the presence of the anti nutrients in pigeon pea seeds identified in this study. The significantly higher percent reduction in the trypsin inhibitor by roasting of PPS for 30 minutes dry (heat treatment) observed in this study agreed with the findings of Liener and Kakade (1980) who reported that the protein inhibitors were easily denatured by heat. In addition, Balogun *et al.* (2001) also reported that heating improved the nutritional value of legume grains and also destroyed most of the heat labile anti nutritional factors. The result obtained also showed that fermentation and boiling as processing methods were effective in destroying ANFs in pigeon pea seeds. This was supported by the report of Liener (1981) who noticed the destruction of trypsin inhibitors during fermentation. Umoren *et al.* (2007) also

asserted that a 48 hours fermentation followed by sun drying for 3 – 4 days processes led to a remarkable reduction in the ANF. In addition, Opoku *et al.* (2003) reported that cooking or soaking can eliminate or reduce phytic acid content present in pigeon pea. However, destruction of some levels of anti nutritional factors in pigeon pea seeds by soaking for different durations such as 24 hours, 48 hours and 72 hours respectively as observed in this study revealed that soaking for 72 hours resulted in greater destruction of anti nutritional factors compared to soaking for 48 hours and 24 hours. This result agrees with the findings of Ologhobo and Fetuga (1984) who reported soaking in water for 96 hours followed by germination as an effective method of reducing phytic acid content of raw soybean seeds.

5.3 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal on Growth and Early Laying Performance of Quail Chicks (2 – 6 weeks)

The significantly higher final weight and weight gain observed in birds fed the control diet T1, T2, T3, T6 and T8 (containing roasted PPSM) could be due to good nutrient utilizationtraceable to effectiveness of processing by soaking PPS for 24 hours, fermentation, and roasting. This result is in agreement with the report of Omeje (1999) and Kaankuka *et al*. (2000) who reported that processing improves the utilization of proteins and energy contained in legumes. The significantly higher and improved feed intake observed with birds fed differently processed PPSM compared to those on the control diet could be attributed to the impact of processing in reducing anti nutritional factors (ANFs) which led to the improved palatability of the diet. This observation agreed with the findings of Nidaullah *et al.* (2010) who reported that smell and taste were critical traits in food selection.

The significantly better feed to gain ratio observed with birds fed the control diet and those on fermented PPSM based diet compared to those fed other dietary treatments could be attributed to improved rate of utilization of the dietary nutrients and conversion to gains. This observation agreed with the findings of Gebhart and Kabanov (2001) who reported that better feed conversion ratio signified that more feed was retained in the animals and less waste to the environment. The significantly better feed cost per gain observed with birds fed the control diet and fermented PPSM diet could be due to the lower feed to gain ratio, hence reduction in feed cost per kg gain of the diets. Generally, the higher feed intake recordedfor birds fed other PPSM based diets consequently resulted in poor feed to gain ratio, with the attendant increase in the cost per kg gain of the diets.

The similarity observed in the age of birds at first egg (days) across the treatments especially diets T1 to T7 could be attributed to high plane of nutrition with balanced amino acids in soybean - pigeon pea combination which may be responsible for the birds maturing early across the dietary treatments (Atteh, 2004). Similarly, lack of significant difference observed in first egg weight of birds fed the dietary treatments except those on diet T5 containing PPSM soaked for 72 hours may suggest balanced utilization of nutrients across the dietary treatments to produce the first eggs in relation to the age of the birds. This result agreed with the findings of Udeh (2010) who reported that a high correlation existed between the egg weights and the age of the birds. The generally low mortality across the treatments observed in this study supported the fact that quails are hardy birds and perhaps less disease - prone than other poultry birds. (Jadhav and Saddiqui, 2010).

5.3.1 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal on the Carcass Characteristics of Quail Birds

The final live weights of the birds in this study were slightly above the range of 136.60 – 143.06 g reported by Yisa *et al*. (2000). The higher live weight observed in birds fed the control diet which was comparable to those fed pigeon pea seed meal (PPSM) baseddiets could be attributed to balanced nutrient profile in terms of dietary amino acid and good nutrient utilization across the treatments.

The similar dressed weight observed in birds fed diets T1 (control), T2, T3 and T6 which were significantly higher than those of other dietary treatments may also be attributed to improved digestibility and better nutrient utilization. This result was in agreement with the report of Omeje (1999) and Kaankuka *et al*. (2000) who reported that processing improved the utilization of proteins and energy contained in legumes. The significantly higher dressing percentage observed in birds fed the control diet (T1) and those on T2, T3 and T6 compared to those on other diets may be attributed to good nutrient utilization which resulted in higher gains. The improved carcass weight observed in birds fed diets T1 (control), T2, T5 and T6compared to those on other dietary treatments was an indication that soaking and fermentation were effective as processing methods.

The significant differences observed in all the cut parts of birds across the dietary treatments is an indication that processing of PPSM was effective in improving the nutritive value of the diets. This result agreed with the findings of Omeje (1999) and Kaankuka *et al*.(2000) who reported that processing improved the utilization of proteins and energy contained in legumes.The similarity observed in the percent weights of heart obtained in birds across the dietary treatments except those on T6 was an indication that the

dietary treatments had no negative effect on the organ weights of the birds. However, the significantly higher percent gizzard weight obtained in birds fed T8 compared to those on other treatments indicated increased retention time of fibre in this organ, hence may affect the development of the gastro intestinal tract in different manners. This result agreed with the findings of Hetland and Svihus (2004). Similarity observed in the values obtained for percent weight of small intestine inbirds across all the dietary treatments except those on diet T6 containing fermented PPSM could be an indication of good nutrient digestibility as enhanced by processing.

The higher liver weights obtained for birds on diets T3, T4, T5 andT8compared to those of other treatments may be attributed to the presence of residual toxic factors in these dietary treatments which could not be detoxified by the organ. This result agreed with the report of Abeke *et al.* (2008) that hypertrophy of the organ may occur as a result of its attempt to increase protein availability or in the process of detoxifying the anti nutritional factors in the body of the birds.

5.3.2 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal on Haematological Parameters and Serum Biochemistry of Japanese Quails

Blood parameters is a reflection of the effects of dietary treatments on the animals in terms of the type, quality and amounts of the feed ingested andavailable for the animal to meet its physiological, biochemical and metabolic necessities (Ewuola *et al.,* 2004; Olorode, 2007;Odetola, *et al.,* 2012). The result of the haematological and serum biochemical indices obtained in this study showed that dietary treatments had significant effect on all the parameters measured except albumin.

Packed cell volume (PCV) is an index of toxicity, any reduction in its concentration in the blood usually suggested presence of toxic factors (haemaggutinins) which has adverse effect on blood formation (Oyawoye and Ogunkunle, 1998). The PCV values obtained in this study fell within the range 35 – 55 % reported for caged birds by Campbell and Coles (1986) which showed that the birds were not anaemic. It has been indicated that a PCV less than 35 % indicated anaemia.The non significant difference in the values of red blood cells (RBC) of birds fed the dietary treatments except those on diets T6 and T7 may suggest nutritional adequacy of the diets and safety of the test ingredient (PPSM).The values obtained for haemoglobin for birds across the treatments fell within the recommended haemoglobin concentration (7- 18.6 g/dl) for healthy birds (Maxwell *et al.,* 1990). The aim of estimating the haemoglobin content was to determine the oxygen carrying capacity of the bird's circulatory system (Mmereole, 1996).

The range of values (6.12 – 9.23 * $10^3/mm^3$) obtained for white blood cell count in birds across the dietary treatments suggests that there was no microbial infection or the presence of foreign bodies in the circulatory system of the birds.The values obtained for mean corpuscular volume (MCV), Mean corpuscular haemoglobin(MCH) and Mean Corpuscular Haemoglobin concentration (MCHC) in this study suggested nutritional adequacy of the diets.The high values (87.33 – 92.17 g/dl) of lymphocytes of birds across the dietary treatmentssuggested the resistance of the birds to disease conditions.The lymphocytes to neutrophil ratio in this study were similar to that reported by Fouad and Bynner (2008) who reported that greater lymphocytes: Neutrophil ratio was observed in caged chicken compared to those reared in floor pens. The cholesterol content of birds (4.19 and 5.82 g/dl.) fell within the normal range reported by Mitruka and Rawnsley, (1977) and Akinola

and Abiola, (1999). The values obtained for total serum protein of birds were within the normal range (3 – 9g/dl) recommended by Altman and Katz,(1979) and Maxwell *et al.* (1990) for healthy chicken. The non significant difference in the total serum protein observed among birds on PPSM based diets may suggest the nutritional adequacy of the diets and safety of the test ingredient.Creatinine level was a pointer to extent of muscular activity in the body of the birds. Similar creatinine values obtained in this study suggested that there was no muscular stress caused by anti nutritional factors in birds across the dietary treatments.

5.3.3 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal on Digestibility of Nutrients by Quails

The significantly higher digestibility of dry matter, crude protein, ash and NFE observed in birds fed the control diet may be attributed to high nutrient profile in terms of balanced protein (amino acid profile) as more amino acids and other nutrients in the diet were consumed and efficiently used for the improved higher weight gain observed in the birds. In addition, the higher similarity observed in nutrient digestibility by birds fed processed PPSM based diets was an indication of equal and balanced nutrient utilization of birds across the treatment groups. This agreed with the findings of Omeje (1999) and Kaankuka *et al*. (2000) who reported that processing improves the utilization of proteins and energy contained in legumes. The comparable values obtained for percentage digestibility of crude fibre observed in birds fed diets T1, T2, T5, T7and T8 was an indication that processing through soaking, boiling and roasting reduced drastically the crude fibre content of the diets, thus enhanced CF digestibility. This result agreed with the work of Opoku *et al.* (2003) who reported that cooking and soaking can eliminate or reduce the phytic acid content present in pigeon pea and mung beans. Balogun *et al.* (2001) also reported that

heating improved the nutritional value of legume grains and also destroyed all the heat labile anti nutritional factors.

The significantly higher percentage ether extract digestibility observed in birds fed the control diet, diets T2 and T5 compared to those on other dietary treatments was an indication of good nutrient utilization. However, the observed improvement in the digestibility of nutrients by birds fed T2 probably may be due to the unique ability of quails to tolerate and handle anti nutritional factors (ANFs) in PPS compared to other poultry speciesespecially because of their adaption in the wild. Generally, the observed improvement in the digestibility of nutrients by birds fed differently processed PPSM based diets which compared favourably with those on the control agreed with the findings of Omeje (1999) and Kaankuka *et al* .(2000) who reported that processing improves the utilization of proteins and energy contained in legumes.

5.4 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal on Laying Performance of Quails and Economic Benefits (7 – 26 weeks)

The significantly higher final weight and percent change in body weights observed in birds fed the control diet T1, T2, T3 and T7 may be due to good nutrient utilization as protein in pigeon pea seeds (PPS) complemented that of soybean leading to the improved weight gain. It also showed that processing through soaking and boiling reduced anti nutritional factors in PPS hence, resulted in higher nutrient utilization and improved weight gain. This result agreed with the work of Opoku *et al.* (2003) who reported that cooking and soaking could eliminate or reduce the phytic acid content present in pigeon pea and mung beans. However, the improved weight gain observed in birds fed diet 2 containing raw PPS disagrees with the report of Amaefule and Obioha (2001) and Kaankuka *et al.* (2000) that

raw or improperly heated legume seeds fed as the main source of protein in diets for monogastrics can depress growth and efficiency of feed utilization.

The significantly higher feed intake observed in birds fed processed PPSM based diets compared to those fed the control diet was an indication that the diets were palatable and attractive.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. The significantly better feed conversion ratio observed in birds fed diets T1, T3, T4 and T6was an indication that feed was converted more efficiently into gains in terms of tissues and egg produced by the birds. In addition, the feed conversion ratio observed in this study compared favourably with the values reported for laying quails fed varying levels of protein by Bawa*et al.* (2011). The significant higher average egg weights observed in birds fed diets T2 and T3may be attributed togood nutrient utilization enhanced by soaking of PPSM for 24 hours. This result agreed with the finding of Ologhobo (1989) who reported soaking of soybeans as effective method of processing.

The significantly higher percent hen housed production observed among birds fed dietsT2, T3, T4, T6 and T8 when compared to other dietary treatments may be attributed to improved feed consumption and good nutrient utilization which led to better production performance. The significantly higher percenthen day production observedin birds fed diets T1, T2, T3, T5 and T7 compared to other PPSM based diets may be attributed to enhanced quality and balanced feed utilization of the treatments. The observed low feed cost per dozen egg and crate of eggs in birds fed diet 4 containing soaked PPSM for 24 hours and the control diet may be attributed to reduction in the cost of feed required to produce a dozen and a crate of eggs respectively. It was more economical to produce a

dozen and a crate of eggs with diet 4 and the control diet than when other diets were used. The significantly better income above cost of feed per dozen and crate of eggs observed in diet 4 and the control diet was an indication of cost effectiveness.

This result was contrary to the report of Abeke (2005) who reported a significantly low income above feed expenses for the laying hens fed diets containing lablab seeds. The result also showed that PPS had no negative effect on the age at which the birds reached peak of egg production. The high plane of nutrition with balanced amino acids in soybean-pigeon pea combination could be responsible fortheobserved values (Atteh, 2004).

5.4.1 Effects of Feeding Diets containing Differently Processed Pigeon Pea seed Meal on External and Internal Egg Quality Characteristics of Laying Quails (7-26 weeks)

The non significant difference observed in the external egg quality characteristics in terms of egg weight, egg height and egg diameter and internal egg quality parameters in terms of yolk, albumen and Haugh unit of birds in this study could be attributed to balanced nutrient utilization across the treatments and that inclusion of PPSM had no negative effect on the external and internal egg quality characteristics of the quails. This result was in agreement with the findings of Abeke (2005) who reported that inclusion of lablab seeds in the diets of laying hens had no significant effect on the yolk index, Haugh unit, shell index, shell thickness and shell percentage.

The albumen quality across the dietary treatments was indicated by the Haugh unit values. The non significant effect noticed in the Haugh unit values was an indication of an improvement in the albumen height and quality caused by feeding PPSM to the quails. The results agreed with the findings of Austic and Nesheim (1990) that Haugh unit was not

influenced mainly by diet but that it was influenced by albumen consistency which was dependent on the age of the hen, genetics and storage of the egg (Jones and Dangl, 2006).

5.4.2 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal on Digestibility of Nutrients by Laying Quails (7 – 26 weeks)

The significant higher dry matter and crude protein digestibility observed in birds fed diets T1, T3, T4, T5, T6 and T7 compared to those on diets T2 and T8 may be attributed to better reduction of anti nutritional factors in the seeds due to processing which led to improved palatability and better nutrient utilization in the dietary treatments. This result agreed with the findings of Opoku *et al*. (2003) who reported that cooking or soaking can eliminate or reduce phytic acid content present in pigeon pea. Purseglore (1968) also associated bitter taste and un - palatability of raw legumes to anti nutritional factors.

The result also showed that processing by boiling and soaking had significant effect on the crude fibre and NFE digestibility as the experimental birds fed diet 7 (containing boiled PPSM) and diet 3 (containing soaked PPSM for 24 hours)were able to digest higher percentage of CF and NFE. This observation suggested that boiling and soaking produced more soluble fibre fraction in pigeon pea seeds and also enhanced the digestibility of the soluble carbohydrates. This finding was supported by Nwokolo and Orji (1985) who established that soaking in water and cooking can also improve the nutritional status of grain legumes.

The similarity observed in the percent digestibility of ether extract in birds across the dietary treatments except those on diet 8 (containing roasted PPSM) suggests balanced nutrient utilization across all the treatments. The significantly higher percentage digestibility of ash by birds fed diets 7 (containing boiled PPSM) and diet 3 (containing

soaked PPSM for 24 hours) compared to other treatments could be attributed to greater reduction in the level of phytin caused by boiling and soaking of PPS for 24 hours which resulted in improved release and utilization of minerals in the diets. This result agreed with the findings of Opoku *et al*. (2003) who reported that cooking or soaking could eliminate or reduce phytic acid content present in pigeon pea.

5.4.3 The Economics of Feeding Diets containing Differently Processed Pigeon Pea SeedMeal to Laying Quails (7 – 26 weeks)

The significantly lowered feed cost per dozen eggs and cost per crate of eggs observed in birds fed diet 4 containing soaked PPSM for 48 hours and those in the control group compared to other treatments may be attributed to lower kg feed consumed per egg produced and reduced feed wastage. This implied that cost of feed for producing eggs of almost the same weight by birds on diet 4 and the control was relatively better when compared to those in other treatment groups. The significantly lower cost of feed per dozen eggs and crate of eggs observed with birds fed diet 4 and those on the control diet justified the accrued higher income above feed cost recorded for birds on these diets. Therefore, in locations where pigeon pea is popularly grown especially during the production season when the supply is in abundance, cost will be drastically reduced and this will certainly cut down production cost, hence a higher income for poultry farmers. In addition, this development will force downthe high demand and the escalated price of soybean for poultry hence, availability of poultry products at affordable price to the final consumers.

5.5 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed meal with Enzyme (Vegpro) Supplementation on the Growth and Early Laying Performance of Quail Chicks (2 - 6 weeks)

The significantly higher final weight and weight gain observed in birds fed T1, T2, T3and T7compared to those on other treatments may be due to higher reduction of anti nutrients in pigeon pea seeds which enhanced better nutrient utilization in the diets. However, the improved weight and weight gain observed in birds fed diet 2 (containing raw PPSM with enzyme) disagreed with the report of Ologhobo and Fetuga (1984) and Kaankuka *et al.*, (2000) who reported that raw or improperly heated legume seeds fed as the major source of protein in diet for monogastrics can depress growth and efficiency of feed utilization.

Significantly higher feed intake observed in birds fed PPSM based diets supplemented with enzymes compared to the control may be attributed to the effect of enzyme supplementation on processed pigeon pea seeds which improved taste; hence the feed intake. This result agreed with Omeje (1999) and Kaankuka *et al.*, (2000) who reported that processing improved the utilization of proteins and energy contained in legumes. Nidaullah *et al.* (2010) also reported that smell and taste were critical traits in food selection. The significantly better feed to gain ratio observed in birds fed diets T1 and T4 compared to those on other dietary treatments may suggest a good nutrient utilization by the birds. It may also be that feed wastage was minimal for birds in these treatments compared to those other groups; hence they were able to eat and convert the feed to tissues. This observation also agreed with the findings of Gebhart and Kabanov(2001) who reported that better feed conversion ratio signified that more feed was retained in the animals and less waste to the environment. The significantly better feed cost per kg gain

observed in birds fed diets T1 and T4 could be as a result of lower feed intake with better feed conversion ratio; hence lower feed cost per kg gain.

The result also showed that birds across the dietary treatments came to lay at early age and this may be attributed to the effect of enzyme supplementation on the dietary treatments. The significantly higher first egg weight (8.33 g) observed in birds fed diets T2 (raw PPSM with enzyme) and T3 (PPSM soaked for 24 hours with enzyme)compared to those in other treatments may be attributed to good nutrient utilizationenhanced by soaking and enzyme supplementation though these were comparable to those on other PPSM based diets.

Generally, it was observed that birds on differently processed pigeon pea seeds with enzyme supplementation had significantly higher first egg weight compared to the control group. This result agreed with the findings of Eruvbetine *et al*. (2002) who reported that the addition of enzyme like amylase and xylanases enhanced the utilization of non starch polysaccharides (NSP) components while proteases enhanced the utilization of proteinaceous components of feeds. It was also observed that the dietary treatments had no negative effect on the performance and health status of the birds. The low mortality recorded in this study agreed with the fact that quails are hardy birds and perhaps less disease – prone than other poultry birds (Jadhav and Saddiqui, 2010).

5.5.1 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro $^{(R)}$) Supplementation on Carcass Characteristics of Quails

The significant higher live weight observed in birds feddiets T1, T2, T3, T4 and T7 compared to those in other treatment groupsmay be attributed to good nutrient utilization in the diets. The significant higher dressed weight observed in birds fed the control diet

compared to those of other treatments may be attributed to good nutrient utilization. However, the non significant difference observed in thedressing percentages and carcass weights of birds across the treatments could be an indication of balanced nutrient utilization enhanced by effectiveness of processing and the adequate amino acids available in the diets. This result agreed with Omeje (1999) and Kaankuka *et al.*, (2000) who reported that processing improved the utilization of proteins and energy contained in legumes.

Significant differences were observed in the values for the percent weight of all the cut parts of the birds which showed that enzyme supplementation of PPSM had significant effect on all the primal cuts. The result obtained for organ weights of birds in terms of heart (%), gizzard (%), and small intestine also showed that the dietary treatment had significant effect on the birds' digestive organs and no negative effect of the diets on both the organs and health status of the birds was recorded. Esonu *et al.* (1999) reported that organ weights were an index of nutrients retained by the birds. However, the significantly higher percent weights of liver observed in birds fed T3, T5and T8 may be due to increased activity of the organs in handling residual toxic factors in PPSM. This agreed with the report of Abeke *et al.* (2008) that hypertrophy of the organ may occur as a result of its attempt to increase protein availability or in the process of detoxifying the anti nutritional factors in the body of the birds.

5.5.2 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on the Haematological Parameters and Serum Biochemistry of Japanese Quails

The similar trend and higher packed cell volume (PCV), heamoglobin (Hb) and red blood cells (RBC)observed in birds fed diets T1 - T 6 with enzyme compared to other dietary treatments may indicate the nutritional adequacy of the diets and safety of test ingredients. The packed cell volume (PCV)values obtained in this study fell within the range 35 – 55 % reported for caged birds by Campbell and Coles (1986) which showed that the birds were not anaemic. It has been indicated that a PCV less than 35 % indicated anaemia. The values obtained for red blood cells (RBC) of the birds across the dietary treatments also showed that the birds were of good health status.

The values obtained for haemoglobin for birds across the treatments fell within the recommended haemoglobin concentration (7- 18.6 g/dl) for healthy birds (Maxwell *et al.,* 1990).The result showed that the birds were not anaemic due to their high oxygen carrying capacity.It has been indicated that birds with low oxygen carrying capacity can easily succumb to any form of respiratory disease while birds with high haemoglobin concentration can be regarded as having high oxygen carrying capacity and such birds were likely to withstand some levels of respiratory stress (Salisbury, 1983).

Significant higher values for white blood cells count (WBC) obtained in birds fed dietsT2, T3, T4, T6 and T7compared to those fed other diets may be as a result of high or very fast rate of production of white blood cells (WBC) population in the bone marrow compared to other dietary treatments. However, the result of the white blood cells count (WBC) could suggest that there was no microbial infection or the presence of foreign body in the circulatory system of the birds. White blood cells (WBC) play prominent role in disease resistance especially with respect to the production of antibodies and the process of phagocytosis (Soetan *et al.,* 2013).

The values obtained for Mean corpuscular volume (MCV) (%), Mean corpuscular haemoglobin (MCH) (pg), and Mean corpuscular haemoglobin concentration (MCHC) (%) across the treatments could suggest that the diets were nutritionally adequate. The lymphocytes values obtained in this study ranged from 87.10 – 94.89 g/dl. The lymphocytes to neutrophil ratio in this study was similar to that reported by Fouad and Bynner (2008) who reported that greater lymphocytes: neutrophil ratio were observed in caged chicken compared to those reared in floor pens.

The non significant difference in total protein of birds across the treatments except those on diet 3 may suggest the nutritional adequacy of the diets and safety of the test ingredient. The values obtained in this study were within the normal range (3 – 9g/dl) recommended by Altman and Katz (1979) and Maxwell *et al*. (1990) for healthy chickens. The cholesterol content of birds (4.30 and 7.16 g/dl) in this study fell within the normal range reported by Mitruka and Rawnsley (1977) and Akinola and Abiola (1999).

5.5.3 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Digestibility of Nutrients by Quail Chicks

The observed similarity in percentage dry matter digestibility by birds fed diets T7 and T8 and those of other treatments except those on T3 may be attributed to the beneficial effect of enzyme supplementation on processed pigeon pea seed meal (PPSM). This result agreed with the findings of Eruvbetine *et al*. (2002) who reported that the addition of enzyme like amylase and xylanases enhanced the utilization of non starch polysaccharides (NSP) components while proteases enhanced the utilization of proteinaceous components of feeds.

The similarity observed in percentage crude protein digestibility by birds across the treatments except those on dietsT2 and T3 showed that enzyme supplementation of processed PPSM reduced anti nutritional factors, hence improved crude protein digestibility by the birds. The similarity observed in the percentage digestibility of crude fibre, ether extract and ash by birds across the dietary treatments except those fed diet 3 was an indication that enzyme supplementation reduced anti nutritional factors in pigeon pea seed hence, enhanced nutrients digestibility. Percentage NFE digestibility was similar and significantly lower in birds fed diets T3 and T6 compared to those on other treatments. Generally, this result may be an indication of balanced ingestion and utilization of nutrients by birds across all the dietary treatments as enhanced by processing of PPSM with enzyme supplementation. This agreed with the findings of Omeje (1999) and Kaankuka *et al*. (2000) who reported that processing improved the utilization of proteins and energy contained in legumes.

5.6 Effects of Feeding Diets containinig Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Laying Performance of Quails and Economic Benefits(7- 26 weeks)

The significantly higher final body weight and percent change in body weight observed in birds fed diets T2, T1, T3and T7 compared to those in other treatment groupsmay be due to good nutrient utilization by birds on the diets which led to the improved weight gain. Furthermore, the result also indicated that soaking and boiling of PPS with enzyme supplementation were effective in reducing anti nutritional factors hence, the improvement inthe nutritive value of the pigeon pea seed and the weight gain of the birds.This result agreed with the work of Opoku *et al.* (2003) who reported that cooking and soaking can eliminate or reduce the phytic acid content present in pigeon pea and mung beans.

However, the improved weight gain observed in birds fed diet 2 containing raw PPS disagrees with the report of Amaefule and Obioha (2001) and Kaankuka*et al*. (2000) that raw or improperly heated legume seeds fed as the main source of protein in diets for monogastrics could depress growth and efficiency of feed utilization. The significant higher feed intake observed in birds fed T6 and other PPSM based diets supplemented with enzyme compared to those in the control group may suggest that anti nutritional factors were drastically reduced through processing which resulted in improved palatability and good aroma of the diets hence, better feed consumption. The significantly betterfeed conversion ratio observed in birds fed the control diet and those on dietsT3 and T4 suggested that feed was converted more efficiently into gains in terms of tissues and eggs produced by birds in these treatment groups. In addition, the feed conversion ratioobserved in this study compared favourably with the valuesreported for laying quails fed varying levels of protein by Bawa *et al.* (2011).

The comparable values of average egg weights obtained in birds fed T2 and T6 and those in other treatment groups except T4 suggestedbalanced and efficient feed nutrient utilization by birds across the treatments.However, the lack of significant difference observed in percent hen housed egg production, percent hen day egg production and percent peak egg production of birds across the treatments could be attributed to equal and balanced nutrients utilization by birds across the dietary treatment groups. This result agreed with the findings of Tuleun and Dashe (2010) who reported no significant difference in the percent hen housed egg production and percent hen day production of laying quails fed dietary levels of toasted mucuna seed meal (TMSM). The result also showed that PPSM with enzyme had no negative effect on the age at which the birds

reached peak of egg production. The high plane of nutrition with balanced amino acids in soybean-pigeon pea combination could be responsible for the observed values (Atteh, 2004).

The significantly lower feed consumed per dozen eggs, feed consumed per crate of eggs and higher income above feed observed in birds fed the control diet (T1) and those fed PPSM diets T2, T3, T4 and T5 supplemented with enzyme could be an indication of cost effectiveness and may be attributed to reduction in the cost of feed required to produce a dozen and a crate of eggs respectively for birds fed diets T1, T2, T3, T4 and T5. It was more economical to produce a dozen and a crate of eggs with diets T1, T2, T3, T4 and T5 supplemented with enzyme compared to diets T6, T7 and T8. Significant differencein mortality observed among birds across the treatments may be due to heat stress during the period of the study.

5.6.1 Economics of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal Supplemented with Enzyme (Vegpro) to Laying Quails (7 -26 weeks)

The result indicated that the inclusion of differently processed pigeon pea seeds meal (PPSM) in the diets of laying quails resulted in a significantly higher kg feed per egg for birds on diet 6 compared to other dietary treatments.

The significantly lower feed cost (₦) per dozen eggs, feed cost (₦) per crate of eggs observed in birds fed diets T1and those on T2, T3, T4 and T5 compared to those on diets T6, T7 and T8may be due to the cost of processing of PPSM by boiling and roasting. Consequently, income above feed cost of birds fed the control diet (₦251.95) was comparable to those on diets T2, T3, T4 and T5 and these were higher and significantly better than those on diets T6, T7 and T8. This result may imply that the control diet

followed by raw PPS and those processed by soaking for durations of 24, 48 and 72 hours with enzyme supplementation respectively were cost effective and profit rewarding in quail diets compared to those fermented, boiled and roasted.

5.6.2 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on External and Internal Egg Quality Characteristics of Laying Quails (7-26 weeks)

Thenon significant differences in external and internal egg quality characteristics of birds across the dietary treatments was an indication that processed pigeon pea seed meal supplemented with enzyme had similar influence on all the parameters measured. The lack of significant differences may be attributed to good and balanced nutrient utilization across all the dietary treatments.

These results also agreed with the findings of Timbrell (1992) who reported that there could be instances where enzyme treatment or supplementation adds little value to particular ingredients or even fails to result in improved performances.

5.6.3 Effects of Feeding Diets containing Differently Processed Pigeon Pea Seed Meal with Enzyme (Vegpro) Supplementation on Nutrient Digestibility by Laying Quails (7- 26 weeks)

The significantly higher percentage digestibility of dry matter observed in birds fed T7and those in other dietary treatments compared to those on T2, T3, T4and T8may be attributed to better reduction of anti nutritional factors through processing which led to improved digestibility of the dry matter. However, the similarity observed in the percentage crude protein digestibility by birds fed diet 7 and those on T1, T5, T6 and T8 was an indication that processing enhanced better nutrient release and utilization in those diets compared to other PPSM based diets T2, T3 and T4.

Significantly higher percent crude fibre and ether extract digestibility by birds fed T7and T5 compared to those of other treatments showed the effectiveness of boiling and soakingof pigeon pea seeds with enzyme supplementation on nutrient utilization by quail birds.

The similarity in percent ether extract digestibility by birds fed T7and other dietary treatments except those on T3 showed balanced nutrient utilization enhanced by processing of PPSM across the treatments. The percent ash and NFE digestibility by birds fed T7 and those on other treatments was an indication that processing enhanced higher release, digestion and utilization of mineral nutrients and soluble carbohydratesin PPS for egg productionand maintenance. Generally, these results agreed with the findings of Omeje (1999) and Kaankuka *et al.* (2000) who reported that processing improves the utilization of proteins and energy contained in legumes.

5.7 Comparison of the Effects of Feeding Diets containing Differently Processed Pigeon Pea Seeds with and without Enzyme Supplementation on Growth and Laying Performance of Japanese Quails

From the results of the studies carried out to investigate the effect of differently processed pigeon pea seeds with and without enzyme supplementation, the following points are deduced to compare the two experiments:

i) The result showed that enzyme supplementation of pigeon pea seeds meal (PPSM) had no significant effect on the final weight and weight gain of birds as birds fed fermented PPSM without supplementation had higher final weight and weight gain compared to those on enzyme supplemented PPSM diets in the chick phase.

ii) Feed intake of birds fed differently processed PPSM with and without enzyme supplementation were significantly ($P<0.05$) better than those on the control diet both at chick and laying phase.

iii) Enzyme supplementation of differently processed PPSM resulted in improved or heavier first egg weight of birds as observed in birds fed diet 2 containing raw PPSM with enzyme and diet 3 containing soaked PPSM for 24 hours with enzyme compared to first egg weight of birds fed differently processed PPSM without supplementation in the chick phase.

iv) Enzyme supplementation improved digestibility of nutrients across all the treatments both at the chick and laying phase.

v) Enzyme supplementation of PPSM had significant ($P<0.05$) effect on the weight of cut parts of birds compared to those fed un-supplemented PPSM diets.

vi) Enzyme supplementation of differently processed PPSM did not significantly ($P>0.05$) affect percent hen day egg production, percent hen housed egg production and percent peak egg production. However, the values obtained were numerically higher compared to those obtained in birdsfed un - supplemented PPSM diets.

vii) Enzyme supplementation of PPSM had lower cost benefit in quail diets when compared with processed PPSM without enzyme as diet 4 containing soaked PPSM for 48 hours without supplementation had higher cost per dozen eggs, cost per crate of eggs and income above cost of feed compared to the PPSM supplemented diets.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

The need to improve the performance of Japanese quails while at the same time reducing the cost of feeding through the use of cheaper and available feed ingredients cannot be over emphasized. In this study four experiments were conducted to evaluate the effect of differently processed pigeon pea seed meal (PPSM)on the growth and laying performance of Japanese quails and possible improvement through enzyme supplementation.

The laboratory analysis showed that PPS has high percent crude protein content (21.25 - 24.75 %) which was an indication that it could be used as a source of protein and the NFE values (63.38 - 68.67 %) recorded was an indication that it was rich in soluble carbohydrates. Thus the potential of PPS in improving performance of poultry and other livestock.Furthermore, the different processing methods led to significant destruction of the anti nutritional factors in pigeon pea seeds especially those identified in this study. Apart from roasting for 30 minutes with the highest reduction of all the anti nutritional factors, boiling for 60 minutes and fermentation were also promising methods for processing pigeon pea. However, soaking of PPS for 24, 48 and 72 hours had the least reduction of anti nutritional factors.

The result of the first experiment showed that the final weight and weight gain of birds fed dietsT1, T6, T2, and T8 were significantly better compared to those on other dietary treatments. This may suggest good nutrient utilization as enhanced by processing of pigeon pea seeds. Higher feed intake observed with birds fed PPSM based diets suggested that processing of PPS enhanced palatability of the diets which resulted in increased feed

consumption compared to those in the control group. Better feed: gain, feed cost per kg gain observed in birds fed the control and those on diet 6 (containing fermented PPSM)was an indication that the control diet and diet 6 had better nutrient utilization, less feed wastage and were also cost effective compared to other PPSM based diets.The non significant difference in the weight of first egg of birds across the treatments except those fed diet 5 was also an indication of balanced nutrient digestibility and utilization by birds.The range of values obtained in all the haematological parameters and serum biochemistry of birdsacross the treatmentsin this study were within the range recommended for healthy chickens. In addition, inclusion of processed PPSM had no negative effect on the health status of the birds and was therefore safe for use in poultry.

In the second experiment (laying phase), the final weight and percent change in body weight were higher for birds on the control diet,diets T7, T3 and T2 compared to those on other treatments. Higher feed intake was recorded in birds fed PPSM based diets compared to those in other treatment group. This was an indication that processing enhanced palatability and nutritive value of PPS which resulted in significantly higher feed consumption. Significantly better feed conversion ratio, lower kg of feed per dozen eggs, cost of feed per crate of eggs, income above cost of feed were recorded in birds fed the control diet and those on diet 4 containing soaked PPS for 48 hours.This was an indication that these diets had better nutrient utilization and were cost effective compared to other dietary treatments.

Higher average egg weights were observed in birds fed diets T3 and T2. There was no significant difference in the age at peak of lay of birds across the dietary treatments. Hen housed production (%) and peak egg production (%) were higher for birds fed diets T2

(raw PPSM), T3 (soaked PPSM for 24 hours), T4 (soaked PPSM for 48 hours), T6 (fermented PPSM) and T8 (roasted PPSM) compared to those in other treatments. However, percent hen day production of birds fed diets T4, T6 and T8 were similar and significantly lower compared to those in other treatment groups. Processing of PPSalso had no significant effect on external and internal egg quality characteristics of birds but enhanced digestibility of nutrients across all the dietary treatments.

The results of the third experiment showed that higher final weight and weight gain were observed in birds fed the control diet, T2 (raw PPSM), T3 (soaked PPSM for 24 hours) and T7 (boiled PPSM) with enzyme supplementation were significantly higher compared to those in other treatment groups. Higher feed intake was obtained in birds fed PPSM based diets as birds consume more of the PPSMbased diets supplemented with enzyme than the control. Better feed to gain ratio and feed cost per kg were obtained in birds fed diets T1 and T4 containing PPSM soaked for 48 hours. The age at first egg (days) of birds were similar across all the dietary treatments which clearly showed that the diets were balanced and efficiently utilized by the birds. Enzyme supplementation of processed PPSM enhanced higher egg weight in birds fed dietsT2 (raw PPS with enzyme) and T3 (soaked PPS for 24 hours with enzyme) and were significantly higher than those in the control group. Enzyme supplementation of PPSMimproved digestibility of nutrients and also had significant effect on the entire carcass and haematological parameters without any negative effect on the performance and health status of the birds.

The result of the fourth experiment showed that birds fed thecontrol diet T1,diet 2 (Raw PPSM with enzyme) and diet 3 (soaked PPSM for 24 hours with enzyme) and diet 7 (boiled PPSM with enzyme) had significantly higher final weight and percent change in

body weight compared to those in other treatment groups. Significantly higher feed intake was observed in birds fed PPSMbased diets compared to those in the control group.

Significantly better feed conversion ratio was observed in birds fed the control diet T1, diet3 (PPSM soaked for 24 hours) with enzyme and diet 4(PPSM soaked for 48 hours) with enzyme compared to those in other treatment group.the control diet T1 and those on T2, T3, T4 and T5had better feed cost per dozen eggs, feed cost per crate of eggs and higher income above feed cost compared to other treatments. However, enzyme supplementation of PPSM had no significant effect on hen housed egg production (%), percent hen day egg production (%) and peak egg production (%)of birds across the dietary treatments which showed uniform effect of enzyme supplementation on all the PPSM diets. Enzyme supplementation of processed PPSM had no significant effect on all the external and internal egg quality parameters but improved digestibility and utilization of nutrients bybirds across all the treatments.

6.2 Conclusion

From the results obtained in this study, the following conclusions are drawn:

1) Roasting, boiling and fermentation of PPS reduced the level of anti nutritional factors inherent in the raw seeds.
2) Boiling, Fermentation and soaking of pigeon pea seeds (PPSM) for 24 hours and raw PPSM enhanced digestibility of nutrients, nutrients utilization and performance of quail birds.
3) Inclusion of 30 % PPS soaked for 48 hours in quail diet resulted in significant reduction of feed cost and higher income above feed cost compared to other PPSM based diets.
4) Inclusion of 30 % raw pigeon pea seed meal (PPSM), 30 % soaked PPSM for 24 hours and 30 % boiled PPSM for 60 minutes with enzyme supplementation in quail diets improved digestibility of nutrients and growth performance of quails
5) Enzyme supplementation of differently processed PPSM enhanced digestibility of nutrients and improved growth performance of quail birds.
6) Enzyme supplementation of differently processed PPSM improved egg laying performance of birds across all the treatments in terms of hen day egg production (%), hen housed egg production, peak egg production and age at peak of lay of quails.
7) Enzyme supplementation of pigeon pea seeds meal (PPSM) especially diet T4 (containing soaked PPSM for 48 hours) had cost benefit in quail diet compared to other PPSM diets.
8) Inclusion of 30 % raw PPSM with or without enzyme supplementation improved performance, cut down cost, removed stress of processing and had had no adverse effect on the health status of quails.

6.3 Recommendations

Based on theabove conclusion, the following recommendations are made:

i) Boiling of pigeon pea seeds (PPS)for 60 minutes, fermentation and soaking for 24 hours are recommended in quail diets for optimum growth and laying performance.

ii) Enzyme supplementation of pigeon pea seeds boiled for 60 minutes and soaked for 24 hours are recommended for optimum egg laying performance in quail diets.

iii) Raw pigeon pea seeds with and without enzyme supplementation in quail diets was cost and energy saving and poses no threat to performance and health status of quail birds.

iv) Pigeon pea seeds is recommended as a good protein source for replacement of soybean in quail diets. Being a seasonal crop, it can be sourced for during the cropping season when its production is abundant and cheaper especially in those locations where its production is popular.

REFERENCES

Abeke, F. O. (2005). *Evaluation of the nutritive value of Lablab purpureus beans in replacement for groundnut cake in poultry diets* (Doctoral dissertation, Ph. D Thesis, Ahmadu Bello University, Zaria, Nigeria).

Abeke, F. O., Ogundipe, S. O., Dafwang, I. I., Sekoni, A. A., Abu, A. and Adeyinka, I. A. (2008). Effect of duration of cooking on the levels of some anti-nutritional factors on nine varieties of Lablab purpureus beans. *Nigerian Journal of Animal Prod*uction 35 (3): 217-223.

Aboosadi, M.A. (1998). *Enzyme supplementation of rice bran based broiler diets*. Ph.D. Thesis. University of Aberdeen, U.K.

Aduku, A. O. (1992). Practical livestock feeds production in the tropics. *Zaria. S. Asekome and Co. Publishers*.

Aduku, A. O. (1993). Tropical feedstuff analysis table. Department of Animal Science, Ahmadu Bello University, Zaria. Nigeria.

Akhtaruzzaman, A.F.M., Saddique, A.B. and Chowdhury, A.R. (1986). Potentiality of pigeon (arhar) plant for pulping. *Bano Bigyan Patrika15*(1-2): 31-36.

Akinola, S.O. and Abiola, S. S. (1999). Blood chemistry and carcass yield of cockerels fed melon husk diets. *NigerianJournal of Animal Science*, *2*(2): 35 - 41.

Akintunde, A.R., Omage, J.J. and Bawa, G.S. (2013). Effects of Allzyme SSF® supplementation of differently processed pigeon pea (*Cajanus cajan*) seeds on the performance and carcass characteristics of broiler chickens. *Nigerian Journal of Animal Science15*: 83-94.

Akpojovwo, A. E. and Onimawo, I. A. (2006). Toasting (dry heat) and nutrient composition, functional properties and antinutritional factors of pigeon pea (*Cajanus cajan*) flour. *Journal of Food Processing and Preservation30*(6): 742-753.

Aleto, V.A. and Ojo.O.I. (1989). Changes in differently processed soybean (Glycine Max) and Phaseolus hunatus. With particular reference to the chemical and their mineral and some inherent anti nutritional constituents. *Nahrung* 33: 1009 – 1016.

Aleto, V.A., Goodchild, A.V. and Abdel Modein, A.M. (1994). Nutritional and anti nutritional characteristics of selected vicia genotypes. *Animal Feed Science and Technology* 47: 125 - 139

Altman, P. L. and Katz, D. D. (1979). Inbred and genetically defined strains of laboratory animals. *Part 2:* Hamster, Guinea pig, rabbit, and chicken. Federation of American Societies for Experimental Biology.

Allen, C.M., Bedford, M.R. and Mc Cracken, K.J.(1996). Effects of rate of wheat inclusion and enzyme supplementation on diet metabolizability and broiler performance. *British Poultry Science37*:544-545.

Amaefule, K.U. and Obioha, F.C. (1998). The substitution of pigeon pea (*Cajanus cajan*) seeds for groundnut cake and maize in broiler finisher rations. *Nigeria Journal of Animal Production* 25 (1): 9 – 12.

Amaefule, K.U. and Obioha, F.C. (2001). Performance and nutrient utilization of *broiler* starters fed diets containing raw boiled or dehulled pigeon pea (*Cajanus cajan*) seeds. *Nigerian Journal of Animal Production* 28 (1): 31-39.

Amaefule, K. U. and Nwagbara, N. N. (2004). The effect of processing on nutrient utilization of Pigeon pea (*Cajanus cajan*) seed meal and Pigeon pea seed meal based diets by Pullets. *International Journal of Poultry Science3*(8): 543-546.

Amaefule, K., Iheukwumere, F. and Nwaokoro, C. (2005). A note on the growth performance and carcass characteristics of rabbits fed graded dietary levels of boiled pigeon pea seed (cajanus cajan). *Livestock Research for Rural Development17*(5): 205.

Amos, H.E., Burdick, D. and Seerly, R.W. (1975). Effect of processing, temperature and lysine supplementation of utilization of sunflower meal by growing rat. *Journal of Animal Science*40:90-95.

Ani, A.O. (2009). Effects of graded level of raw bambara-nut (*Voandazia subteranian L*) waste on nutrient Intake, digestibility and utilization of rabbits. *Nigerian Journal of Animal Production* 36 (2): 237 – 245.

Annongu, A.A. and Joseph, J.K. (2008). Proximate analysis of castor seeds and cake. *Journal of Applied Science and Environmental Management* 12 (1): 39 – 41.

Anon, L. (1991). Micro-livestock: Little Known Small Animals with promising Economic Future. Board of Science and Technology for International Development, National Academy Press and Washington D.C. 147-155.

A.O.A.C (1990). Official methods of Analysis (15th Ed.). Association of Official Analytical Chemist, Washington D.C. U.S.A.

Apata, D.F. and Ologhobo, A.D. (1993). Biochemical evaluation of some Nigerian Legume Seeds. *Food Chemistry* 49: 33 - 38.

Atteh, J.O. (2004). Response of broiler chicks to dietary fungal or bacteria feed enzyme additives. Paper presented at the Bio Ingredients (Nig) Ltd, Seminar on Enzyme. Lagos, 21st May, 2004.

Augustin, J., Beck, C.B., Kalbfleish, G., Kagal, L.C. and Mattthews, R.H. (1981). Variation in the vitamin and mineral content of raw and cooked commercial phaseolus vulgaris classes. *Journal of Food Sciences* 46: 1701 – 1706

Austic, R.E. and Neishem, M.C. (1990). Poultry Production (13th Edition). Lea and Febiger Publishers.

Badejo, W. A. (1983). Poultry Production: Problems and Solutions. *West African Farming System7*(3): 20-35.

Balogun, T.F., and Koch, B.A. (1979). Raw or roasted groundnuts as potential protein and energy source in rations for growing pigs. *Tropical Agriculture (Trinidad)* 56 (2): 135-142.

Balogun, T.F., Kaankuka, F.G. and Bawa, G.S. (2001). Effect of period of boiling full fat soybeans on its amino acid profile and on performance of pigs. *Nigerian Journal of Animal Production* 28 (1): 45-51.

Bamgbose, A. M., Jegede, O. M., Idowu, O. M. O., Oso, O. A. and Abioye, A. O. (2007). Utilization of fermented pigeon pea (*Cajanus cajan*) by broiler chicken. *Proceedings of the 2nd Nigeria International Poultry Summit. Held at Abeokuta, Ogun state, Nigeria between 19th - 22nd February, 2007. Editors: Fanimo, A.O., Idowu, O.M.O., Peters, S. O., Sogunle, O.M. and Jegede, A.V., 83- 89.*

Batterham, E.S., Andersen, L.M., Buraham, B.V. and Taylor, G.A (1986). Effect of heat on the nutritional value of lupin (lupines angustifolus) seed meal for growing pigs. *Animal Feed Science and Technology* 13, 171 – 182.

Batterham, E.S., Saini, H.S., Andersen, L.M. and Braigent, R.A (1993). Tolerance of growing pigs to trypsin and chymotrypsin inhibitors in chickpeas (*Cicer arietinum*) and pigeon peas (*Cajanus cajan*). *Journal of the Science of Food and Agriculture* 61:211-216.

Basil, O. N. (2011). Poultry production and management. First edition, ISBN: 978-978-48275-2-2.

Bawa, G.S., Tegbe, T.S.B., Ogundipe, S.O., Dafwang, L.I. and Abu, E.A. (2003): The effect of duration of cooking lablab seeds on the level of some anti-nutritional factors. *Proceedings of the 28th Annual Conference of the Nigerian Society for Animal Production*, Pp. 213-214.

Bawa, G. S., Lombin, L. H., Karsin, P., Musa, U., Payi, E. and Shamaki, I. D. (2011). Response of Japanese Breeder Quails to varying dietary protein levels in the Tropics. *Nigerian Journal of Animal Production 38 (1): 43 – 54.*

Bedford, M.R. and. Morgan, A.J. (1996). The use of enzymes in poultry diets. *World Poultry Science Journal* 52:61-68.

Bedford, M.R.(2003). New enzymes technologies for poultry feeds. Zymetrics. Chestnut house, Beckhampton, Marlborough, Wiltshire, UK.S.14-16.

Bedford, M.R., Scott, T.A.,Silversides, F.G., Classen, H.L., Swift, M.L. and Pack, M. (1998).The effect of wheat cultivar, growing environment and enzyme supplementation on digestibility of amino acids by broilers. *Canadian Journal of Animal Science*78:335-342.

Bender, A.E. (1983). Haemagglutinins (Lectins). *Food Chemistry*. 11:309 – 320.

Brenes, A., Rotter, B.A., Marquardt, R.R. and Guenter, W. (1993). The Nutritional value of raw autoclaved and dehulled peas (*Pisum sativum* L) in chicken diets as affected by enzyme supplementation. *Canadian Journal of Animal Science* 73:605-614.

Bressani, R. (1993). Grain quality of common beans food. *Reviews International* 9: 217 – 219.

Bresani, R.E., Hernandez, I.E. and Braham, J.E. (1998). Relationship between content and intake of bean polypphenols and protein digestibility in humans. *Plant Food and Human Nutrition* 38:5 - 21

Broz, J. and Frigg, M. (1990). Influence of trichoderma viride enzyme complex on nutritive value of barley and oats for broiler chickens. *Arch. Geflugelk*. 54: 34-37.

Bryden, W.L., Gill, R.J, and Balnave, D. (1994). Feed enzyme supplement improves the apparent metabolisable energy of lupins for broiler chickens. *Proceedings of the Australian Poultry Science Symposium*, 6:115.

Campbell, T. W. and Coles, E. H. (1986). Avian clinical pathology. *Veterinary Clinical Pathology 4*: 279-300.

Campbell, L. D. and Bedford, M.R. (1992). Enzyme application for monogastric feeds: A Review. *Canadian Journal of Animal Sci*ence 72:449-466.

Chang, K.C. and Satterlee, L.D. (1981). Isolation and characterization of the major protein from Great Northern bean (*Phaseolus vulgeris*). *Journal of Food Sc*ience46:1368-1373.

Chesson, A. (2001). Non – starch polysaccharide degrading enzymes in poultry diets: Influence of ingredients on the selection activities. *World's Poultry Science Journal* 57: 251 – 253.

Choct, M. (1997). Enzymes in animal nutrition. The unseen benefits. Department of AnimalScienceUniversity of New England, Armidale, Nsw 2351, Australia.

Classen, H.L., Campbell, G.L., Rassnagel, B.G., Bhatty, R.S., and Reichert, R.D. (1985). Studies on the use of hulles barley in chicks diets: deleterious effect and methods of alleviation. *Canadian Journal of Animal Science* 65:725-733.

Classen, H.L., Scott, T.A., Irish, G.G., Huck, P., Swift, M. and Bedford, M.R. (1995). The relationship of chemical and physical measurement to the apparent metabolisable energy (AME) of wheat when fed to broiler chickens with and without a wheat enzyme source. In: *Proceedings of the Second European Symposium on Feed Enzymes.* Pp. 65-69.

Classen, H.L and Cooper, R. (1998). Improving animal feed through enzyme use. Feed Notes Publication. Vol 1 issue 3. Prairie feed resource centre.

Cooper, A.M (1989). The Japanese quail. In: the UFAW Handbook on the care and management of laboratory animals. 6th ed. Poole, T.B. (ed.) Longman group Ltd. London. pp. 678-686.

Dafwang, I.I. (2006). Meat, eggs and milk from farm wastes: Exploration in animal nutrition research and extension.An inaugural lecture presented on 19th April, 2006 series in Ahmadu Bello University, Zaria.

Dafwang, I., Ikani, E.J., Chikwendu, D.O., Adesheinwa, A.O.K., Annate, A.I. and Iwuayanwu, I.E.J. (2006). An assessment of adoption of non – conventional feedstuffs. *Journal of Poultry and Rabbit Research*25 (3): 3 – 5.

Desphande, S.S. and Salunkhe, D.F. (1982). Estimation of protein degradation in the rumen from incubation measurement according to the rate of passage. *Journal of Production Science*47: 2080 – 2081.

Desphande, S.S., Sathe, S.K.,Salunkhe, D.K.and Cornforth, D.P. (1985). Effects of dehulling on phytic acid, polyphenols and enzyme inhibitors of dry beans (*Phaseolus vulgaris*). *Journal of Food Science* 47: 1846.

D'hurandhar, N.H. and Chang, K.C. (1990). Effect of cooking on firmness, trypsin inhibitors, lectins and cystein/cystein content of navy beans and a red kidney beans. *Journal of Food Science* 55:470-474.

D'Mello, J.P.F. (1992). Chemical constraints to the use of tropical legumes in animal nutrition. *Animal Feed Science and Technology* 38 (2/3) 237-261.

D'Mello, J.P.F. (1995). Amino acids in farm animal nutrition. 1. Metabolism, partition and consequences of imbalance. *Feed Compounder*.

Earp, C.F., Akinghala, J.O., Ring, S.H. and Rooney, L.W. (1981). Evaluation of several methods to determine tannin in sorghum with varying kernel characteristics. *Cereal Chemistry* 58: 234-238.

Edache, J. A., Musa, U., Haruna, E. S., Esilonu, J. O., Jibrin, I., Okpala, E. J. and Dogo, I. G. (2005). Replacement Value of Guinea Corn for Maize In Practical Diet Fed To Quail (*Coturnix coturnix japonica*) Chicks. *Animal Research International2*(2): 311-31.

Ekpenyong, T. E. and Borchers, R.L. (1980). Effects of cooking on the chemical composition of winged bean. *Journalof Food Science* 45 (6): 1559-1560.

Elwinger, K. and Saterby, B. (1987). The use of B-glucanase in practical broiler diets containing barley or oats. Effect of enzyme level, type and quality of grain *SwedishJournal of Agricultural Research*. 17:133-140.

El-Difrawi, E. A., and Hudson, B. J. (1979). Identification and estimation of carotenoids in the seeds of four Lupinus species. *Journal of the Science of Food and Agriculture 30* (12), 1168-1170.

Eruvbetine, D., Dipeolu, M.A. and Oguntona, E.B. (2002). Composition of enzyme and antibiotic inclusion in diets for laying hens. *Proceedings 27th Conference Nigerian Society for Animal Production (NSAP)March* 17-21, 2002. Federal University of Technology. Akure, Nigeria Pp 101-104.

Estevez, A.N., Castillo, F., Figuerola, F. and Yanez, F. (1991). Effects of processing on some chemical and nutritional characteristics of precooked and dehydrated legumes. *Plant Food for Human Nutrition* 41: 193-201.

Ewuola, E. O., Ogunlade, J. T., Gbore, F. A., Idahor, K. O., Salako, A. O. and Egbunike, G. N. (2004). Biochemical and haematological responses of rabbits fed diets containing micro doses of fumonisin. *Tropical Journal of Animal Science*, *7* (1), 169-176.

Fasuyi, A.O. (2005). Nutrient composition and processing effects on cassava leaf (*Manihot esculenta*, Crantz) anti-nutrients.*Pakistan Journal of Nutrition*. 4 (1): 37 – 42.

Faris, D.G., Saxena, K.B., Mazumdar, S. and Singh, U. (1987). Vegetable pigeon pea: A promising crop for India. Patancheru, A.P. India, International Crops Research Institute Semi Arid Tropics, 13 pp.

Faris, D.G. and Singh, U. (1990). Pigeon pea: Nutrition and products: In the Pigeon pea (Nene, Y.L., Hall, S.D. and Sheila, V.K., eds). Walling Ford, Oxon, U.K; CAB International.

Farran, M.J., Dakessian, P.B., Darwish, A.H., Uwayjan, M.G.,Dbouk, H.K., Sleiman, F.T. and Ashkarian, V.M. (2001). Performance of broilers production and egg quality parameters of laying hens fed 60% raw or treated common cetch (*Vicia Sativa*) seeds. *Poultry Science* 80 (2): 23 – 28.

Fouad, N. A. and Bynner, J. (2008). Work transitions. *American Psychologist63*(4): 241 - 244.

Gatel, F. and Grosjeani, F. (1990). Composition and nutritive value of peas for pigs: A review of European results. *Livestock Production Science* 26: 155-175.

Gebhart, C. L. and Kabanov, A. V. (2001). Evaluation of polyplexes as gene transfer agents. *Journal of Controlled Release 73*(2): 401-416.

Geervani, P. (1981). Pigeon pea utilization: International Crops Research Institute Semi Arid Tropics (1981). *Proceeding of the International Workshop on pigeon pea,* Vol.2, 15-19. Dec. 1980 Patancheru, A.P. India 427-434.

Grimaud, P. (1988). The pigeon pea (*Cajanus cajan*); A possible alternative for traditional pig and poultry farming in new Caledonia *Revue-de Elevage-et-de- Medicine-veterinary de Nouvelle* 29-36.

Hanovar, P.M., Shih, C.P. and Liener, I.E. (1962). Inhibition of growth of rats by purified hemagglutinin fractions isolated from phaseolus vulgaris. *Journal of Nutrition77:*109 – 112.

Haruna, E.S., Musa, U., Okewole, P.A., Shemaki, D., Lombin, L.H., Molokwu, J.U., Edache, J.A. and Karsin, P.D. (1997). Protein requirement of quail chicks in Plateau State, Nigeria. *Nigerian Veterinary Journal 18: 108-113.*

Haugh, R. R. (1937). US Egg and Poultry Magazine, 43: 522 – 555, 572 – 573.

Hetland, H., Chost, M. and Svihus, B. (2004). Role of insoluble non-starch polysaccharides in poultry nutrition.*World Poultry Science Journal 60: 415 -422.*

Hughes, R.J. and Zviedrans, P. (1999). Influence of dietary inclusion rate of wheat on AME, digesta viscosity and enzyme response. *Proceedings of Australian Poultry Science Symposium* 11: 101-104.

Huo, G.C., Fowler, V.R., Inborr, J. and Bedford, M. (1993). The use of enzymes to denature anti-nutritive factors in soybeans. In recent Advances of Research in Antinutritional Factors in Grain Legumes Seeds, Pp. 517-521 (A.F.B van der poel, J. Huisman and H. Saini, editors). EAAP publication No.70 Wageningen press, the Netherlands.

Huskey, L.L., Synder, H.E. and Gbur, E.E. (1990). Analysis of single soybean seeds for oil and protein.*Journal of American Oil Chem*ical *Society* 67:686-688.

Ichihara, M., Mutia, R., Uchida, S., Djajanegara, A. and Sukmawati, A. (1994). Nutritional value of autoclaved wing bean (Psophocarpus tetragonolobus) for rats. *Proceedings of the 711/AAAP Animal Science Congress, Bali, Indonesia,* 3:179-180.

ICRISAT (1987). Variations in soil properties along three toposequences in Burkina Faso and implications for the development of improved cropping systems. *Agriculture, Ecosystems and Environment 19*(3): 241-264.

ICRISAT (1991). Microclimatic interactions in agroforestry systems. *Forest Ecology and Management 45*(1): 31-44.

ICRISAT (1992). International Crop Research Institute of Semi Arid Tropics. Annual report 2001. Patancheru India. ICRISAT 51 – 54.

ICRISAT (1993). International Crop Research Institute for Semi Arid Tropics. Pigeon pea research for rain fed and irrigated production. ICRISAT Annual research for planning meeting. Patancheru, A.P. India.

ICRISAT (2002). International Crops Research Institute of Semi Arid Tropics. Annual Report 2001. Patancheru India ICRISAT.

Iyayi, E.A. and Egharevba, J.I. (1998). Biochemical Evaluation of Seeds of an under utilized legume (*Mucanus utilis*). *Nigerian Journal of Animal Production 25 (1): 49-45.*

Iyayi, E.A. and Davies, B.I. (2005). Effect of enzyme supplementation of palm kernel meal and brewer's dried grain in the performance of broilers. *International Journal of Poultry Science* 4 (2): 76-80.

Iyengar, A.K. and P.R. Kulkarni (1977). Oligosaccharide levels of processed legumes. *Journal of Food Science and Technology*14: 222-223.

Jadhav, N.V. and Saddiqui, M.F. (2010). Handbook of Poultry Production Management. Jaypee Brothers, Medical Publisher, 1 Jan. 2010. Poultry 383 pages.

Jambunathan, R. and Singh, R (1980). Grain quality of pigeon pea. Proceeding of International Workshop on pigeon pea, vol. 1, International Crops Research Institute Semi Arid Tropics Centre, Patancheru, India Pp 351-353.

Jones, J. D. and Dangl, J. L. (2006). The plant immune system. *Nature*,*444*(7117), 323-329.

Jongbloed, A.W., Ohman, A., Van Diepen, J.T.M., Van der Klis, J.D., Knap, I.H. and Versteegh, H.A.J. (1997). Comparison of pigs and broilers in their response to microbial phytase*Journal of Animal Science 75 (Suppl.1). 185.*

Jorgensen, H., Sauer, W.C. and Thacker P.A. (1984). Amino acid availability in soybean meal, sunflower meal, fish and meat – bone meal fed to growing pigs. *Journal of Animal Science* 58: 926 – 934.

Kaankuka, F.G., Balogun, T.F. and Tegbe, T.S.B. (1996). Effects of duration of cooking of full fat soybeans on proximate analysis, levels of anti nutritional factors and digestibility of weaning pigs. *Animal Feed Science Technology* 62:229-237.

Kaankuka, F.G., Balogun, T.F.,Bawa, G.S. and Dim, S. (2000). Effect of cooking soybean on DM digestibility and Energy in pigs. *Indian Journal of Animal Sc*ience 70 (7): 740-743.

Kadam, S.S., Smithard, R.R., Eryc, M.D. and Armstrong, D.G. (1987). Effects of heat treatments of anti nutritional factors and quality of protein in winged bean *Journal of the Science of Food and Agriculture* 39:267-275.

Kakade, M.L., Simons, N.R. and Liener, I.E. (1969). An Evaluation of Natural Vs Synthetic Substrates for measuring the Antitryptic Activity of Soybeans Samples. *Cereal Chemistry.* (46): 518.

Kakade, M.L., Simons, N.R. and Liener, I.E. (1974). An Evaluation of Natural Vs Synthetic Substrates for measuring the Antitryptic Activity of Soybeans Samples. *Cereal Chemistry.* (46): 518.

Kaura, M.B. (1985). The Acceptability and Physical Properties of Pigeon Pea Fortified Bread*:*M.Sc. PG Thesis, Animal Science Department, Ahmadu Bello University, Zaria.

Kay, D.E. ((1979). Crops and product digest No 3. *FoodLegumesLondonTropical Product Institute.* Page 322-333.

Kemme, P.A., Jongbloed, A.W., Mroz, Z., Kogut, J. and Beynen, A.C. (1999). *Aspergillus niger* phytase, phytate and lactic acid levels affect digestibility of nutrients in growing-finishing pig.2. Apparent total tract digestibility of phosphorus, calcium and magnesium and ileal degradation of phytic acid. *Livestock Production Science* 58:119-127.

Kornnegay, E.T., Denbow, D.M. and Zhang, Z. (1997). Phytate supplementation of corn-soybean meal broiler diets from three to seven weeks of age. *Poultry Science Abstract* 76:6.

Kumar, R. (1992). Anti nutritional factors, the potential risks of toxicity and methods to alleviate them. Proceedings of the FAO expert consultation held at the Malaysian Agricultural Research and Development Institute (MARDI) in Kauk. Lumpur Malaysia, 14-18 October, 1991 Edited by Andrew speedy and Pierre – Luc Pugliese.

Leaky, C.L.A. and Wills, J.B. (1977). Food crops of the lowland tropics. Oxford University Press. Walton Street, Oxford OX2 6PP, Great Britain.

Lee, C.K. and Karunanithy, R. (1990). Effect of germination on the chemical composition of glycine max and phaseolus lunators beans. *Journal of Food Science and Agriculture* 50: 437-445.

Liener, I.E. (1981). Factors affecting the nutritional quality of soy products. *Journal of American Oil ChemistrySociety*58:406-415.

Liener, I.E. (1994). Implication of anti nutritional components in soybeans foods. *Critical Reviews in Food Science and Nutrition* 34:31-67.

Liener, I.E. and Kakade, M.L. (1980). Protease Inhibitors: in Toxic Constituents of Plants food stuffs, 2nd Edition. Academic press Inc. Pp 1-71

Madu, C. T., Sogbesan, O. A. and Ibiyo, L. M. O. (2003). Some Non-conventional fish feed resources in Nigeria. In: A.A. Eyo (Ed.), *Proceedings of the Joint Fisheries Society of Nigeria/National Institute For Freshwater Fisheries Research/FAO-National Special Programme For Food security National workshop on Fish feed development and Feeding Practices in Aquaculture held at National Institute for Freshwater Fisheries Research,* 73-82.

Makkar, H.P.S; Singh, B. and Dawra, R.K. (1982). Protein quantification assay for Tannins; *International Journal of Animal Science* 2: 127-140.

Maldo, O.M. and Rasario, R.R. (1989). Soybean flour from sand-roasted soybean. *ThePhilippine Agriculturists* 72: 21 – 29.

Marquardt, R.R., Boros, D., Guenter, W. and Crow, G. (1994). The nutritive value of barley, rye, wheat and corn for chicks as affected by the use of a Trichoderma reesei enzyme preparation. *Animal Feed Science Technology* 45:363-378.

Marty, B.J., and Chavez, E.R. (1993). Effect of heat processing on digestibility of energy and other nutrient digestibility of full-fat soybeans fed to weaner, grower and finisher pigs. *Canadian Journal of Animal Science* 73: 411 – 419.

Matthew, U.D., Tegbe,T.S.B., Omage, J.J. and Adeyinka, I.A. (2010). The effect of duration of cooking pigeon pea (*Cajanus cajan*) seeds on the performance and carcass characteristics of broiler chicks. *Nigerian Journal of Animal Production* 37: 13-24.

Maxwell, M. H., Robertson, G. W., Spence, S., and McCorquodale, C. C. (1990). Comparison of haematological values in restricted-and *ad libitum*-fed domestic fowls: White blood cells and thrombocytes. *British Poultry Science 31*(2): 399-405.

McDonald, P., Edwards, R.A. and Greenhalgh, J.F.D. (1987). Animal Nutrition. 3rd Edition published by longman Group (FE). Ltd. Hong Kong P.96.

McDonald P., Edwards, R.A. and Greenhalgh, J.F.D. (1990). Animal Nutrition 5th Edition published by Longman Group (FE) Ltd. Hong Kong P.96.

Mitruka, B. M. and Rawnsley, H. M. (1977). Clinical biochemical and hematological reference values in normal experimental animals. Masson Pub. Inc., New York, pp 21 – 84.

Mmereole, F. U. C. (1996). The study of haematological parameters in the Nigerian local chicken. *Nigerian Journal of Animal Production*1: 94-97.

Morton, J.F. (1976). The pigeon pea (*Cajanus cajan Millsp*) a high protein tropical bush legume. *Horticultural Science* 11 (1): 11-19.

National Research Council (1994). Nutrients requirements of Domestic Animals. 1. Nutrients Requirement of Poultry. 9th edition National Academy Press Washington D.C.

Nene, Y.L. and Sheila, V.K. (1990). Pigeon pea: Geographical and Importance In: Nene, Y.L., Sheila S.D Leds, V.K). The pigeon pea CAB ml, ICRISAT, India, pp 1-4

Ngoka, D.A. (1997): Crop production in the tropics: Theory and practice. Alphabet Nigeria publishers, Owerri Nigeria. Pp.125

Nidaullah, H., Durrani, F. R., Ahmad, S., Jan, I. U. and Gul, S. (2010). Aqueous extract from different medicinal plants as anticoccidial, growth promotive and immune stimulant in broilers. *Journal of Agricultural and Biological Science* 5 (1) 53-59.

Nwokolo, E. and Orji, U.I (1985). Variation in metabolizable energy content of raw or autoclaved white and brown varieties of three tropical grain legumes. *Animal Feed Science and Technology*. 13 (1/2): 141-146.

Nworgu, F.C. and Ologhobo, A.D. (2000). Effects of Agro- industrial wastes on the performance of exotic cockerels. *Tropical Journal of Animal Science.* 3 (1): 17 – 24.

Obioha F.C. (1992). A guide to production of legumes in the tropics. Acena Pub. Enugu. Nigeria.

Odetola, O. M., Adetola, O. O., Ijadunola, T. I., Adedeji, O. Y. and Adu, O. A. (2012). Utilization of moringa (*Moringa oleifera*) leaves meal as a replacement for soya bean meal in rabbit's diets. *Scholarly Journal of Agricultural Science2*: 309-313.

Ogundipe, S.O. (1980). Effects of boiling/ roasting on subsequent utilization of soybeans by chicken Ph.D, Dissertation, Michigan State University, East-Lansing, Mich. U.S.A.

Ogundipe, S.O., Abeke F.O., Sekoni A.A., Dafwang, I.I. and Adeyinka I.A.(2003). Effects of cooking duration on the utilization of (*Lablab purpureus*) beans by pullet chicks. *Proceedings of the 28th Annual Conference of the Nigerian Society for Animal Production, Pp*. 233-235.

Oke, D.B., Tewe, O.O. and Fetuga, B.L. (1995). The nutritional composition of cowpea varieties. *Nigerian. Journal of Animal Production* 22 (1) 32-36.

Ologhobo, A.D. (1981). *Biochemical and Nutritional studies of cowpea and lima beans. With particular reference to some inherent anti nutritional components.* Ph.D Thesis, University of Ibadan.

Ologboho, A.D. (1989). Improving the nutritive value of soybeans (*Glycine max*) through processing. Biochemical and protein quality studies. *Tropical Agriculture* 66:290-296.

Ologhobo, A.D. (1992). The Nutritive value of some tropical (West African) legumes for poultry. *Journal of Applied Animal Research*(2): 104-293.

Ologhobo, A. D., and Fetuga, B. L. (1984). Distribution of phosphorus and phytate in some Nigerian varieties of legumes and some effects of processing. *Journal of Food Science, 49*(1): 199-201

Olomu, J.M. (1995). Monogastric Animal Nutrition. *Principles and Practice.* Jachempublication Benin City. 1st Edition. Pp 146-164.

Olomu,J.M. (2011). Monogastric Animal Nutrition. Principles and Practice. 2nd Edition. Pp 113– 122.

Olorode, B.R., Ibitoye, E.B and Abiola, J.O. (2007). Evaluation of Moringa Oleifera seed meal as replacement for groundnut cake in broiler diets. *Tropical Journal of Animal Science 10*(1-2): 59 – 62.

Olubamiwa, O., Haruna, E.S., Musa, U., Akinwale, T.O., Combin, L.H. and Longe, G.O. (1999). Effects of Different Energy Levels of Cocoa Based Diets on the productive Performance of Japanese Quail. *Nigerian Journal of Animal Production*26:88-92.

Olupona, .I.A., Nworgu, F.C., Odejimi O.O. and Omole, A.J. (1998). The effect of some conventional processing techniques for *Thevetia peruviana* seed on performance of rabbits. *Proceedings Silver Anniversary, Conference of the Nigerian Society for Animal Production (NSAP) and the inaugural conference of the West African Society for Animal Production (WASAP),* Abeokuta, Nigeria. March, 1998. Eds O.O Oduguwa, A.O. Fanimo, O.A. Osinowo, Pp 204-205.

Oluyemi, J.A. and Roberts (2000). Poultry production in warm wet climates. Macmillan Pub. Ltd. London Pp 196.

Omeje, S.I. (1999). Issues in Animal Science. Ray Kennedy Scientific Pub. Enugu Nigeria. *Proceedings of 29th Annual Conference of the Nigerian Society for Animal Production, Pp. 240-244.*

Onwuka, C. F. I. (1996). Plant phytates, oxalates and their effects on nutrient utilization by goats. *Nigerian Journal of Animal Production 23*(1): 53-60.

Onwuka, G.I (2006). "Soaking, boiling and anti-nutritional factors in pigeon pea (*Cajanus cajan)* and cowpea (*Vigna unguiiculata*). *Journal of Food Processing*http://www.hort.purdue.edu/newcrop/duke-energy/*cajanus-cajan*.html.

Opoku, A., Tabil, L., Sundaram, J., Crear, W.J. and Park S.J. (2003). Conditioning and Dehulling of Pigeon Peas and Mung Beans. A publication by the Canadan Society for Engineering in Agricultural, Food and Biological Systems. Paper No. 03-347, P.1.

Ovimaps, (2012). Ovi location map; Ovi earth imagery date; May 20th, 2012.

Oyawoye, E. O., and Ogunkunle, M. (1998). Physiological and biochemical effects of raw jack beans on broilers. In *Proc.: Annual Conference of Nigerian Society for Animal Production, Abeokuta, Nigeria Pp*. 141-142.

Oyawoye, E. O. (2002). Eradication of Animal Protein Malnutrition in Nigeria through the Production and Consumption of Micro-Livestock: A task that must be done. *28th Inaugural Lecture. Abubakar Tafawa Balewa University, Bauchi*.

Oyenuga, V. A. (1968). Nigeria's Food and Feeding Stuffs. Ibadan University Press.

Pathak, G.W. (1970). Redgram. In: Pulse crops of India. *Indian Journal of Agricultural Research, India, Pp*. 14-53.

Petterson, D. and Aman, P. (1987). Enzyme supplementation of a poultry diet containing rye and wheat. *British Journal of Nutrition*62:137-149.

Phillips, D.E. (1997). Protein Quality in seeds meal of *Phaseolus vulgaris* and heat stable factors affecting the utilization of protein. *Journal of Food Science and Agric*ulture 32: 423-432.

Pukushima, D. (1979). Internal Structure of 75 and 115 globulin molecules in soybean proteins. *Cereal Chemistry* 45: 203 – 224.

Purdue University, (2006). Centre for crops and plant products. *Cajanus Cajan* (L.) Millsp.

Purseglove, J. W. (1968). Tropical crops. Dicotyledons 1 and 2. *Tropical crops.*

Purseglove, Y.W. (1988). Tropical crops dicotyledon. English language book society (ELBS).

Quin, G., Ter Elst, E.R., Bosch, M.W. and Van der Poel, A.F.B. (1996). Thermal processing of whole soybeans: studies on inactivation of anti nutritional factors and effects on ileal digestibility in piglets. *Animal Feed Science and Technology* 57:313-324.

Rachie, K.O. and Roberts L.M. (1974). Grains legumes of the lowland tropics. *Advances in Agronomy* 26. 1-132.

Robbins, M. P., Hartnoll, J., and Morris, P. (1991). Phenylpropanoid defence responses in transgenic Lotus corniculatus 1. Glutathione elicitation of isoflavan phytoalexins in transformed root cultures. *Plant Cell Reports 10*(2): 59-62.

Salah, H. E. (2012). Fibre plays a supporting role in poultry nutrition. World poultry magazine, 1(28).

Sallisbury, D. (1983). Blood Quality Evaluation. Annual Health. 1st edn. Granada Publication Ltd. New York, USA. In: *Nigerian Journal of Animal Production*23 (1): 94 - 97

Salunkhe, D.K. (1982). Legumes in Human Nutrition: Current status and future research needs. *Current Science* (51): 387-394.

Salunkhe, D.K, Kadam S.S. and Chavan J.K. (1985): Post-harvest Biotechnology of Food Legumes; CRC press Inc. Boca Raton. Florida USA.

SAS (2008). SAS/ STAT User's Guide. Version 9.2 for windows. SAS Institute Inc; SAS Campus Drive Carry, North Califonia, U.S.A.

Scott, T.A., Silversides, F.G., Classen, H.L., Swift M.L., Bedford, M.R. and Hall, J.W. (1998a). A broiler chick bioassay for measuring the feeding value of wheat and barley in complete diets. Poultry Science 77:449-455.

Scott, T.A., Silversides, F.G., Classen, H.L., Swift M.L. and Bedford, M.R. (1998b). Effect of cultivar and environment on the value of Western Canadian wheat and barley samples with and without enzyme supplementation. *Canadian Journal of Animal Science* 78:649-656.

Selim, K. and Ibrahim S. (2004). Phenotypic correlations between some external and internal egg quality traits in Japanese quails. *International Journal of Poultry Science* 3(6) 400-405.

Siegel, A. and Faweett, B. (1976). Food legumes processing and utilization (with special emphasis on application in developing countries). International Development Research Centre (IDRC-TSC), Ottawa, Canada.

Singh, K.W. and Kush, A.K. (1981). Effect of population density on growth pattern and yielding ability in pigeon pea. In: Proceedings of the International Workshop on Pigeon Peas. Vol, 1, 15-19 December, 1990. International Crops Research Institute Semi Arid Tropical Centre India Patancheru, A.P. India. Pp.165-170.

Singh, U. and R. Jambunathan, (1982). Distribution of seed protein fractions and amino acids in different anatomical parts of chickpea (*Cicer Arietinum* L) and pigeon pea (*Cajanus cajan* L.). Qual*ifas plantarum*/ *plant products for Human nutrition* (31): 347-354.

Singh,U.M.S., Kherdekar, M.S., Sharm, I. andSaxena, K.B. (1984). Cooking quality and chemical composition of some early, medium and late maturing cultivars of pigeon pea (*Cajanus cajan* L. Millsp.) *Journal of Food Science and Technology* 21:367-372.

Singh, U. (1987).Cooking quality of some important Indian legumes. Paper presented at the national symposium on present status and future perspectives research institute, Mysove, India.

Singh, F. and Diwakar, B. (1993). Nutritive value and uses of pigeon pea and groundnut. Skill development series no.14 Human Development Programme, International Crops Research Institute for the Semi-Arid Tropics, Partancheru, Ahncha Pradesh 304 - 502, India.

Smarth, J. (1976). Tropical pulses. Longman Group Limited, London. Pp.348.

Smith, A.K. and Circle, S.J. (1978). Soybean Chemistry and Technology. Vol. 1 Proteins AVI.

Soetan, K.O. and Oyewole, O.E. (2009). The need for adequate processing to reduce the anti nutritional factors in plants used as human foods and animal feeds: A review: *African Journal of Food Science* 3 (9):223 – 232.

Soetan, K. O., Akinrinde, A. S. and Ajibade, T. O. (2013). Preliminary studies on the haematological parameters of cockerels fed raw and processed guinea corn (Sorghum bicolor). *Proceeding of Annual Conference of Nigerian Society of Animal Producti*on Pp. 49-52.

Sogbesan, O. A., Adebisi, A. A., Falaye, B. A., Okaeme, B. N. and Madu, C.T. (2006).

Some aspects of dietary protein deficiency diseases in semi-intensive cultured fishes. A Review*: Journal of Arid Zone Fishery* 2(1): 80-89.

Steenfeldt,S., Mullertz, A. and Jensen,J.F. (1998). Enzyme supplementation of Wheat based diets for broilers. Effect on growth performance and intestinal viscosity. *Animal Feed Science Technology* 75: 27-43.

Sundaram, T.S. (1989). Comparative Egg Production Efficiency of Chickens, Ducks and Quails. *Poultry International Journal* 28 (5): 60 - 65.

Sutardi, I. and Buckle, K.A. (1985). Reduction in phytic acid levels in soya bean during temperature, production, storage and frying. *Journal of Food Science* 50: 260-263.

Sylvester, O.I., Kehinde T.O. and Maurice A.A. (1993). Effects of processing methods on phytic acid level and some constituents in bambara groundnut (*Vigna subterranea*)and pigeon pea (*Cajanus cajan*). In: *Food chemistry*. (50): 142 – 151.

Tangtaweewipat, S. and Elliot, R. (1989). Nutritional value of pigeon pea (*Cajanus cajan*) meal in poultry diets. *Animal Feed Science and Technology* 25 (1-2): 123-135.

Tewe, O.O. and Bokanga, M. (2001). Post harvest technologies in Nigeria's livestock industry: Status, challenges and capacities. Paper presented at GFAR – GIPhT Workshop, 17 – 21st September, 2001. Entebbe, Uganda. Pp 224 – 228.

Timbrell, J.A. (1992). Principle of Biochemical Toxicology. Taylor Francis Ltd, London. Pp. 403 – 412

Tuleun, C.D. and Dashe, N.A (2010). Effect of dietary levels of toasted mucuna seed meal (TMSM) on the performance and egg quality parameters of laying Japanese quails (*Cortunix cortunix japonica*). *Proceedings of 35th Annual Conference of the Nigerian Society for Animal Production* (Pp. 330-332).

Udeh, I. (2010). Repeatability of egg number and egg weight in two strains of layer type chicken. *International Journal of Poultry Science 9*(7): 675-677.

Udedibie, A.B.I. (1995). Jackbean (*Cancivalia enciformis*) meal in poultry diets. In: Sonaiya, E.B. (Ed). 1997. Sustainable Rural Poultry Production in Africa. Proceedings of an International Workshop held on June 13-16, 1995 at the International Livestock Research Institute. Addis Ababa, Ethiopia. Pp 97-107.

Udedibie, A.B.I and Carlini, C.R (2002). Relative effects of dry and moist heat treatment on haemagglutinating and antitrypsic activities of selected legume grains. *Nigerian Journal of Poultry Science* 1:81-87.

Umoren, U. E., Isika, M. A., Asanga, E. P. and Ezeigwe, P. N. (2007). Effect of Replacement of Maize with Earth Ball (*Icacinia manni*) Meal on the Performance of Broiler Chickens. *Pakistan Journal of Biological Sciences10* (14): 2368-2373.

Van Berneveld, R. J., Batterham, E.S. and Norton, B.W. (1993). Nutritional implication of heating proteins: the effect of heating protein concentrates on the digestibility and metabolism of Lysines in growing Pigs. In Recent Advances in Animal Nutrition in Australia, Pp. 201-212 (D.I. Farrell, editor) UNE, Armidale, Nsw.

Van der Measen, C.J.G (1990). Pigeon pea, Origin, history and taxonomy. Pg 16 in the pigeon pea (Nene Y.L., Hasll, S.D., and Sheila, V.K., eds) Wallingford,Oxon, UK: CAB international.

Van der Poel, A.F.B. (1990). Effects of processing on anti-nutritional factors and protein nutritional value of dry beans (*Phaseolus vulgaris*). A Review. *Animal Feed Science and Technology* 29:179-208.

Vijayakumari, K., Siddhuraju, P. and Janardhanan, K. (1995). Effects of various water or hydrothermal treatments on certain anti-nutritional compounds in the seeds of the tribal pulse, Dolichos lablab var. Vulgarish. *Plant Food for Human Nutrition* 48 (1):17-29.

Wallis, E.S., Faris, R., Elliot, I. and Byth D.E (1986). Varietal improvement for small holder livestock production systems. In: Proceeding of the Crop Livestock Systems Research work, 7-11 July 1986, Khon Kaen, Thailand. Farming systems research institute, Department of agriculture, Thailand and Asian rice farming systems Network, International Rice Research Institute, Philippines, Pp, 536-553.

Wallis, E.S., Woolcock, R.F. and Byth, D.E. (1988). Potential for pigeon pea in Thailand, Indonesia and Burma. CGPRT Centre no, 15, Bojor, Indonesia; CGPRT; Centre, Pp. 74.

Weignartner, K.E. (1987). Processing nutrition and utilization of soybeans. In: Soybeans for the tropics, research, promotion and utilization.S.R. Singh, K.O. Rashie and K.E. Dashiell. Eds IITA Publications. Pp 149-178.

Whiteman, P.C. and B.W. Norton, (1981). Alternative uses of pigeon pea. In: Proceedings of the International Workshop on Pigeon Pea, Volume, 5-19 Dec. 1980. Centre. India. Patanecheru A.P., India; ICRISAT PP. 365-377.

Wu. Williams, W.P., J.C. Huang, Y., Wardlaw, F.B. and Grimes, L.W (1996). Thermal effects on net protein ratio or red kidney beans (*PhaseolusVulgaris*). *Journal of the Science of Food and Agriculture* 71:419-495.

Wyatt, C.L, Moran, E., Bedford, M.R. (1997). Utilizing feed enzymes to enhance the nutritional value using the Ileal digestibility method. Proceedings Australian Poultry Science symposium 11:108-111.

Yavelov, J., Finlay, T.H.,Kennedy, A. R. and Troll W (1983). Bowman –Bisk Soybean protease inhibitor as an Anti-carcinogen. *Cancer. Research*. 43:2454-2459.

Yisa, A.G., Edache, J.A., Atam, S.K and Samuel, S.M (2000). Carcass Yield of finishing cockerels fed graded levels of boiled pigeon pea (*Cajanus cajan (L*.) Millsp. Proceedings of the 44th Annual Conference of the Agricultural Society of Nigeria (ASN) held at Ladoke Akintola University of Science and Technology, Ogbomosho. Pp 658-660.

Zank, H.M. (1991). Chasing the enzymes of secondary metabolism. Plant cell cultures as a pot of goal. *Photochemistry*, 30 (12): 3861 – 3863.

APPENDIX 1

UNIT PRICE OF FEED INGREDIENTS DURING THE PERIOD OF THE STUDY

(APRIL, 2014 – JUNE, 2015)

INGREDIENTS	**UNIT PRICE (₦ /kg)**
Maize	50
Soybean	115
Groundnut cake	130
Pigeon pea seed	100
Bone meal	60
Limestone	17
Common salt	70
Methionine	1650

Lysine	800
Vitamin premix chicks	480
Vitamin premix Layers	400
Enzyme (₦ 50/0.01kg)	