EFFECT OF PEARL MILLET AND SELECTED GRAIN LEGUMES ON GROWTH PERFORMANCE AND CARCASS QUALITY OF BROILER CHICKEN

BY

FAITH WAIRIMU WAKIBIA

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE DEGREE OF MASTER OF SCIENCE IN ANIMAL NUTRITION AND FEED SCIENCE

IN THE FACULTY OF AGRICULTURE

DEPARTMENT OF ANIMAL PRODUCTION

UNIVERSITY OF

NAIROBI

2015

DECLARATION

This thesis is my original work and has never been presented for any degree in any other university.

Signed.. Date 27th October 2015

Faith Wairimu Wakibia

This thesis has been submitted for examination with our approval as university supervisors.

Signed.. Date 27th Oct. 2015

Prof. B.N. Mitaru

Department of Animal Production

Signed.. Date 27th Oct. 2015

Dr. J.G. Maina

Department of Animal Production

ACKNOWLEDGEMENT

First I would like to give praise, glory and honor to my savior Jesus Christ for giving me strength and good health to be able to complete my study.

I would like to express my deepest appreciation to my chief supervisor, Professor B.N. Mitaru, for his guidance, assistance and valuable comments during research and writing of the thesis. I would also like to offer my sincere gratitude to my second supervisor, Dr. J.G. Maina, for her support, encouragement and advice during the entire period.

Very special appreciation is expressed to the following people; Mr. Micah for his great assistance during data collection and taking care of the broilers, Mr Jackson Muchiri and Eliud Korir for their assistance during data collection and slaughtering of the broilers. My Appreciation also goes to Mr. Benjamin Kyalo and Mr. Dismon Ambale for their assistance during laboratory analysis, Dr. Felix Kibegwa, Mr. Obudho and Mr. Gideon Nyakundi for their invaluable assistance during data analysis.

Appreciation is expressed to the Association of Strengthening Agriculture in East and Central Africa (ASARECA) for their financial support in this research project. I truly give thanks.

Finally, I wish to convey my warmest appreciation and deepest gratitude to my sister (Susan Wakibia), for her financial, emotional support and her constant encouragement. Appreciation also goes to all my family members for their prayers and the love they gave me throughout the study. Special thanks to my late grandfather (Eliud Wakibia) for his love, encouragement and prayers.

DEDICATION

TO MY LATE PARENTS MR AND MRS WAKIBIA

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ANF:	Anti-Nutritional Factor
ANOVA:	Analysis of Variance
AOAC:	Association of Official Analytical Chemists
BW:	Body Weight
Cal:	Calorie
CF:	Crude fibre
CP:	Crude Protein
CRD:	Completely Randomized Design
CWP:	Cowpeas
df:	Degrees of Freedom
DM:	Dry matter
EE:	Ether Extract
F.pr:	Fr Probability
FCR:	Feed Conversion Ratio
g:	Gram
GE:	Gross Energy
GG:	Green Gram
GoK:	Government of Kenya
H_A:	Alternative hypothesis
KEBS:	Kenya National Bureau of Standards
kg:	Kilogram
LB:	Lablab Bean
m.s:	mean sum of square

ME:	Metabolizable energy
Mg:	Milligram
NRC:	National Research Council
PM:	Pearl Millet
SBM:	Soybean meal
ss:	Sum of Square
TIA:	Trypsin Inhibitor Activity
v.r:	Variance ratio
vs:	Versus

ABSTRACT

The increasing cost of feed in broiler chicken production has compelled nutritionists to look for alternative sources of energy and protein. Two experiments in this study were carried out to determine the effect of replacing maize with pearl millet (PM) and including varying (0, 10, 20, and 30%) levels of green grams (GG), cowpeas (CWP) and Lablab beans (LB) respectively in PM-soybean meal (SBM) based diets on growth performance and carcass quality of broiler chicken. The diets were isocaloric at 3000kcal/ kg of metabolizable energy (ME) for both the starter and finisher periods and isonitrogenous with a crude protein content of 22 and 20% for the starter and finisher diets respectively. A total of 80 and 400 male sexed Arbor Acres broilers were used in experiment one and two respectively. Broilers were reared for 42 days in both experiments and normal management procedures such as feeding, watering and disease control were conducted. Data on feed intake, body weight gain, Feed Conversion Ratio (FCR) as well as dressed weight, weight of breast muscle, drumstick, abdominal fat pad, gizzard, liver and pancreas were collected and analyzed. Results showed that, chicken fed on PM based diets had higher ($P<0.05$) weight gain than those fed on maize based diets. However, there was no significant effect on feed intake, FCR and all the carcass parameters investigated for the two diets. Results of experiment 2 showed that inclusion of GG in broiler chicken diets at levels of 10, 20 and 30% had no effect ($P>0.05$) on body weight gain, feed efficiency and all carcass parts studied. However, its inclusion above 20% level caused a significant reduction in feed intake. Inclusion of CWP at 10, 20 and 30% level had no effect ($P>0.05$) on feed intake, feed efficiency and all carcass parts studied. However, its inclusion above 10% level resulted in a reduction ($P<0.05$) in body weight gain. Inclusion of LB at all levels resulted in a significant reduction in feed intake, body weight gain and feed efficiency but it had no effect ($P>0.05$) on the weights of the carcass parts. The results also indicated that GG fed broilers had a better performance in terms of body weight gain, live weight, dressed weight and drumstick weight followed by CWP while those on the LB diets had the least performance. It was also noted that broilers on all diets based on GG had a distinct yellow coloration of the shanks, skin and beaks. Color is important for visual appeal and consumers in Kenya prefer broilers with yellow skins similar to the indigenous chicken. Higher profit (Ksh 26.46/bird) was realized from chicken on PM compared to those fed on maize based diets in experiment one. Broilers in the 10% CWP diets had a higher net profit (4.8Ksh/bird) compared to the broilers on the 0%LGM diet. The high cost of GG and LB however, caused the feeds to be expensive resulting in lower profits than those on the 0%LGM diet. Therefore PM can be used to replace maize in broiler chicken diets resulting in higher body weight gain and profit. Green gram can be used in diets of broiler chicken at a level of 30% and CWP at a level of 10% without negatively affecting performance. However use of LB in broiler chicken diets should be discouraged as it reduces performance.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

Broiler chicken industry is important and is placed second to pork in terms of meat production in the world (Yang and Jiang, 2005). The population in Kenya is growing and is projected to increase to about 65 million people by 2050 (NCAPD, 2010). There will also be a rapid economic growth that will be accompanied by an increase in per capita income resulting to increase in animal protein consumption (MoLD, 2008).

Most of this animal protein is expected to come from the broiler industry due to its increasing popularity in urban and peri-urban areas. This popularity is partly due to the low capital and space requirement and the fact that broilers take less time to mature compared to other animals (Kingori *et al*., 2010).

However, the poultry industry is characterized by high cost of feeds which account for 60-80% of the total production cost (MoLD, 2009). The increased costs of feeds is due to the high costs of maize and SBM which are the main raw materials used in the production of broiler chicken feed.

1.2 Problem statement

Broiler feed in Kenya accounts for 60-80% of the total production cost making it the most expensive input in production (MoLD, 2009). This consequently leads to increase in the production cost of the broiler chicken and lowered profit margins.

Maize is the major source of energy and most utilized cereal in formulation of broiler feeds in the world contributing to about 50-60% in most poultry diets (Panda *et al*., 2010; Ibitoye, 2012). It supplies approximately 65% of the total ME requirement of the chicken (Cowienson, 2005). In

Kenya maize is the most widely consumed cereal (by 96% of the population). This creates high competition between human food and animal feed manufacturers (Byerlee and Eicher, 1997). The competition combined with the fact that maize production has been declining due to climate change and high incidences of pest and diseases, has led to increased importation of maize to meet human and animal food/feed industry demands (Nyoro *et al*., 2007). Consequently this has led to the increase in the cost of maize. A locally available alternative source of energy for the poultry feed industry would significantly reduce the cost of production.

Fish meal and SBM are the main animal and plant protein sources respectively that are used in the poultry feed industry in Kenya (Gakuya *et al*., 2014). Soybean meal is preferred due to its high amount of ME and crude protein (44-48%) with well balanced amino acids that are highly digestible (NRC, 1994). In Kenya, it is not produced in enough quantities to satisfy the food and feed industries' demand and the deficit is usually imported from the neighboring countries such as Uganda, Tanzania and as far as India (Tinsley, 2009; FAO, 2011).

Fish meal can only be added in small amounts in broiler chicken feed due to high cost and the smell which might be transferred to the animal products if added in large quantities (more than 10 %) (Austic and Nesheim, 1990). With this in mind therefore, it is important to search for locally available grain legumes which can be used to partially substitute SBM in broiler feeds.

1.3 Justification

The unavailability of inexpensive maize and SBM has forced nutritionists to look for suitable alternative energy and protein sources respectively which will reduce the reliance on the two in the broiler chicken industry (Baurhoo *et al*., 2011). Substituting maize in poultry feeds with cheaper locally available feed ingredients will significantly reduce the cost of poultry production

(Bamgbose *et al*., 2004). Pearl millet is high in ME, crude fat, minerals and crude protein when compared to maize. Its amino acid profile is also more balanced with higher amounts of lysine and methionine compared to maize (Adeola and Rogler, 1995; Amato and Forrester, 1995).

Grain legumes such as GG, CWP, and LB have an almost similar amino acid profile and metabolizable energy to SBM and can be suitable replacements (Wiryawan, 1997; Indriani and Murwani, 2005; Moawia, 2015). Utilization of grain legumes in poultry diets has been researched around the world and information on nutritional value and the amounts and types of anti-nutritive factors in the legumes is available (Mubarak, 2005; Afiukwa *et al*., 2012; Soetan, 2012). However, the available data may not be replicated for diet formulation under local conditions since nutritional value of grain legumes depends on differences in cultivars, soil, climate and agronomic factors. Also, levels of anti-nutritive factors depend on species and cultivars of the grain legumes (Gatel, 1994; Smits and Annison, 1996).

Most studies done with broiler chicken using the three legumes used either maize or sorghum as the main source of energy (Abeke *et al*., 2008; Murwani, 2008; Chakam *et al*., 2010) but very few if any have used PM. Therefore research on the potential of the above legumes combined with PM would be important.

In addition, very few studies have been done on utilization of GG as broiler chicken feed and it would therefore be important to find out the effects of inclusion and the suitable level of inclusion in broiler chicken diets.

Kenya has a large proportion of land mass (80%) which is arid and semi arid (MOA, 2010). Pearl millet, GG, CWP and LB, perform comparatively better than maize and soy beans under these conditions of high temperatures and low rainfall. Use of these crops in poultry feed production would result in reduced reliance on maize and soybean as the sole provider of energy and protein respectively and would also provide a market for these dryland crops.

Overreliance on maize and SBM can be overcome by use of PM to replace maize and tropical grain legumes (GG, CWP and LB) to partly substitute SBM. The purpose of this study therefore was to determine the effects of using PM, GG, CWP and LB on the growth performance and carcass quality of broiler chicken.

1.4 Objectives of the study

1.4.1 Broad objective

To determine the effects of PM as a dietary replacement of maize and substitution of SBM with varying levels of GG, CWP, or LB on growth performance and carcass quality of broiler chicken

1.4.2 Specific objectives

i. To evaluate the effects of replacing maize with PM on growth performance and carcass quality of broiler chicken
ii. To determine the effects of partially substituting SBM with varying dietary levels of GG, CWP, or LB on growth performance and carcass quality of broiler chicken
iii. To evaluate the economics of production when PM replaces maize and GG, CWP, or LB replace part of SBM in broiler chicken diets.

1.4.3 Hypothesis

Alternative hypothesis (H_A) -

i. Pearl millet has potential to replace maize as an energy source in broiler chicken diets without affecting growth performance and carcass quality

ii. Green gram, CWP, or LB have potential to partly substitute SBM in broiler chicken diets without affecting growth performance and carcass quality

iii. Pearl millet replacing maize and GG, CWP, or LB replacing part of SBM have potential of making economical feeds for broiler chicken in Kenya

CHAPTER TWO: LITERATURE REVIEW

2.1 Overview of poultry sector in Kenya

Poultry industry has transformed to become the most important in the livestock sector. It provides food, employment, income and contributes 50% of the total livestock sector earnings, 30% of the Agricultural sector earnings and 7.8% of the Gross Domestic Product. It also grows the economy by having linkages with other industries such as, the input suppliers, feed manufacturing and the hotel industry. The increased popularity could be attributed to its low capital and space requirements, quick return to investment and relatively simple management practices (MoLD, 2009).

Kenya has an estimated 31.9 million chickens with indigenous ones occupying the highest percentage of 80.9% comprising 25.8 million while commercial chickens are 19.1% equivalent to 6.1 million. Indigenous chicken are mainly reared in the rural areas by small scale farmers under none or semi commercial systems that are characterized by low input low output situations (MOLFD, 2007). Commercial chicken (broilers and layers) on the other hand are kept in the outskirts of main urban centers with broiler production being the most important enterprise in the livestock sector. Annually, the country produces about 20 tons of poultry meat worth Kenya shillings (Ksh) 3.5 billion and 1.3 billion eggs worth Ksh 9.7 billion.

According to the MoLD (2009), livestock feeds in Kenya account for between 60-80 % of the total production costs. Inconsistent supply of some feed ingredients, especially imported oil-seed cakes and meals, has affected both the quality and quantity of feed production. Therefore, to cope with both short-term and long-term needs for animal feeds, the Kenyan government is working to promote diversification of the feed base through the use of alternative sources of both energy and protein.

2.2 Maize (*Zea mays*)

2.2.1 Agronomic characteristics of maize

Maize/corn ('mahindi' in Swahili) is one of the oldest domesticated crops that belong to the poaceae family. It originated from Mesoamerican region probably the Mexican highlands and it's the third most important cereal in the world after wheat and rice (Watson and Dallwitz, 1992).

Maize has a rainfall requirement of 500-600mm which is higher compared to the requirements for other cereals such as sorghum (400mm) and pearl millet (300mm) (Ledér, 2004). It is grown all over the world but at varying magnitudes. In 2012, 875,226.630 tons of maize was produced worldwide with USA contributing 31%, China 24% and Brazil 8% of the total production (FAO, 2012).

In Kenya, maize is a staple crop and the most widely consumed cereal by 96% of the population (Byerlee and Eicher, 1997). This results in increased competition between human food and animal feed industries. Its production has also been declining due to erratic climatic conditions, high incidences of pests and diseases and lack of production enhancing technologies (Nyoro *et al*., 2007). Low production and competition between human and animal feeds industries has led to increase in maize demand above what the country can produce. The deficit is usually met by importation leading to increase in the cost of maize.

2.2.2 Nutrient composition of maize

Proximate composition of maize is presented in Table 2.1 below. Maize has various characteristics which make it the most favorable grain for broiler chicken feed formulation; It has a high ME of 3,448 which is contributed by its starchy endosperm that is composed of amylopectin and the germ (Leeson and Summers, 2009), is low in crude fiber (22 g/kg) and contains a fat content of 1.5-3.8 which is rich in linoleic acid (an essential fatty acid) (NRC, 1994). The maize protein which is mainly prolamin or zein is low (7.5-8.1%) and is limited in lysine and tryptophan (Rosenberg *et al*., 1960).

Table 2.1: Nutrient composition (%) of pearl millet and maize grains (DM)

Nutrient composition	Maize	Pearl millet	References
Gross energy, kcal/kg	3350	2675	NRC (1994)
	3788	4132	Adeola and Orban (1995)
	4154	4347	Lawrence *et al*. (1995)
Crude protein (%)	8.5	14	NRC (1994)
	7.5	11.1	Adeola and Orban (1995)
	8.1	12.0	Lawrence *et al*.(1995)
Crude fat (%)	3.8	4.30	NRC (1994)
	1.51	5.06	Adeola and Orban (1995)
	2.9	6.7	Lawrence *et al*.(1995)

2.2.3 Anti-nutritive factors in maize grain

Maize contains low concentrations of soluble Non Starch Polysaccharides and other anti-nutritive factors such as phytin, trypsin inhibitors, tannins, polyphenols and lectins (Eeckhout and DePaepe, 1994; Choct, 1997; Awada *et al*., 2005). Non Starch Polysaccharides increase the viscosity of the digesta, act as a barrier between nutrients and enzymes and in turn reduce the digestion of nutrients (Sandberg, 2002).

2.2.4 Utilization of maize in poultry diets

2.2.4.1 Broiler chicken

Maize is the most utilized cereal in formulation of broiler feeds in the world (Panda *et al*., 2010). It constitutes about 50-60% in most poultry diets (Ibitoye, 2012) contributing approximately 65% of the total ME requirement for the chicken (Cowienson, 2005).

In a eight week study on broiler chickens, Joseph and Abolaji (1997) found that maize can be replaced by 20% cooked mango kernel seed meal without affecting (P>0.05) daily feed intake, FCR, live weight gain and dressed weight. Partial replacement of maize with date pits at 10 and 20% produced similar (P>0.05) feed intake (Masoudi *et al*., 2010). Similar (P>0.05) feed intake (119.02, 124.52 and 119.60g/bird), FCR (2.80, 2.63 and 2.59), weight gain (2012.10, 1995.70 and 1881.40g/bird), drumstick weight (8.91, 8.07 and 8.66%) and abdominal fat (0.12, 0.05 and 0.13%) were reported for forty two day old broiler chicken fed on diets based on maize, sorghum and millet respectively (Kwari *et al*., 2014). Barley can replace maize in broiler chicken diets at 40% without negatively affecting growth and feed efficiency in grower and finisher diets (Brake *et al*., 1997).

Some authors have shown that broilers fed on maize diets performed poorly compared to those fed on other energy sources. Ibe *et al*. (2014) showed that broilers on maize based diets had a lower (P<0.05) feed intake (5506.6 g/bird) compared to those fed on pearl millet and finger millet based diets (5885.2 and 5811.1g/bird respectively), weight gain (2009.01, 2408.38 and 2301.1 g/bird respectively), dressed weight (1398.33, 1637.33 and 1581.67g respectively) and poor FCR (2.74, 2.44 and 2.53 respectively). Carcass quality in terms of reduced abdominal, liver and thigh fat was reported when maize was replaced by finger millet in diets of broiler chickens (Rama Rao *et al*., 2004).

2.2.4.2 Layer chicken

Studies conducted comparing maize to other energy sources in layer diets have shown better performance of chicken fed on maize based diets. Salami and Odunsi (2003) observed higher egg weight at 56 and 72 weeks in chicken fed on maize based diets compared to those on diets based on cassava peel meal at 50, 75 and 100% inclusion levels. However poor FCR (2.9) was reported in chicken fed on diets based on maize compared to those on 50 and 75% cassava peel meal. Layers on maize based diets had higher (P>0.05) feed intake (109.02 g/bird) than those on 25, 50, 75 and 100% cassava root meal (101.97, 104.78,101.2 and 101.6g/bird respectively) (Anaeto *et al*., 2010). Reduced performance and low egg quality for chickens fed on barley based diets compared to those fed on maize based diets was observed (Benabdeljelil and Arbaoui, 1994; Mohammed *et al*., 2010).

Similar bird performance and egg quality parameters were reported for layers fed on whole grain paddy rice and maize based diets (Sittiya and Yamauchi, 2014). Similarly Subramanian and Metta (2000) reported no differences in egg production rate and feed intake for chicken on sorghum and maize based diets. Use of either pelleted or mash diets based on maize or sorghum resulted in comparable feed intake, body weight, FCR and egg production rate (Reddy *et al*., 2005). Maize and barley fed to white leghorn layers compared similarly in terms of growth, feed efficiency and sexual maturity (Ernst *et al.,* 1994). Inclusion of cassava root meal at 25% and 100% produced similar (P>0.05) egg production per hen per day and egg weight respectively (Anesto *et al*., 2010).2.3 Pearl millet (*Pennisetum glaucum*)

2.3.1 Agronomic characteristics of pearl millet

Pearl millet locally known as 'Mawele' in Swahili is believed to have originated from the western edges of the Sahara desert (Hidalgo *et al*., 2004). It is an economically important cereal grain that is ranked as the fifth most important tropical cereal crop in the world after rice, wheat, maize, and sorghum (Poncet *et al*., 2000). It is also the most important cereal crop of the hot arid regions of the world (Andrews and Kumar, 1992).

In Africa, PM is the most popularly grown millet covering 76% of the total area under millet production (Obilana, 2003). This could be due to its drought tolerance ability (Lee and Hanna, 2002; Mehri *et al*., 2010) requiring an average rainfall of 200 to 600 mm/year which is not sufficient for the cultivation of either maize or sorghum (NRC, 1996). It is also early maturing, deep rooted, well adapted to droughty, sandy acidic soils of low fertility and requires about 70% less fertilizer for cultivation than maize (Mangat *et al*., 1999; Davis *et al*., 2003).

In Kenya, PM is grown in the drier parts of the country, particularly in Tharaka, Mbeere and Mwingi subcounties and to a lesser extent in parts of Lamu, Makueni, Machakos, Embu, and Kirinyaga counties (Maundu *et al*., 1999).

2.3.2 Nutrient composition of pearl millet

The Gross Energy (GE), Crude Protein (CP) and crude fat values of PM are summarized in Table 2.1. Although the nutritive value of pearl millet is influenced by genotype and factors such as climatic conditions and cultural practices including fertilizer application (Burton *et al*., 1972), it is superior to maize in terms of CP, crude fat, calcium, available phosphorous and all essential amino acids (NRC, 1994). The GE of the PM grain ranges from 2675- 4347kcal/kg depending on the soil and climatic conditions (Table 2.1). Fancher *et al.* (1987) reported that the GE is usually underestimated by 20%. Amino acid content of pearl millet is well balanced compared to maize (Adeola and Rogler, 1995; Amato and Forrester, 1995). Lysine in pearl millet is 40% more than in maize at 0.45% and 0.27% respectively while methionine is 30% more than maize at 0.25% and 0.18% respectively. Calcium and available phosphorous are higher in pearl millet compared to maize at 0.05% versus (vs) 0.02% and 0.12% vs 0.08% respectively (NRC, 1994). Compared to maize, pearl millet is richer in omega-3 fatty acids, including linolenic (3.7% vs 1.2%), palmitic (20.1% vs 14%) and stearic (3.9% vs 2.4%) (Burton *et al*., 1972). Millets are also rich sources of micronutrients and phytochemicals (Mal *et al*., 2010; Singh *et al*., 2012). However it is higher in crude fiber than maize (NRC, 1994; Tulasi *et al*., 2004).

2.3.3 Anti-nutritive factors in pearl millet grain

Pearl millet contains various anti-nutritive components among them, tannins, phytic acid, polyphenols, goitrogens, and oxalic acid (Ledér, 2004). Their concentrations in the pearl millet grain depend on genetic, agronomic and other environmental factors (Wayne, 2013). However their concentrations are generally lower than in most cereal grains (Choct, 2006), therefore they do not pose a major problem in utilization of pearl millet and heat treatment is not necessary to destroy anti-nutritive factors (Andrews and Kumar, 1992).

2.3.4 Utilization of pearl millet in poultry diets

2.3.4.1 Broiler chicken

Various studies have indicated that growth performance parameters compared favorably for broilers fed PM and maize based diets. Body weight gain for finisher broilers fed PM and maize was 173.08 and 170.58g respectively, feed intake was 532.85 and 535.62g respectively, while

FCR was 3.12 and 3.09 respectively (Ibitoye *et al.*, 2012). Bashar *et al*. (2012) reported similar results where weight gain (1279.52 and 1262.99 g/bird) and FCR (2.94 and 3.18) were not significantly different for broilers fed PM and maize diets respectively. There were no significant differences in body weight gain (1862, 1788, 1768 and 1578g/bird) and FCR (2.24, 1.45, 2.88 and 2.94) when maize was replaced with PM, low tannin or high tannin sorghum respectively in broiler diets (Clement *et al.*, 2010). When 75% maize was replaced with PM there were no negative effects on body weight and feed efficiency (Manwar and Mandal, 2009). Body weight gain and FCR were also similar for broiler chicken fed 5-10% whole PM grains and maize based diets (Hidalgo *et al*., 2004). Davis *et al*. (2003) reported that when 50% maize was replaced with whole grain PM, growth and carcass yields compared well.

However some authors have reported that PM is superior to maize in terms of growth performance and carcass yields. Significantly higher body weights of (1632 vs 1550 g/bird), and FCR (2.20 vs 2.31) were reported when broilers were fed diets containing 25% PM and maize respectively (Tornekar *et al.*, 2009). Baurhoo *et al*. (2011) reported improved body weight, feed intake and feed efficiency when broilers were fed PM based diets.

2.3.4.2 Layer chicken

Collins *et al*. (1995, 1997) and Mehri *et al*. (2010) reported that partial or total replacement of maize with PM had no effect on body weight, feed conversion and egg production. Garcia and Dale (2006) also indicated that whole PM grains can be included in layer diets up to a 10% level without positively or negatively affecting feed consumption and egg production. Amini and Riuz (2007) reported that PM can totally replace maize in diets of laying hens without adversely effecting feed intake, egg production and egg quality but it affects yolk pigmentation score. They also reported that PM results in production of n-3 fatty acid enriched eggs since PM grain contains a larger amount of n-3 fatty acids compared to maize grain. Dietary flax seeds are usually included in layers diets to produce n-3 fatty acids enriched eggs. The use of PM resulted to reduced use of the flax seeds. Higher inclusions and longer use of flax seeds is associated with liver hemorrhage and development of off-flavors in eggs (Jiang *et al.*, 1992).

Kumar *et al*. (1991) reported increased egg size and better feed efficiency when maize was substituted with 60% PM by weight. However Rama Rao *et al*. (2000) reported that PM inclusion in layer diets resulted in reduced egg weight compared to the maize based diets.

2.4 Grain Legumes

This is a diverse group of plants belonging to the family Fabaceae/Leguminosae. The name legume is derived from the Latin word ‘legumen’ which means seeds that are harvested from pods. They are useful in the formulation of monogastric animal feeds due to the higher concentration of proteins which is at least twice that in cereal seeds (Allen and Davis, 2013). Although the protein content in the legume seed depends on genotype and environmental factors according to Allen and Davis (2013), grain legumes are moderate to good sources of protein providing 150 to 400 g/kg crude protein (Hedley, 2001). The predominant protein fraction in legume seeds is made of storage proteins globulins (60-90%) rich in arginine, aspartic acid, glutamic acid, and their amides.

Their amino acid profile is relatively well balanced with high amounts of lysine Coertze and Ventor (1996) but poor in sulphur containing amino acids (methionine and cysteine) and Tryptophan (Wang *et al*., 2003). However the deficiency in sulphur containing amino acids does not pose a major problem in poultry nutrition due to presence of synthetic methionine which is usually included in feeds during formulation. Although grain legumes have a low methionine level (Coertze and Ventor, 1996), this does not pose a major challenge since synthetic methionine is usually added as a supplement in broiler feeds. The problem of low levels of sulphur containing amino acids could also be overcome by mixing grain legumes with cereals which are relatively good sources of sulphur containing amino acids (Shewry and Tatham, 1999).

Legumes are also used in crop rotations because of their ability to fix nitrogen in the soil making them important in maintaining soil fertility. They also contribute to the reduction in global warming, eutrophication and land degradation through reduced inorganic fertilizer use (Graham and Vance 2003).

2.4.1 Soybean (*Glycine max*)

2.4.1.1 Agronomic characteristics of soybean

Soybean (SB), a leguminous crop belonging to family *fabaceae* and genus *glycine*, is believed to have originated from China around 1500 -1100 BC. It is one of the world's most important crops that is cultivated for its nutritional benefits and its ability to improve soil fertility through nitrogen (N) fixation. It is estimated to fix 44-103 kg of N/ha (Sanginga *et al*., 2003). It is also the world's leading oil crop and the most produced protein feedstuff accounting for two-thirds of the total world output of protein feedstuffs (Cober *et al*., 2009).

The largest producers of SB in the world in order of importance include the USA, Brazil, Argentina, China and India, while the main consumers are USA, Canada and China (FAO, 2011).

Soybean production in Kenya is estimated at 2425 Metric Tons (MT) which accounts for 0.7% of the world production (FAO, 2011). The consumption which is estimated at 100, 000 MT/year is constantly growing exceeding the produced amounts (Tinsley, 2009). The deficit is usually imported and the volumes imported increased from 50000MT in 2008 to 120,000 MT in 2011 (FAO, 2011). Consumption of SB in Kenya is divided between human and livestock feed. Human consumption accounts for only 10-15% of the total. Within the livestock feed consumption, the poultry industry is the main consumer followed by the dairy industry (Chianu *et al*., 2008).

2.4.1.2 Nutrient composition of soybean

Soybean meal (SBM) is a product of oil extraction from SB. The proximate composition of SBM is presented in Table 2.2 below. It is the richest plant protein source and is a standard to which other plant protein sources are compared (Blair, 2008). It contains high CP content (44-49%) that has a well balanced amino acid profile which is high in lysine, tryptophan, isoleucine, valine and threonine that are often lacking in cereal grains (NRC, 1994). The protein from SBM is comparable to high quality animal protein with the exception of sulphur containing amino acids (Endres *et al.,* 2001). It is also very high in ME due to its high oil content and low in fiber (less than 3%) (Gatlin *et al*., 2007).

2.4.1.3 Anti-nutritive factors in soybean

Raw SB contains various anti-nutritive factors that have toxic effects on monogastric animals. Protease inhibitors and lectins represent the largest percentages of the anti-nutritive factors (Liener, 1994).

Saponins, tannins, phytates, estrogens, oligosaccahrides, antigens, non starch polysaccharide, anti-vitamins and goitrogens are also present but in smaller amounts incapable of causing significant effects (Ishaaya and Birk, 1969; Yoshiki *et al*., 1998; Doerge and Sheehan, 2002).

Table 2.2: Nutrient composition (%) of soybean meal (DM)

Nutrient composition	Amount (%)	References
Crude Protein	49.00	NRC (1994)
	48.00	Willis (2003)
	43.8	Van Eys *et al*. (2004)
Ether extracts	1.00	NRC (1994)
	2.50	Willis (2003)
	0.55	Van Eys *et al*. (2004)
Crude fiber	3.90	NRC (1994)
	4.20	Willis (2003)
	4.3	Van Eys *et al*. (2004)

Anti-nutritive factors cause reduced feed intake and nutrient digestibility thereby affecting growth rate and feed utilization and can also affect reproduction (Bau, 1997).

Heat treatment of SB during oil extraction destroys heat labile anti-nutritive factors such as protease inhibitors and lectins making it suitable for use in monogastric diets (Newkirk, 2010). Two major processes of oil extraction from the SB exist; the expeller and the solvent methods. The expeller method uses a screw press that squeezes the beans and removes oil, the resultant soy product is the soybean cake. In the solvent method, a solvent such as hexane is used to extract oil from the bean. The bean is later heated to remove the excess hexane. The resulting product is the SBM (Newkirk, 2010). Some anti-nutritive factors such as oligosaccharides are heat stable but are removed by the solvent during the solvent extraction method (Parsons *et al.*, 2000).

2.4.1.4 Effects of soybean on performance of poultry

Soybean meal is a major source of protein for all types of poultry due to the amount and quality of its protein and amino acids. An experiment conducted for eight weeks using 51 weeks old layers showed higher feed intake for SBM fed layers (117.9g/b/d) compared to those on 25, 50, 75 and 100% palm kernel meal (111.4, 111.5, 106.6 and 102.3g/b/d respectively). Layers fed on the SBM based diets also had higher egg shell thickness (0.34 mm) and better FCR (2.02) than those fed the 75 and 100% palm kernel meal (0.31 and 0.32mm) and (2.36 and 2.75) respectively (Sinurat *et al*., 2014).

There was no significant effect (P>00.5) reported on egg production (75.65, 73.23, 73.08 and 72.60%) and live weight gain (250, 251, 278 and 288g) of layers fed on diets based on SBM and 25, 50 and 75% imported sesame meal (Tangtaweewipat and Cheva-Isarakul, 1993). Ciurescu *et al*. (2009) reported that layers on SBM diets performed similarly in terms of laying performance and egg quality compared to those on rapeseed meal and canola seed meal at 15 and 20% respectively. Similar feed consumption, egg production and egg size was reported for layers fed on SBM and diets based on 16, 18 and 21% peanut meal (Pesti, 2003). Layers fed on SBM performed similarly (P>0.05) to those fed on sunflower meal at 24.84% (Shi *et al.*, 2012). Leeson *et al*. (1987) reported no effect (P>0.05) on feed intake, weight gain and FCR for layers fed on SBM and canola meal based diets.

Higher weight gain (1649.05 vs 1529.00g/bird) and better FCR (2.18 vs 2.72) was reported for broilers fed on SBM based diets compared to those fed on cassava leaf meal and blood meal diets respectively (Adeyemi *et al.*, 2012). Higher weight gain and better FCR was reported for broilers fed on diets containing 4, 8, 12 and 16% rapeseed meal compared to those fed on SBM based diets (Reza *et al.*, 2008).

Ghadge *et al*. (2009) reported lower weight gain (224.22 vs 267.33) and poor FCR (2.00 vs 1.77) for broilers fed on SBM based diets and groundnut based diets respectively.

2.4.2 Green gram (*Vigna radiata*)

2.4.2.1 Agronomic characteristics of green gram

Green gram known as 'Pojo' in Swahili is a popular leguminous crop of Asia that belongs to Leguminosae/Fabacea family and sub family Papilionoideae (Agugo, 2003). Green gram, a native plant of India and Central Asia (Tomooka *et al*., 1992), is an erect annual legume with a short growth period (75-90 days). It is drought tolerant and does not require nitrogen fertilization just like other legumes.

Green gram is either green or yellow in color, with a shiny or dull seed coat (Pal *et al*., 2010). The seed color and presence or absence of a rough layer on the seed distinguishes the different types of green grams (Lambrides and Godwin, 2006).

India is the world's largest producer of GG contributing to about 70 % of the world's production in an area of 2.99 million hectares (ha) per year. China is the world's second largest producer of GG which represents about 19% of its legume production (USDA, 2011). Although Thailand is not the major producer of GG it is the main exporter and its production is increasing (Lambrides and Godwin, 2006).

Green gram production in Kenya rose by 58% from 296,808 bags (90kg bag) in 2008 to 470,372 bags in 2009. The area under production has also increased from 87,510 ha in 2005 to 112,997 ha in 2009 (MoA, 2010).

2.4.2.2 Nutrient composition of green gram

The proximate composition of GG (CP, crude fiber and ether extracts) has been summarized in Table 2.3 below. Crude protein values are relatively high ranging from 22.9-27.5%. The protein in GG is rich in lysine and tryptophan although it is poor in sulphur containing amino acids similar to other legumes (Khalil, 2006). It has a relatively low oil content which ranges from 0.8-2.8% with Linoleic, palmitic and oleic acids as the predominant fatty acids (Anwar *et al*., 2007). The crude fiber varies considerably with values ranging from 1-8%. Green gram is also rich in carbohydrates, energy, vitamins, iron, magnesium, phosphorous, potassium, copper and vitamin E, including tocopherols and tocotrienols (Gopala *et al*., 1997; Khalil, 2006).

2.4.2.3 Anti-nutritive factors in green gram

Green gram contains various anti-nutritive factors which have been shown to have some effect on growth and performance of monogastric animals. The factors are however minimal in this grain and include; trypsin inhibitor, tannins, lectins, phytic acid, phenols and saponins (Siddhuraju *et al*., 2002; Mubarak, 2005; Khalil, 2006).

2.4.2.4 Effects of green gram on monogastric animals performance

Few studies have been conducted on utilization of GG in monogastric animals especially broiler chickens.

Table 2.3: Nutrient composition (%) of green gram grain (DM)

Nutrient composition	Amount (%)	References
Crude Protein	25.0	Bhatty *et al*. (2000)
	27.5	Mubarak (2005)
	22.90	Agugo *et al*. (2009)
Ether extracts	2.83	Bhatty *et al*. (2000)
	1.85	Mubarak (2005)
	1.43	Agugo *et al*. (2009)
Crude fiber	1.68	Bhatty *et al*. (2000)
	4.63	Mubarak (2005)
	8.95	Agugo *et al*. (2009)

Robinson and Singh (2001) reported that raw GG could form up to 28% of wheat or sorghum based diets without reducing the performance of broiler chicken. In another study the same investigators reported that delta or emerald varieties of green gram could be included up to 300g/kg in layer diets without negatively affecting their performance.

Murwani (2008) reported that the body weight gain of broilers fed maize- green gram based diet was nearly the same as the body weight of broilers fed maize- soybean diet. Wiryawan *et al.* (1997) reported that Berkin variety of green gram in diets of pigs at levels of up to 300 g /kg was nutritionally satisfactory.

2.4.3 Cowpea (*Vigna unguiculata*)

2.4.3.1 Agronomic characteristics of cowpea

Cowpea locally known as ‘Kunde’ in Swahili is one of the most important indigenous legumes in the tropics and sub tropics (NRC, 2006). It is widely distributed in sub-Saharan Africa (where it is thought to have originated) (Allen and Davis, 2013), Asia, Central and South America, USA and some parts of southern Europe (Singh *et al.*, 1997). Cowpea is a heat and drought tolerant crop (Apata and Ologhobo, 1997) and can tolerate soils of low fertility due to its high rate of nitrogen fixation.

Approximately 7.6 million tons of CWPs are produced annually in Africa. It is the largest producer in terms of acreage at 64% of the 12.8 million ha of land under cowpeas in the world while America is the second at 21% of the total acreage followed by Europe and Asia (Pereira *et al*., 2001).

In Kenya, CWP is the third most important grain legume, after beans and pigeon pea, and covers an area of about 18,000 ha. It is grown in the ASALs of former Central, Coast, Eastern and Western Provinces (Muthamia and Kanampiu, 1996). Locally, it is a preferred vegetable crop by small scale farmers in rural areas due to its high protein content (20-25%), palatability and relative freedom from metabolites or other toxins (Singh *et al*., 1997; Aveling, 2000).

2.4.3.2 Nutrient composition of cowpea

A summary of CP (23.78-26.4%), Crude fiber (2.45- 5.8%) and ether extracts (1.27-2.0%) values of CWPs are presented in Table 2.4 below. The nutrient and energy content of cowpeas is similar to that of SB, with similar amino acid profiles (Ravindran and Blair, 1992) rich in lysine but poor in sulphur amino acids (Coertze and Venter, 1996). The variation in protein level within species of cowpeas may be attributed to differences in genotypic, environmental and agronomic factors (Ali-khan and Youngs, 1973).

Table 2.4: Nutrient composition (%) of cowpea grain (DM)

Nutrient composition	Amount (%)	References
Crude Protein	25.3-26.4	Tshovhote *et al*. (2003)
	26.51	Chakam *et al*. (2010)
	23.78	Akanji *et al.* (2012)
Ether extracts	1.3-1.4	Tshovhote *et al*. (2003)
	2.20	Chakam *et al*. (2010)
	1.27	Akanji *et al*. (2012)
Crude fiber	5.15-5.81	Tshovhote *et al*. (2003)
	5.28	Chakam *et al*. (2010)
	2.45	Akanji *et al*. (2012)

2.4.3.3 Anti-nutritive factors in cowpeas

Cowpea grain has been reported to contain various anti-nutritive factors such as haemagglutinins, protein inhibitors, phytic acid and tannins among others (Oluwatosin, 1999; Maia *et al.*, 2000; Amaefule and Osuagwu, 2005; Téguia and Beynen, 2005).The level of these anti-nutritional factors depends on environmental conditions and genotypes of the CWP. Trypsin inhibitor content is determined by genotypes, while phytic acid, haemagglutinin and tannin levels, are mainly dictated by the environment (Oluwatosin, 1999).

2.4.3.4 Effects of cowpea on broiler chicken performance

Growth performance parameters of broilers fed different levels of CWP were better than those fed on the control diet. Eljack *et al*. (2009) reported higher weight gain and better feed conversion as the levels of cowpeas were increased in broiler chicken feed. In a study done by Akanji *et al*. (2012) on broilers to test the effect of de-hulled cooked and de-hulled roasted CWPs, no significant differences (P>0.05) were observed in terms of weight gain, feed efficiency and Protein Efficiency Ratio (PER). Abdelgani *et al*. (2013) reported that performance parameters such as feed intake, weight gain, live weight, carcass weight and dressing percentage were not affected by inclusion of CWPs at 5-15% levels in broiler chicken diets. Chakam *et al*. (2010) reported that up to 20% cooked CWP could be included in broiler finisher diets without negatively affecting feed consumption, live weight, weight gain, feed conversion ratio, cost of producing a kg of meat, carcass yield, some carcass parts, mortality and serum creatinine.

2.4.4 Lablab bean (*Lablab purpureus*)

2.4.4.1 Agronomic characteristics of lablab bean

Lablab bean, known as ‘Mfiwi’ in Swahili is a grain legume belonging to the family Fabaceae. It is a vigorous, annual or perennial twiner native to Africa and Asia (Pengelley and Maass, 2001; Robinson and Singh 2001). It is a drought tolerant crop that is grown in semi-arid and humid regions with rainfall amount between 200-2500mm/year (Shivashankar *et al*., 1993; Murphy and Colucci, 1999).

It is cultivated for its edible green leaves or mature seeds. The seeds have different colors ranging from black, brown, white, speckled red, plain red, to mottle. The red type is rare in Kenya and its seeds have been reported to be poisonous after a few generations (Maundu *et al.*, 1999). The leaves are eaten as vegetables and can also serve as a fodder (Maundu *et al*., 1999). Lablab is either cultivated as pure stands or intercropped with maize, millet, sorghum, groundnut or castor (Kinyua *et al*., 2008). It can also be grown as a cover crop due to its dense green cover that protects the soil against erosion. In Kenya, it is produced in over 7000 ha predominantly by small scale farmers in Kiambu, Lamu, Machakos, Makueni, Meru, and Nyeri counties (MoA, 2005).

2.4.4.2 Nutrient composition of lablab bean

The summary of CP (24.26- 24.92%), Crude fiber (11.66- 10.93%) and ether extracts (0.98- 9.51%) of lablab LB is presented in Table 2.5 below. Lablab bean is rich in protein, carbohydrates, energy, thiamine, niacin, calcium and iron (Deka and Sarkar, 1990; Salimath and Tharanathan, 1992).

Table 2.5: Nutrient composition (%) of lablab bean

Nutrient composition	Amount (%)	References
Crude Protein	24.26	Abeke *et al*. (2008)
	22.8	Kunyanga and Imungi (2010)
	24.92	Ragab *et al*. (2010)
Ether extracts	9.51	Abeke *et al*. (2008)
	1.00	Kunyanga and Imungi (2010)
	0.98	Ragab *et al*. (2010)
Crude fiber	11.66	Abeke *et al*. (2008)
	4.6	Kunyanga and Imungi (2010)
	10.93	Ragab *et al*. (2010)

2.4.4.3 Anti-nutritive factors in lablab bean

Lablab bean contains various types of anti-nutritive factors which make it unsuitable for use in large amounts in diets of monogastric animals. They include trypsin inhibitors, tannins, lectins, phytic acid and polyphenols (Deka and Sarkar, 1990; Ramakrishna *et al*., 2008). It also contains small amounts of hydrogen cyanide, oligosaccharides (raffinose, stachyose, verbascose) and non protein amino acids (Kamatchi *et al*., 2010; Kalpanadevi and Mohan, 2013).

2.4.4.4 Effects of lablab bean on performance of broiler chicken

Abeke *et al.* (2008) reported that 5 and 10% cooked LB meal could be included in broiler starter and broiler finisher diets respectively without adversely affecting the performance of broiler chicken. In another study, Bawa *et al*. (2003) observed no significant effect (P>0.05) on feed intake, body weight gain, final live weight, feed efficiency and feed cost/ kg gain when broiler chicken were fed on LB that had been cooked for 30 minutes.

Sarwatt *et al*. (1991) reported reduced weight gain when 25% LB meal was included in broiler chicken diets. Moawia (2015) reported that inclusion of decorticated LB in broiler chicken diets at 0, 5, 10 and 15% resulted in reduced feed intake (1392.75, 1079.31, 708.62 and 617.18g/b respectively) and weight gain (816.24, 556.72, 319.68 and 242.61g/b respectively) and the effect increased as the level of LB in the feed was increased. Rickets was also reported in broiler chicken fed diets containing levels above 15% LB. The rickets was suggested to have been attributed to presence of phytic acid in the bean that made phosphorous unavailable.

2.5 Growth performance as a measure of feed utilization

Performance of broiler chicken can be assessed using several parameters. These include growth, Feed Conversion Ratio (FCR), mortality and the days used to reach market weight. Growth rate and FCR are the most important and the commonly used parameters in determining the potential of a feed (Leeson, 2000).

Growth is the constructive synthesis of ingested nutrients which occurs through accumulation of meat, fat and bone in the body. It is as a result of a positive difference between catabolic and anabolic processes in the body (Brody, 1945) which is accompanied by an increase in weight, length or skeletal size (Pond *et al*., 1995).

Absolute growth rate determines the efficiency of feed conversion into meat while the ratio of lean to bone tissue is an important factor in carcass quality and value determination. Fattening occurs when a diet is nutritionally imbalanced, when feed intake exceeds maintenance needs and when mature lean mass is obtained and the feed ingested has no other function (Whittemore, 1988).

Feed conversion ratio is an important estimate of nutrient adequacy in a test diet (Pond *et al*., 1995). It is the ratio of feed intake to weight gain and it measures how effectively a bird converts a feed into live weight. A high FCR is an indication of poor conversion of a feed to live weight. Increase in FCR could translate to economic losses since poultry feeds contribute to 70% of the total production cost (Waller, 2007). Diets that promote a higher rate of weight gain usually result in better FCR since the animal utilizes a smaller percentage of the total feed consumed on maintenance and a higher percentage on deposition of muscles (Pond *et al.,* 1995). Apart from feed, other factors such as the environmental temperature, diseases, age of the bird, human factors also affect FCR.

Feed intake is also an important factor since it is directly related to the weight change and the FCR. Environmental temperature, energy density of a feed, diseases, presence of anti-nutritive factors in the feed which affect palatability have been attributed to reduced feed intake in broilers.

2.6 Carcass quality as a measure of feed utilization

Carcass performance is an indication of feed utilization by the animals while the size of some organs such as the gizzard, liver and the pancreas is an indication of the quality of a feed.

2.6.1 Breast and leg muscles

Definition of a high quality broiler chicken is one which contains less abdominal fat and more breast muscle. Breast and the leg muscles (thigh and drumstick) are the most valuable broiler cuts in the market and contribute to the highest proportions of edible meat in the chicken. Although the breast muscle develops faster compared to the leg muscles, they are both important and their contribution to live weight of the broiler chicken is key (Vieira and Angel, 2012).

Several studies have shown that the amount of dietary protein and lysine in the feed increase the proportion of the two (Tessseraud *et al.*, 1996; Nasr and Kheiri, 2011). Increasing dietary protein results in reduction of carcass fat by diverting energy into lean tissue accumulation instead of fatty tissue growth.

2.6.2 Abdominal fat

Breeding broiler chicken for quick growth has led to increased fat deposition in the carcass. Fat deposition is a balance between absorbed fat, fat catabolism by β-oxidation (lipolysis) and fat synthesis (lipogenesis). Abdominal fat in poultry lowers the carcass value since consumers choose against it due to the associated risk of cardiovascular diseases (Micha *et al.*, 2010). Increased abdominal fat is also associated with reduced feed efficiency and sometimes economical loss since some chickens are sold as pieces and the fat is usually eviscerated (Emmerson, 1997).

A reduction in the amount of dietary energy has been shown to cause a significant reduction in the amount of abdominal fat relative to the live weight of the broilers (Rabie and Szilagyi, 1998; Fan *et al.*, 2008). The reduced body fat deposition is as a result of decreased activity of some enzymes linked to liver lipogenesis, including fatty acid synthase (FAS), nicotinamide, 6-

phosphogluconate dehydrogenase and glucose-6-phosphate dehydrogenase (G-6-PDH) (Tanaka *et al*., 1983).

Low protein levels in the diet also cause an increase in abdominal fat (Collin *et al.*, 2003; Yalçin *et al*., 2010). Reducing the level of protein in a diet results in an increase in FAS mRNA expression in the liver of broiler chicken (Choi *et al*., 2006). The FAS is a vital enzyme in the *de novo* lipogenesis in the liver (Back *et al*., 1986).

An increase in the amount of dietary lysine and methionine has been shown to significantly reduce the amount of abdominal fat in broilers (Berri *et al.*, 2008; Andi, 2012). An increase in methionine level in the diet decreases carcass fat by reducing the activity of FAS which is involved in lipogenesis and increases the activity of hormone-sensitive lipase (HSL) that is involved in lipolysis (Takahashi and Akiba, 1995). Lysine causes a reduction in carcass fat by inhibiting lipogenesis (Grisoni *et al*., 1991).

Manganese supplementation in the diet has also been reported to reduce broiler chicken fattiness (Lu *et al*., 2006). This occurs by decreasing the activity of lipoprotein lipase and increasing the activity of HSL in the abdominal fat (Lu *et al.*, 2006).

2.6.3 Gizzard

The gizzard is a thick muscular organ that contracts rhythmically thereby grinding and mixing feed particles (McDonald *et al.*, 2002). It does not produce any digestive enzymes but the hydrochloric acid and the pepsin from the proventriculus work in the gizzard (Jurgens, 1969). The narrow exit of the poultry pylorus prevents feeds with big particles from passing. This feed is therefore retained for longer time in the gizzard thereby promoting the muscular development of the gizzard (Hetland and Svihus, 2007). The development results in improved grinding and eventual digestion of feed (McNab and Brooman, 2002; Amerah *et al*., 2009). Therefore an increase in the weight of the gizzard as a percentage of the live weight may be an indication of a feed with high crude fiber content (Hetland and Svihus, 2007).

2.6.4 Liver

The liver is the largest gland in the body whose functions include; secretion of bile, detoxification of substances formed in the digestive tract and destruction of worn out red blood cells (Morrison, 1948). Presence of anti-nutritive factors in a feed have been attributed to an increase in the size of the liver. Some anti-nutritive factors are toxic to the animal and the liver is forced to detoxify them. To increase its detoxifying activity against the harmful anti-nutritive factors, the liver increases in size (Liener, 1989: Ologhobo *et al*., 1993).

2.6.5 Pancreas

Pancreas is a slender gland that is located next to the small intestines whose functions include releasing of digestive enzymes such as amylases, proteases, nucleases and lipases (Slack, 1995). It also releases hormones such as insulin, somatostatin, and pancreatic polypeptidase (Scanes *et al*., 2004). A decline in digestion of protein through protease enzyme inhibition by trypsin inhibitors has been shown to affect the weight of the pancreas. To counter this effect, an increased secretion of trypsin is achieved by inducing hypertrophy and hyperplasia of the pancreas (Liener, 1994).

CHAPTER THREE

3.1: Effects of dietary replacement of maize with pearl millet on growth performance and carcass quality of broiler chicken

3.1.1 Introduction

The poultry industry has been faced with increasing cost of production over the past years due to the increasing prices of ingredients such as maize that constitute the highest percentage of ingredients used in poultry feeds (MoLD, 2009). As indicated in the literature review, PM is a potential replacement for maize since it is known to have a higher or similar nutritive value to maize (NRC, 1994). It grows in the drier parts of Kenya therefore its incorporation in broiler diets would reduce reliance on maize and even result in reduced costs of production. Although the nutritive value of PM has been documented in many studies around the world, Adeola and Orban (1995); Lawrence *et al.* (1995), the correct nutrient information of local varieties of PM is unavailable for feed formulation under local conditions. Therefore the aim of the study was to determine the suitability of pearl millet grown in Kenya for broiler chicken feed formulation.

3.1.2 Objectives

The objectives of this experiment were

i. To determine the effect of replacing maize with pearl millet on growth performance and carcass quality of broiler chicken
ii. To evaluate the cost effectiveness of using pearl millet in broiler chicken diets

3.1.3 Materials and methods

3.1.3.1 Experimental diets and management of chicks

Raw materials used in formulation of the experimental diets were procured from Mbeere in Embu County and transported to Nairobi where formulation was done. After the formulation the feed ingredients were taken to a commercial feed mill where they were mixed. The two experimental diets were; a maize based diet and a pearl millet (PM) based diet. The diets were formulated to be isocaloric and isonitrogenous at 3000 kcal/ kg ME for the starter and finisher diets and a protein content of 22 and 20% for the starter and finisher diets respectively. The diets are presented in Table 3.1.1 below.

Eighty (80) day-old male sexed Arbor Acres broiler chicks were bought from a commercial hatchery in Nairobi for the experiment. The chicks were fed on a commercial diet (maize based diet) for three days during which they were acclimatized to the experimental conditions. On the fourth day the chicks were weighed in groups of ten and randomly allocated to the two experimental treatments with four replicates of ten chicks each, in a Completely Randomized Design (CRD).

The house was well ventilated and lit to ensure comfort of the experimental broilers. Each experimental unit (pen) measured 1.5 m by 1.5 m and a height of 1 m therefore providing a floor space of 0.225m^2 per chick. Prior to arrival of the chicks, the house and all the equipment were disinfected and the floor covered with wood shavings to about 10cm deep.

Brooding during the starter period (first three weeks) was done using charcoal burners .The chicks were vaccinated against New Castle Disease on the 7th and 21st day and Infectious Bursal disease (Gumboro) on the 14th day.

Table 3.1.1: Composition (kg) of the starter and finisher diets used in experiment one

Ingredients	Starter diet		Finisher diet	
	TI	T2	TI	T2
Maize	61.37	-	67.01	-
Pearl millet	-	65.19	-	75.02
Soybean meal	25.47	20.98	23.58	13.61
Fish meal	8.00	8.00	5.46	8.00
Limestone	0.65	-	0.89	1.27
Berger fat	1.91	2.56	0.90	0.93
Meat and bone meal	1.50	2.49	1.50	0.50
Vitamin- mineral premix[1]	0.25	0.25	0.25	0.25
Iodized salt (NaCl)	0.24	0.20	0.20	0.30
Lysine HCL	0.10	0.01	0.10	0.10
DL methionine	0.07	0.10	0.01	0.01
Dicalcium phosphate	0.44	0.22	0.10	0.01
TOTAL	100	100	100	100

T1= maize based diet; T2= Pearl millet based diet.

[1]Vitamin mineral premix- The composition of the premix was: vitamin A, 10,000,000 IU; vitamin D_3 2,000,000 IU; vitamin E, 24,000 IU; vitamin K_3, 3,200 mg; choline chloride, 350,000 mg; folic acid, 960 mg; thiamine, 1,600 mg; riboflavin, 5,600 mg; Nicotinic acid, 32,000mg; panthothenic acid, 8,000 mg; pyridoxine, 4,000 mg; Biotin, 96 mg; vitamin B_{12}, 24 mg; Copper, 5,000 mg; Iron, 40,000 mg; Manganese, 150,000 mg; Zinc, 45,000 mg; Cobalt, 200 mg; Iodine, 1,400 mg; and Selenium, 120 mg.

An anti-stress agent was administered to the broilers during the first three days, during transfer to the experimental pens and before and after each vaccination and weighing. The experimental period was divided into two phases: starter phase (1 to 21 day) and the finisher phase (22 to 42 day). In all the phases, feed and water were provided *ad-libitum*.

3.1.3.2 Data collection

Data on body weight and feed intake was determined weekly. From this data, body weight gain and FCR were computed. The overall body weight gain per bird (0-42 days) per replica was calculated as the difference in weight between the last and the initial weights of the chicks. The weight was then divided by number of broilers per replica to get the total weight gain per bird per replica.

At the beginning of each week, feed was measured and was put into the feeding troughs for each replica. At the end of each week the feed remaining on the troughs was emptied into buckets of known weight and weighed. Feed intake was then determined by subtracting the amount of feed left over from the quantity given at the beginning of the week.

Feed Conversion Ratio was determined as the ratio between total feed intake during the 42 days and the final total body weight gain per bird per replica.

Mortality was monitored daily by recording and collecting the number of broilers that died, which were then taken for post-mortem.

At the end of week six (42 days), four broilers were taken at random from each treatment and fasted overnight. Their live weight was measured and the broilers bled by severing the jugular vein, scalded in hot water and de-feathered. The dressed weight was measured after the head, neck, viscera and shanks were removed. The weight of the breast muscle, drumstick, abdominal fat, liver, gizzard and pancreas were also recorded as a percentage of the live weight as indicated below.

$$\text{Organ weight \%} = \frac{\text{Organ weight (g)}}{\text{Live weight (g)}} * 100$$

3.1.3.3 Chemical analysis

Duplicate samples of feed, raw materials and experimental diets used in the experiment were sampled from different sections of the bag containing them and taken to the laboratory where they were analyzed for Dry Matter (DM), Crude Protein (CP), Crude Fiber (CF), Ether Extracts (EE) and ash according to procedures of the Association of Official Analytical Chemists (AOAC, 2002).

Dry Matter (DM) was estimated by oven drying the samples at 105°C for 12 hours. The ash content was determined by burning the samples in a muffle furnace at 600°C for 3 hours. Crude lipid was quantified as the loss in weight after its extraction from the sample using diethyl ether. Crude fiber was quantified as that portion of carbohydrates that resists digestion by 2.04 N H_2SO_4 and 1.78N KOH solutions. Crude protein was estimated by the Kjeldahl nitrogen method in which the nitrogen measured was multiplied by a factor of 6.25. Nitrogen-free Extracts (NfE) was calculated by subtracting the percent of the above determinations from 100%.

3.1.3.4 Statistical analysis

All data obtained on feed intake, body weight gain, FCR and the carcass parts (as a percentage of live weight) were subjected to a one way Analysis of Variance (ANOVA) using Genstat Discovery 14th edition. The significant difference between treatment means was tested at statistical significance level of $P \leq 0.05$ and when found to be significant they were separated using Tukey's multiple comparison procedure.

3.1.3.5 Cost - benefit analysis

Only the cost of feed was considered to vary across the treatments and was calculated based on the quantities of and the cost of each raw materials used. The other production costs including labour, drugs, fuel, among others were assumed to be constant across the various treatments.

The return per bird per diet was calculated as the sale of a bird per kg live weight minus the cost of the feed consumed throughout the experimental period. The sale price was the money offered at the market for a kg live weight of bird at the period of the experiment. The cost benefit was then calculated by subtracting the profit of the PM diet from the maize based diet (De- Pach *et al*., 2012). The prices of the ingredients are presented in Appendix 2.12.

3.1.4 Results and discussion

3.1.4.1 Chemical analysis

The proximate composition of the raw materials used is presented in Table 3.1.2 below. Crude protein values for maize (8.2%) were lower compared to that of the PM (12.35%). Similarly the ether extracts were 3.82% and 4.09% for maize and PM respectively. The CP values of maize and PM (8.1 and 12.0 respectively) were similar to what was reported by Lawrence *et al.* (1995). NRC (1994) however reported higher values of CP in PM grain (14%) and similar values of maize CP (8.5%) compared to the current study. Adeola and Orban on the other hand reported lower values of CP (7.5%) in maize grains compared to the current study.

Table 3.1.2: Proximate composition (%) of raw materials (g/kg DM)

	Maize	Pearl millet	Soybean meal	Fish meal
Analyzed (DM basis)				
Dry matter (%)	87.81	88.48	88.88	91.77
Crude protein (%)	8.2	12.35	43.47	54.56
Crude fiber (%)	2.905	3.35	7.7	0.52
Ether extracts (%)	3.82	4.09	1.28	12.7
Ash (%)	1.75	2.43	6.29	16.77

The crude protein value of SBM was 43.47%. The value is consistent with Van Eys *et al*. (2004) who reported a value of 43.8 % but was lower than what was reported by NRC (1994) (49.00%) and Willis (2000) (48.00%).

The diets were formulated to be isonitrogenous at 22 and 20% CP for the starter and the finisher phases respectively. However the actual CP of the starter diets was 22.07% and 22.34% while that of the finisher diets was 20.56% and 20.43% for the Maize and PM based diets respectively (see Table 3.1.3 below).

The actual CF content in the starter diets was 3.45% and 3.71% while for the finisher diets it was 4.09% and 5.54% for the Maize and the PM based diets respectively. The analyzed nutrient compositions had variations from the calculated composition which may be due to variations in the quality of the raw materials used.

However, the CP and the CF were within the recommended values by KEBS (2009) of 20 and 18% CP for the starter and finisher diets respectively and 7.5 % CF. The starter and the finisher diets were formulated to contain 3000 kcal/ kg which was similar to the recommended values of KEBS (2009).

3.1.4.2 Broiler chicken performance

The effect of complete replacement of maize with PM on feed intake (g/bird), body weight gain (g/bird) and FCR of broiler chicken from 0-42 days of age is shown in Table 3.1.4 below.

Table 3.1.3: Proximate composition (%) of starter and finisher diets (g/kg DM)

	Starter		Finisher	
	T1	T2	T1	T2
Dry matter	87.49	88.59	87.49	88.59
Crude protein	22.07	22.34	20.56	20.43
Crude fiber	3.45	3.71	4.09	5.54
Ether extracts	4.01	7.14	6.29	6.29
Ash	6.29	6.29	3.3	3.22
<u>Calculated analysis (DM basis)</u>				
Calcium	0.90	1.00	0.90	0.90
Total Phosphorous	0.73	0.74	0.6	0.63
Lysine (% protein)	1.25	1.20	1.00	1.00

T1= maize based diet

T2= Pearl millet based diet

Table 3.1.4: Effects of replacing maize with pearl millet in broiler chicken diets on feed intake, weight gain (g/ bird) and FCR from 0-42 days

Parameter	T1	T2	[1]P- value	[2]SEM
Feed intake (g/bird)	2834^a	3172^a	0.065	105.9
Body weight gain (g/bird)	1452^a	1668^b	0.011	42.4
FCR	1.97^a	1.91^a	0.739	0.1207

Means within a row with different superscripts differ significantly (P<0.05)

T1- Maize based diet

T2- Pearl millet based diet

[1]P- value – Probability value

[2]SEM – Standard error of mean

Feed intake

There were no significant differences between feed intake of broilers fed on PM based diets (3172g/bird) and maize based diets (2834 g/bird) (see Table 3.1.4). However the intake of those on PM based diets tended to be higher.

The results of this study are in agreement with what was reported by Ojewola and Oyim (2006); Hafeni *et al.* (2010); Ibitoye *et al*. (2012) and Kwari *et al*. (2014) who did not observe any ($P > 0.05$) effect in feed intake when PM replaced maize in growing cockerel rations and broiler chicken diets respectively.

Results of the current study however, are contrary to the observations of Tornekar *et al*. (2009) who reported that there was a significant effect on feed intake when PM replaced 50% of dietary maize in broiler chicken diets. Baurhoo *et al.* (2011) and Sharma *et al.* (2012) reported that broilers fed PM ate significantly less feed compared to those fed maize based diets.

Mehri *et al*. (2010) and Ibe *et al*. (2014) reported significantly higher feed intake in layer chicken fed on diets containing 75-100% PM and broiler chicken fed diets containing 100% PM compared to those fed on maize based diet respectively.

Weight gain

Broiler chickens fed on PM based diets were significantly ($P<0.05$) heavier than those fed on maize based diet at 1668 and 1452g/bird respectively. The results of this study are consistent with those of Davis *et al.* (2003); Baurhoo *et al*. (2011) and Ibe *et al.* (2014) who reported that broilers fed PM diets had a significantly ($P<0.05$) higher weight gain than those fed maize based diets. In another study Tornekar *et al.* (2009) reported significantly $P<0.01$) higher weight gain when PM replaced 50% of maize in broiler chicken diets.

However, Medugu *et al.* (2010) did not observe any significant effect (P >0.05) on body weight gain of broilers fed on maize (1788g/bird) and those fed on PM based diets (1862.0g/bird). Other investigators also reported the same when PM replaced maize either partially or completely in broiler chicken diets (Hildago *et al*., 2004; Manwar and Mandal, 2009; Kwari *et al*., 2014).

The differences observed in the total weight gain at 42 days for broilers fed PM based diet (1668g/bird) compared to that of the broilers on the maize based diet (1452 g/bird) could be due to several reasons. Pearl millet grain contains higher concentrations of essential amino acids than maize (Adeola and Orban, 1995) which are required for protein synthesis and rapid meat deposition in broiler chicken. It may also be due to the higher amounts of analyzed crude fat contents in the starter diets of PM diet compared to the maize based diets (4.08 vs 7.14%). This may have led to a higher feed intake in broilers fed PM based diets compared to those fed on maize based diets. Oil has been reported to enhance growth by improving the palatability of a feed (Fuller, 1981; Moran, 1986).

Feed Conversion Ratio (FCR)

Results from the present study showed that replacing maize with PM had no (P>0.05) effect on FCR (g feed/g live weight gain) for broiler chickens from 0-42 days of age. The FCR of broilers fed on diets based on maize was 1.97 while those fed on diets based on PM was 1.91 as presented in Table 3.1.4 above.

The above results are in agreement with what was reported by Davis *et al*. (2003); Hafeni *et al.* (2010) and Kwari *et al*. (2014) who did not observe any differences when PM totally replaced maize in broiler chicken diets. Bashar *et al*. (2012) also reported no differences in FCR for broiler finishers fed either PM or maize based diets. Mehri *et al*. (2010) reported the same for layer broilers fed on diets where pearl millet replaced 75% of maize in the diet.

The results of the present study are in variance with those reported by Baurhoo *et al*. (2011) who reported a significant difference (P<0.05) in FCR when maize was totally replaced with PM in broiler chicken diets. Tornekar *et al*. (2009) also reported the same at (P<0.01) when PM replaced 50% of dietary maize in broiler diets.

Mortality

Three broilers which are an equivalent of 3.75% of the total died during the experimental period. One was stepped on by a worker during feeding while two were suffocated by the other chicks.

3.1.4.2.2 Effects maize and pearl millet based diets on carcass quality of broiler chicken

Table 3.1.5 below presents the results on the effects of PM and maize diets on selected carcass parts (dressed percentage, breast muscle, drumstick, abdominal fat, gizzard, liver and the pancreas) weights/yield (g) of broiler chicken at 42 days of age (expressed as a percentage of the live weight).

Results revealed that, replacing maize with PM had no significant effects (P>0.05) on all the carcass parameters studied. Results on dressed percentage observed in this study (74.2%) vs (74.13%) were not significantly different (P>0.05) similar to what was reported by Davis *et al*. (2003) for male broilers (73.92%, 73.89%) and Ibe *et al*. 2014 for broilers fed maize and PM based diets respectively. However Sharma *et al*. (2012) observed significant difference (P<0.05) in dressed percentage when PM replaced maize in broiler diets (73.54%) vs (75.04%).

Table 3.1.5: Effects of replacing maize with pearl millet in broiler chicken diets on weight (%) of carcass parts of broiler chicken at 42 days of age

Parameter	T1	T2	[1]P-value	[2]SEM
Dressed (%)	74.7	74.2	0.970	9.100
Breast muscle (%)	17.21	22.2	0.080	1.680
Drumsticks (%)	4.56	4.89	0.700	0.569
Abdominal fat (%)	1.68	1.53	0.691	0.257
Gizzard (%)	1.80	2.17	0.268	0.217
Liver (%)	2.78	2.72	0.909	0.356
Pancreas (%)	0.26	0.30	0.383	0.030

Means within a row without superscripts do not differ significantly (P>0.05).

T1- Maize based diet

T2- Pearl millet based diet

[1]P- value – Probability value

[2]SEM – Standard error of mean

The breast muscle weight was not significantly different (P>0.05) for broilers fed on maize and PM based diets at 17.21 vs 22.2% respectively. This disagrees with the results by Sharma *et al*. (2012) who reported significant reduction in breast muscle weight (with bones) when PM replaced maize in broiler chicken diets. However the findings are consistent with what was reported by Kwari *et al. (*2014).

The abdominal fat weight for broilers fed PM diets (1.53%) was not significantly different (P>0.05) from those fed on maize based diets (1.68%) similar to what was observed by Hafeni *et al.* (2010) 45 vs 38.3g and Yunusa *et al*. (2014) 1.36 and 1.18% for broilers fed on PM and maize based diets respectively. However, higher abdominal fat for sorghum and yellow maize fed broilers compared to PM fed broilers respectively was reported by Singh *et al*. (2009); Rao *et al*. (2004).

Results on the weights of Gizzard, (1.80%) vs (2.17%); liver, (2.78%) vs (2.72%) and pancreas (0.26%) vs (0.30%) for maize and PM based diets respectively observed in this study did not differ significantly (P>0.05) similar to what was reported by Torres *et al*. (2013). Hafeni *et al*. (2010) did not observe any difference in the weight of gizzard 41.3g vs 48.3g for Maize and PM based diets respectively. Yunusa *et al*. (2014) and Kwari *et al*. (2014) reported higher (P<0.05) weights of gizzards for the broilers fed on the maize based diets compared to those fed on the PM based diet.

The weight of pancreas for the broilers fed PM diets were numerically higher (P>0.05) than for those fed maize based diets. Similar to the current study Torres *et al*. (2013) did not observe any significant differences in pancreas percentage when broiler chicken were fed on diets containing maize (0.32%) whole grain pearl millet (0.23%) or ground pearl millet (0.30%).

3.1.4.3 Cost - benefit of using pearl millet and maize in diets of broiler chickens

The results of the cost benefit analysis of replacing maize with PM in broiler chicken diets are presented in Table 3.1.6 below. The data from the analysis was not statistically analyzed but the discussion is based on a significant weight change.

Although the cost of producing a kilogram of PM based diet (Ksh 119.3/kg) was higher than that of producing a kilogram of maize based diet (Ksh 106.28/kg), broilers fed on PM based diets had a profit of 242.55 compared to Ksh 216.09 /kg for those fed on the maize based diets. This profit from PM based diets was therefore Ksh 26.46 more than the proceeds from broilers fed on the maize based diets.

Rao *et al*. (2002) and Medugu *et al*. (2010) observed that it was more economically rewarding to use PM grain in broiler chicken diets instead of maize. They observed that the cost of feed required to produce a kg of live weight was less for PM compared to maize. The net profit from the broilers fed on the PM based diets in the current study may have been due to a better feed utilization by the broilers on the PM based diets (1.91) compared to those on maize based diets (1.97) and the higher ($P<0.05$) body weight gain reported for broilers fed on PM (1668g/bird) compared to those fed on maize based diets (1452g/bird).

The cost benefit analysis shows that PM can be used in the formulation of broiler chicken diets and is economically superior in terms of net returns when compared to maize.

Table 3.1.6: Cost- benefit for using pearl millet versus maize in broiler diets

Diets	Maize based diet	PM based diet
Feed intake (kg/broiler)		
Starter period	0.7	0.87
Finisher period	2.13	2.3
Cost of feed (Ksh/kg)		
Starter	55.92	62.55
Finisher	50.36	56.75
Total	106.28	119.3
Live weight (kg/bird)	1.45	1.71
Sale of bird (at Ksh 250/kg)	362.5	427.5
Cost of feed (Ksh/bird)[3]		
Starter	39.14	54.42
Finisher	107.27	130.53
Total	146.41	184.95
Return (Ksh/bird/diet)[4]	216.09	242.55
Cost benefit (Ksh/bird/diet)[5]	**0**	**+26.46**

[1]Live weight (kg) per bird at day 42

[2]Cost of selling 1kg live weight of broiler

[3]Cost of feed multiplied by amount consumed

[4]Profit per bird after the total cost of feed is deducted

[5]Comparative advantage of using pearl millet

3.2: Effects of dietary inclusion of green gram, cowpea and lablab bean in pearl millet-soybean based diets on growth performance and carcass quality of broiler chicken

3.2.1 Introduction

Soybean meal, an important raw material in the broiler chicken diets due to its high protein level (44-48% CP) and ME NRC (1994) is unavailable in enough quantities to meet consumer demands in the country (Tinsley, 2009). In order to meet the demand, the deficit is usually imported from countries such as Uganda and Tanzania making it expensive.

Kenya is largely arid and semi arid lands (ASALs) and legumes such as green gram, cowpeas and lablab beans grow well in these areas. These grain legumes contain similar amino acid profile as SBM and can be used as substitutes in diets of broiler chicken.

Studies on utilization of these legumes have been conducted elsewhere combined with either maize or sorghum (Murwani, 2008; Chakam *et al.*, 2010; Moawia, 2015). Research on the potential of the above legumes combined with PM would therefore be important. The nutritional value in the legumes also varies with cultivars and climatic conditions (Allen and Davis 2013). Therefore the available data may not be replicated for diet formulation under local conditions. The main objective of the study was to determine the effects of three legumes grown in Kenya on growth performance and carcass quality of broiler chicken.

3.2.2 Objectives

The objectives of this experiment were

i. To determine the effects of including green grams, cowpeas and lablab beans at varying dietary levels on growth performance and carcass quality of broiler chicken.

ii. To assess the cost effectiveness of dietary inclusion of the three selected legumes in the production of broiler chicken.

3.2.3 Materials and methods

3.2.3.1 Experimental diets and management of the chicks

Pearl millet-soybean based diets were formulated to contain 0, 10, 20, or 30% GG, CWP or LB. The diets were isocaloric containing 3000kcal/ kg ME for both the starter and finisher periods and isonitrogenous with a CP content of 22 and 20% for the starter and finisher diets respectively. The diets are presented in Table 3.2.1 and 3.2.2 below.

Four hundred (400) day- old male sexed Arbor Acres chicks were bought from a commercial hatchery in Nairobi for the feeding trial. The chicks were fed on a commercial diet for the first three days during which they were acclimatized to the experimental conditions. On the fourth day they were weighed in groups of ten and randomly allocated to the treatments with four replicates of ten chicks in each treatment. The design of the experiment was a 3*4 factorial in a Completely Randomized Design (CRD). The management of the chicks is as described in section 3.1.3.1.

3.2.3.2 Data collection

Data on body weight and feed intake was determined weekly while dressed weight, dressed percentage and weight of breast muscle, drumstick, abdominal fat, gizzard, liver and pancreas were taken at day 42 as described in section 3.1.3.2.

Table 3.2.1: Composition (%) of the starter diets

Treatments	TI	T2	T3	T4	T5	T6	T7	T8	T9	T10
Ingredients										
Pearl millet	65.19	59.31	51.99	44.51	59.27	51.91	44.37	58.69	50.89	43.99
Soybean meal	20.98	16.58	13.97	11.39	16.59	13.97	11.39	16.93	15.29	11.39
Green gram	-	10.00	20.00	30.00	-	-	-	-	-	-
Cowpea	-	-	-	-	10.00	20.00	30.00	-	-	-
Lablab bean	-	-	-	-	-	-	-	10.00	20.00	30.00
Fish meal	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Limestone		0.29	0.26	0.19	0.30	0.28	0.25	-	-	-
Berger fat	2.56	2.52	2.55	2.65	2.52	2.58	2.70	2.21	3.35	3.45
Meat and bone meal	2.49	2.54	2.54	2.54	2.56	2.57	2.60	2.25	0.72	0.18
Vitamin- mineral premix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.20	0.40	0.33	0.36	0.49	0.42	0.42	0.50	0.32	0.71
Lysine HCL	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
DL methionine	0.10	0.10	0.10	0.10	0.01	0.01	0.01	0.10	0.10	0.10
Dicalcium phosphate	0.22	-	-	-	-	-	-	1.06	1.07	1.92
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

T1= 0%LGM -Diet with 0% of the selected legumes; T2 = 10% Green gram; T3 = 20% Green gram; T4= 30% Green gram; T5 = 10% Cowpea; T6 = 20% Cowpea; T7 = 30% Cowpea; T8 = 10% Lablab bean; T9= 20% Lablab bean; T10 = 30% Lablab bean. [1]Vitamin mineral premix- The composition of the premix was: vitamin A, 10,000,000 IU; vitamin D_3, 2,000,000 IU; vitamin E, 24,000 IU; vitamin K_3, 3,200 mg; choline chloride, 350,000 mg; folic acid, 960 mg; thiamine, 1,600 mg; riboflavin, 5,600 mg; Nicotinic acid, 32,000; pantothenic acid, 8,000 mg; pyridoxine, 4,000 mg; Biotin, 96 mg; vitamin B_{12}, 24 mg; Copper, 5,000 mg; Iron, 40,000 mg; Manganese, 150,000 mg; Zinc, 45,000 mg; Cobalt, 200 mg; Iodine, 1,400 mg; and Selenium, 120 mg.

Table 3.2.2 Composition (%) of the finisher diets

Treatments Ingredients	TI	T2	T3	T4	T5	T6	T7	T8	T9	T10
Pearl millet	75.02	67.92	60.55	54.08	67.87	60.46	52.94	67.53	59.57	52.07
Soybean meal	13.61	10.51	7.86	5.28	10.52	7.86	5.29	10.53	8.02	5.82
Green gram	-	10.00	20.00	30.00	-	-	-	-	-	-
Cowpea	-	-	-	-	10.00	20.00	30.00	-	-	-
Lablab bean	-	-	-	-	-	-	-	10.00	20.00	30.00
Fish meal	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Limestone	1.27	0.78	0.73	0.69	0.75	0.75	0.72	0.35	0.00	0.00
Berger fat	0.93	0.93	0.99	1.08	1.02	1.02	1.13	1.54	2.30	2.26
Meat and bone meal	0.50	1.24	1.32	0.47	1.35	1.35	1.38	1.46	1.50	0.85
Vitamin- mineral premix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.34	0.29	0.14	0.14	0.30	0.28	0.31	0.29	0.28
Lysine HCL	0.10	0.02	-	-	0.05	-	-	0.02	-	-
DL methionine	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Dicalcium phosphate	0.01	-	-	-	0.04	-	-	-	0.06	0.46
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

T1= 0%LGM -Diet with 0% of the selected legumes; T2 = 10% Green gram; T3 = 20% Green gram; T4= 30% Green gram; T5 = 10% Cowpea; T6 = 20% Cowpea; T7 = 30% Cowpea; T8 = 10% Lablab bean; T9= 20% Lablab bean; T10 = 30% Lablab bean. [1]Vitamin mineral premix- The composition of the premix was: vitamin A, 10,000,000 IU; vitamin D_3 2,000,000 IU; vitamin E, 24,000 IU; vitamin K_3, 3,200 mg; choline chloride, 350,000 mg; folic acid, 960 mg; thiamine, 1,600 mg; riboflavin, 5,600 mg; Nicotinic acid, 32,000; pantothenic acid, 8,000 mg; pyridoxine, 4,000 mg; Biotin, 96 mg; vitamin B_{12}, 24 mg; Copper, 5,000 mg; Iron, 40,000 mg; Manganese, 150,000 mg; Zinc, 45,000 mg; Cobalt, 200 mg; Iodine, 1,400 mg; and Selenium, 120 mg.

3.2.3.3 Chemical analysis

Feed ingredients and experimental diets were sampled and analyzed for proximate components according to AOAC (2002) as described in section 3.1.3.3.

3.2.3.4 Statistical analysis

Data on feed intake, body weight gain, FCR and the carcass parts (as a percentage of live weight) were subjected to Analysis of Variance (ANOVA) using Genstat Discovery 14th edition as explained in section 3.1.3.4 and significant treatment means separated using Tukey's multiple comparison procedure.

3.2.3.5 Cost benefit analysis

The cost benefit was determined by subtracting the returns of the various treatments from that of the 0%LGM diet. The rest of the calculations were done as explained in section 3.1.3.5.

3.2.4 Results and discussion

3.2.4.1 Chemical analysis

Proximate composition of raw materials and experimental diets are presented in Tables 3.2.3, 3.2.4 and 3.2.5 below.

The analyzed CP and the CF values in all the treatments were within the recommended values by KEBS (2009) (20 and 18% for CP in the starter and finisher diets respectively) and 7.5 % for CF.

Table 3.2.3: Proximate composition (%) of the raw materials used in experiment two (DM basis)

Composition	Pearl millet	Fish meal	Soybean meal	Green gram	Cowpea	Lablab
Dry matter (%)	88.48	91.77	88.88	89.93	89.60	88.81
Crude protein (%)	12.35	54.56	43.47	26.14	25.35	24.24
Ether extracts (%)	4.09	0.52	7.70	2.17	2.24	1.53
Crude fiber (%)	3.35	12.70	1.28	6.40	6.03	10.40
Ash (%)	2.43	16.77	6.29	4.25	2.90	3.53

Table 3.2.4: Proximate composition (%) of the starter diets (DM basis)

Treatments / Component	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Dry matter (%)	88.59	88.41	88.56	88.64	88.28	87.70	88.53	88.04	88.31	87.10
Crude Protein (%)	22.34	22.63	22.07	22.73	22.09	23.30	22.56	22.52	23.45	22.76
Crude Fiber (%)	3.71	5.20	4.11	4.59	3.70	4.36	4.57	4.45	4.22	6.29
Ether Extracts (%)	7.14	5.24	4.86	5.54	5.10	5.09	4.84	5.81	5.62	6.07
Ash (%)	6.29	6.17	6.41	6.78	6.46	6.35	6.61	6.19	5.95	7.45

T1= 0%LGM - Diet with 0% of the selected legumes; T2 = 10% Green gram; T3 = 20% Green gram; T4= 30% Green gram; T5 = 10% Cowpea; T6 = 20% Cowpea; T7 = 30% Cowpea; T8 = 10% Lablab bean; T9= 20% Lablab bean; T10 = 30% Lablab bean.

Table 3.2.5: Proximate composition (%) of the finisher diets (DM basis)

Treatments / Component	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Dry matter (%)	88.55	88.32	86.64	87.20	84.62	87.73	88.10	87.86	88.76	87.07
Crude protein (%)	20.43	20.63	19.92	20.14	20.78	19.96	20.21	21.12	20.56	20.15
Crude fiber (%)	5.54	4.61	5.01	4.82	4.54	4.65	4.28	5.09	5.65	4.36
Ether extracts (%)	6.29	6.17	6.41	6.78	6.46	6.35	6.61	6.19	5.95	7.45
Ash (%)	3.22	4.20	4.15	3.55	3.25	3.85	3.50	4.45	4.05	3.90

T1= 0%LGM -Diet with 0% of the selected legumes; T2 = 10% Green gram; T3 = 20% Green gram; T4= 30% Green gram; T5 = 10% Cowpea; T6 = 20% Cowpea; T7 = 30% Cowpea; T8 = 10% Lablab bean; T9= 20% Lablab bean; T10 = 30% Lablab bean.

3.2.4.2 Broiler chicken performance

The results of feed intake, body weight gain and FCR of broiler chicken at 42 days of age are presented in Figure 1-3 and Table 3.2.6 below.

3.2.4.2.1 Effects of legume type and inclusion levels on growth performance

A significant interaction ($P<0.05$) was observed between legumes and dietary levels for all growth parameters. Feed intake and body weight gain of broilers on GG and CWP diets increased when 10% of the legumes were added but declined at 20 and 30% inclusion levels. However the feed intake and body weight gain of the broilers on LB diets was totally different from those on GG and CWP based diets. A decline in these parameters was seen as the different levels were added in the diet. The FCR for the broilers on different diets also portrayed a different picture. While broilers on LB diets had an increasing (poor) ($P<0.05$) FCR with increase in the legume levels in the diet, those on GG had a better FCR as the levels were added although not significant ($P>0.05$). The ones on CWP diets however, had a better FCR at 20% followed by 30% and lastly at 10% inclusion level.

Effects of green grams on growth performance of broiler chicken

Broilers that were fed on the 0%LGM diet had a higher ($P<0.05$) feed intake (3172g/bird) when compared to those fed on 20 and 30% GG (3051 and 2818g/bird respectively) but they had a lower intake ($P<0.05$) when compared to those fed on 10% GG (3557g/bird). The reduced feed intake could be as a result of increased amounts of tannins with higher dietary levels of GG in the diet.

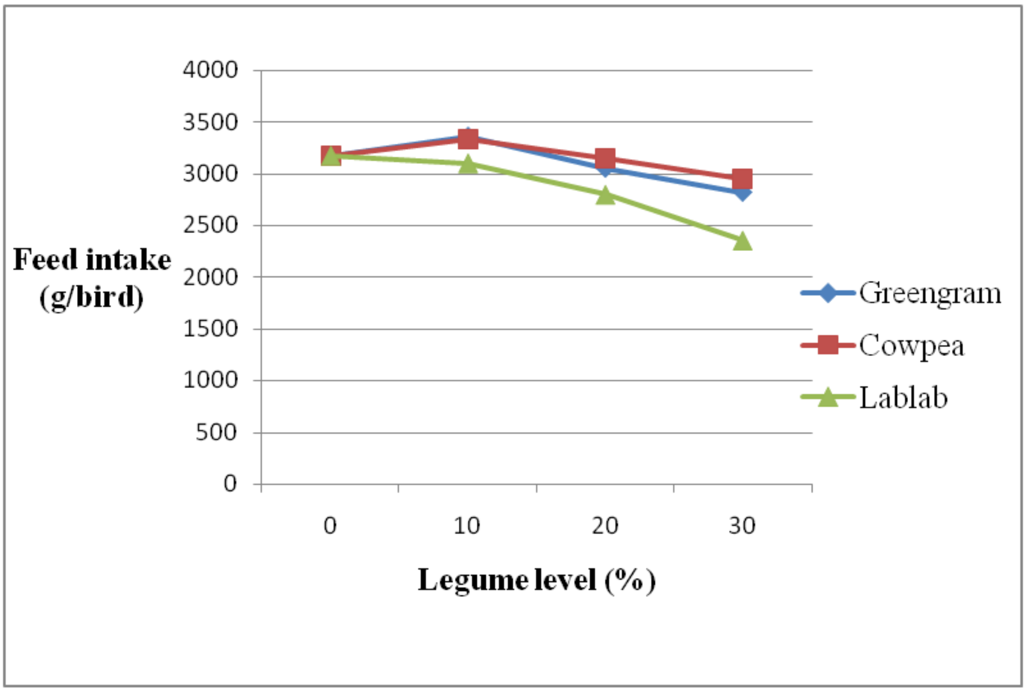

Figure 1: Effects of different legumes and levels on feed intake of broiler chicken at 42 days of age.

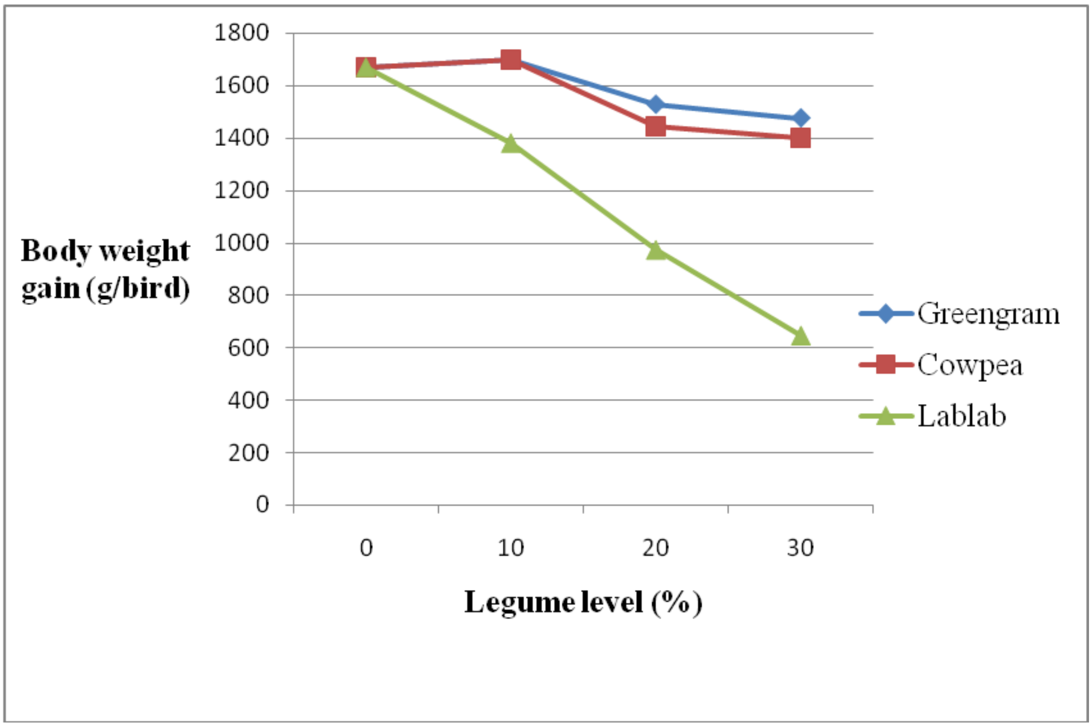

Figure 2: Effects of different legumes and levels on body weight gain of broiler chicken at 42 days of age.

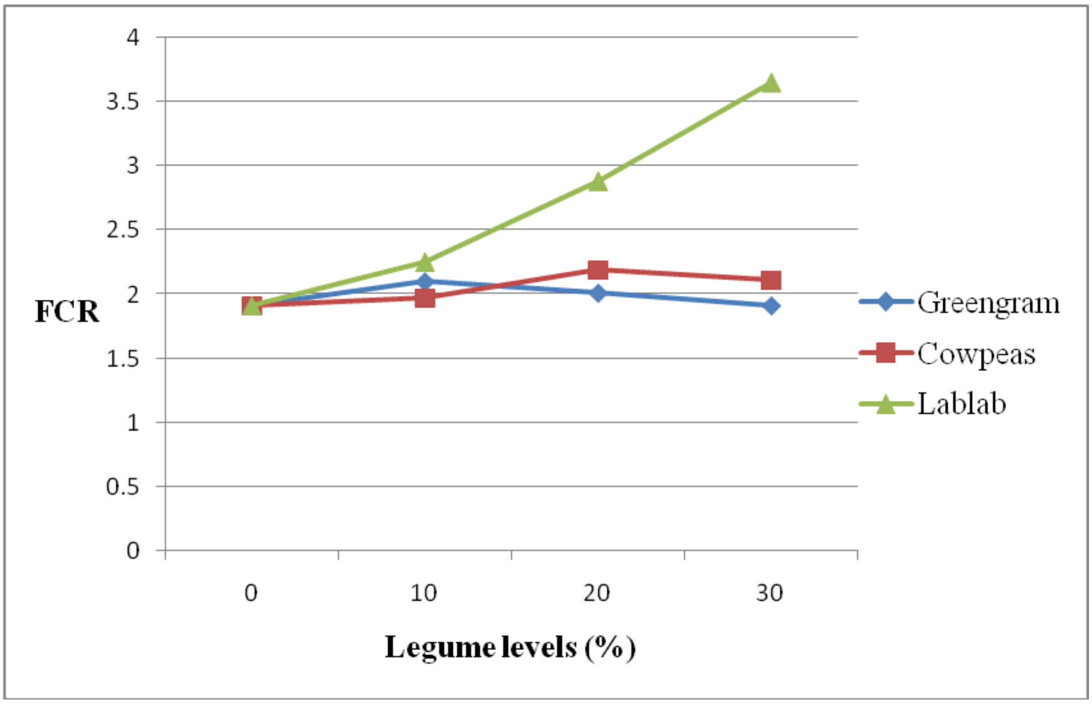

Figure 3: Effects of different legumes and levels on FCR of broiler chicken at 42 days of age

Table 3.2.6: Effects of legume type and inclusion levels on broiler performance after 42 days

Means within a row with different superscripts differ significantly (P<0.05).

Parameter	0%[1]LGM	10%[2]GG	20%GG	30%GG	10%[3]CWP	20%CWP	30%CWP	10%[4]LB	20%LB	30%LB	[5]SEM
Feed intake (g)	3172^{cd}	3357^{e}	3051^{bcd}	2818^{b}	3337^{de}	3152^{cd}	2952^{bc}	3099^{bc}	2796^{b}	2354^{a}	59.5
Body wt gain (g)	1668^{de}	1699^{e}	1527^{cde}	1475^{cd}	1698^{e}	1445^{c}	1401^{c}	1380^{c}	974^{b}	648^{a}	39.1
[6]FCR	1.91^{a}	2.10^{a}	2.01^{a}	1.91^{a}	1.97^{a}	2.19^{a}	2.11^{a}	2.25^{a}	2.88^{b}	3.65^{c}	0.09

[1]0%LGM - Diet with 0% of the selected legumes

[2]GG - Green gram

[3]CWP - Cowpea

[4]LB - Lablab bean

[5]SEM - Standard error of mean

[6]FCR - Feed Conversion Ratio

Murwani (2008) also reported reduced feed intake for broilers fed diets containing 50% GG in maize based diets compared to those fed on maize-soybean based diets.

Broilers fed on GG had higher (P>0.05) weight gain at 10% level of inclusion (1699g/bird) when compared to those on 0%LGM (1668g/bird). Those on 20% GG level (1527g/bird) and 30% GG (1475g/bird) however, had a similar (P>0.05) weight gain to those on the 0%LGM (1668g/bird). The results of the current study are in agreement with those reported by Miller and Holmes (1992) who observed a reduction (P<0.05) in body weight gain when GG was included in broiler chicken diets at a level of 30%. Wiryawan *et al*. (1997) and Murwani (2008) however, found no significant effect on average daily gain and body weight when GG was added up to 30 and 50% level in diets of finishing pigs and broiler chicken respectively.

The difference between the present study and the study by Miller and Holmes (1992) could be from the differences in the amounts of anti-nutritive factors present in GG which vary with species, soil and climatic factors (Gatel, 1994; Smits and Annison, 1996).

Broilers fed on different levels of GG had an FCR of 1.91, 2.0, 2.01 and 1.91 for 0%LGM, 10, 20 and 30% GG respectively. Although the FCR values were similar (P>0.05), broilers fed on 0%LGM and 30% GG tended to have a better feed conversion. Creswell (1981) and Robinson and Singh (2001) reported similar results where no significant (P>0.05) effect on FCR was reported when broiler and layer chicken were fed GG based diets at an inclusion level of 40% and 30% respectively.

Effects of cowpeas on growth performance of broiler chicken

Broilers that were fed on diets containing CWP followed a similar trend as those fed on GG in terms of highest and lowest feed consumption. Broilers fed on 30%CWP had the least (P<0.05) feed intake (2952g/bird) compared to those fed 10%CWP (3337 g/bird) but was similar (P>0.05) to those on 20%CWP and 0%LGM (3152 and 3172 g/bird respectively). The reduced feed intake in the broilers on the 30% CWP could have been due to presence of higher amounts of tannins which reduce feed palatability and affect feed intake. Akanji (2012) and Abdelgani *et al.* (2013) reported reduced feed intake when levels of cowpeas were increased in diets of broiler chicken. Kur *et al*. (2014) reported no significant difference (P>0.05) when broilers were fed on diets based on either 15% of cooked (1223.7g/bird) or roasted (1200.5g/bird) CWP compared to those that did not contain any CWP (1263.3g/bird).

Similarly, body weight gain of the broilers fed on CWP decreased with increase in the level of CWP in the diet; 1668, 1698, 1445 and 1401g/bird for 0%LGM 10, 20 and 30%CWP respectively. Those on 10% CWP had higher (P<0.05) body weight gain when compared to those on 20% CWP and 30% CWP but similar to those on the 0%LGM. The lowered feed intake for the broilers on the 20% and 30% CWP may have caused the reduced weight gain. Chakam *et al*. (2010) and Abdelgani *et al*. (2013) also reported decreased body weight when levels of cowpeas were increased in broiler chicken diets. Kana *et al*., 2012 observed reduced body weight gain when 20%CWP was added in diets of broiler chicken (1536.13 and 1287.85g/bird for broilers fed on SBM and CWP based diets respectively).

FCR values for 0%LGM, 10, 20 and 30%CWP were not significantly different (P>0.05) at 1.91, 1.97, 2.19 and 2.11 respectively. A study conducted by Kur *et al*. (2014) did not find any significant difference (P>0.05) when 15% of either cooked (2.90) or roasted cowpeas 2.50) were used in broiler diets to replace SBM (2.70). Similarly Abdelgani *et al*. (2013) did not report significant differences (P>0.05) in FCR for broilers fed on 5, 10 and 15% levels of CWP diets. However Chakam *et al.* (2010) reported poorer FCR values when cooked CWP were added in broiler finisher diets at 25 and 30% levels but similar FCR when the same was added at 10 and 20% levels.

Effects of lablab beans on growth performance of broiler chicken

The feed intake of the broilers fed on diets based on LB declined (P<0.05) with increase in the levels of the bean in the diet (3172, 3099, 2796 and 2354g/bird) for 0%LGM, 10, 20 and 30%LB respectively. The decline in feed intake with increased levels of LB in the diet may have been due to increase in the amount of tannins in the diet. Tannins are bitter in taste and have been associated with reduced palatability of legume seeds by animals (Aletor, 1993). Abeke *et al*. (2008) also reported a reduction in feed intake with increased levels of cooked LB in the diets of broiler chicken.

Broilers fed on Lablab beans (LB) based diets had a decreasing (P<0.05) body weight gain (1668, 1380, 974 and 649g/bird) for 0%LGM, 10, 20 and 30%LB respectively. This decline followed the trend of feed intake. A significant reduction of body weight gain with increase in the levels of LB in the diet was also reported by Moawia (2015) and Abeke *et al*. (2008) for broiler chicken fed decorticated LB and lablab beans cooked for 30 minutes respectively.

Broilers fed on diets containing LB had poorer FCR with increased level of legume in the diet. Broilers fed on diets containing 0%LGM had better (P<0.05) FCR (1.91) when compared to those fed on 10% LB (2.25), 20% (2.88) and 30% LB (3.65). This is an indication that those diets were poorly converted into meat probably due to inhibitory effects of various anti-nutritive factors present in the LB beans. The poorer FCR with increased dietary level of LB was also reported by Abeke *et al*. (2008) when broiler chicken were fed on diets containing decorticated lablab bean at 10, 20 and 30% level.

3.2.4.2.1.1 Comparison of the effects of the three legumes on growth performance and physical appearance of broiler chicken

In general feed intake decreased with an increase in the levels of all the three legumes in the diet. This may have been due to an increase in the amounts of anti-nutritive factors in the feed particularly tannins. Broilers on GG and CWP based diets had a higher ($P<0.05$) feed intake compared to those on LB based diets. Published values of total tannins have been reported to be 2.16-2.73, 3.6 and 3.5-4.7 tannins in mg/g sample in GG, CWP and LB respectively (Sharma *et al*., 1991; Iyayi *et al.,* 2008; Soetan, 2012). The higher amounts of tannins in the LB grains compared to those in the GG and CWP grains may have caused the lower feed intake observed in LB fed broilers.

The body weight gain of the broilers fed different legumes decreased with increased level of legume in the diet (Figure 2). The reduced body weight gain with increase in the levels of legumes in the diet in the present study may have been due to various anti-nutritive factors among them protease inhibitors, phytic acid, haemagluttinins and tannins contained in legumes. These anti-nutritive factors bind dietary protein and digestive enzymes forming complexes that are not readily digestible thereby interfering with the digestion and absorption of nutrients in the gastrointestinal tract resulting in depressed growth (Aletor and Fetuga, 1987; Aletor, 1993; Alledredge, 1994; Islam *et al*., 2002). Therefore increase in the levels of the legumes in the diet resulted to increased amounts of anti-nutritive factors thereby affecting growth negatively.

It could also have been due to the feed intake that also decreased with increased levels of the legumes in the diet. Body weight gain in poultry has been shown to be directly related to the amount of feed intake and the efficiency of utilization of the feed (Dada *et al*., 2000). Esonu *et al.* (2003) and Dousa *et al*. (2011) also reported a reduction ($P<0.05$) in body weight gain and live weight as the level of pigeon peas and plant concentrate were increased in broiler chicken diets respectively.

Broilers fed on GG and CWP based diets had a higher ($P<0.05$) weight gain compared to those fed on LB based diets. This observation is similar to what was reported by Robinson and Singh (2001) who reported the least performance for the broilers fed on LB diets compared to those fed diets containing cowpeas, chickpeas and mungbean (green gram). The trends observed in the current experiment could have been due to presence of higher amounts of anti-nutritive factors in LB compared to the other two legumes. Anti-nutritive factors interfere with feed intake and nutrient utilization hence affecting weight gain. Robinson and Singh, (2001) observed a higher amount of Trypsin Inhibitors Activity (TIA) in lablab beans (3.8 - 5.5mg/g) compared to 1.9 - 2.9mg/g and 3.1mg/g in GG and CWP respectively. Trypsin inhibitors cause increased secretion of the enzyme trypsin by inducing hypertrophy and hyperplasia of the pancreas. This in turn causes growth depression through endogenous loss of amino acids in the form of enzymes secreted by the hyperactive pancreas (Liener, 1994).

Feed Conversion Ratio (FCR) also followed the trend of feed intake and body weight gain. Broilers on GG and CWP based diets had better ($P<0.05$) FCR compared to their LB fed counterparts. This may be due to the same reason as discussed in feed intake and weight gain. LB may have more anti-nutritive factors which interfere with the conversion of feed to live weight gain.

Physical appearance of experimental broilers

The relative sizes of the broilers fed diets based on the three legumes showed that those fed GG based diets had the largest size followed by CWP and lastly LB (Plate 1).

The broiler sizes were consistent with broiler weights and those on the GG diets under any inclusion level were heaviest followed closely by those on CWP diets and lastly by those under the LB diets.

There was a noticeable yellow coloration of the shanks, skins and the beaks of the broilers on all diets based on GG (Plate 1 and 2).

Plate 1: Broilers fed on 20% inclusion levels of [1]Cowpea,[2] Lablab and [3]Green gram.

Plate 2: Shanks of broilers fed on diets based on [1]green gram, [2]cowpeas and [3]lablab beans

The yellow coloration is caused by fat soluble pigments known as carotenoids that occur naturally in some feed ingredients such as the seed coat of green gram (Raghavan, 2001). They are yellow, red or orange pigments that are classified in two groups; carotenes and xanthophylls (Jin *et al*., 2003). Color enhances the visual appeal of a product and it is the most important sensory quality that a consumer looks for when purchasing food (Saltmarsh, 2000). In some countries a bird with yellow colored shanks is considered to be healthy and the degree of coloration determines how fast the broilers are sold (Raghavan, 2001). In Kenya, consumers prefer broilers with yellow skins similar to the indigenous chicken and they pay a higher price for such a bird. Use of GG seed coats has been documented to increase yolk color when included in layers' diets at 5-20% level (Bien and Thieu, 2007).

Apart from the small sizes of the broilers on the LB based diets, poor feather development was also evident (Plate 1). Feathers are made up of over 85% crude protein which contains large amounts of amino acids such as; cysteine, arginine, phenylalanine, valine, serine, threonine and glycine (MacAlpine and Payne, 1977; Onifade, 1998; Mariana, *et al*., 2008). Poor protein utilization through the inhibitory effect of anti-nutritive factors present in the bean may have caused the poor feather development.

Mortality

A total of fourteen bird's equivalent to 3.5 % of the total broilers died during the experiment. This data was however not analyzed statistically.

3.2.4.2.2 Effects of legume type and inclusion levels on carcass quality

The results of carcass quality of broiler chicken fed on different legumes at varying levels are presented in Table 3.2.7 and 3.2.8 below. The interaction between the legumes and levels for all the carcass parameters was not significant (P>0.05). This indicates that the broilers performed in the same way with inclusion of each legume at different levels. Therefore only the main effects of the legumes will be reported.

Broilers fed on diets based on the three legumes and the 0%LGM had similar weights of various carcass parts apart from the mean dressed weight and the breast weight (%). Broilers on LB based diets had a lower (P<0.05) mean dressed weight and breast weight (%) compared to those fed on GG, CWP and the 0%LGM diets. These low weights could be due to low protein utilization which has been reported to affect the weight of carcass parts of broiler chicken (Salami and Boorman, 1999).

Mean dressed weight (g/bird)

The mean dressed weight for the broilers fed on different diets was 1226, 1248, 1208 and 904g/bird for broilers fed on the 0%LGM, GG, CWP and LB based diets respectively.

Those on LB based diets had the least (P<0.05) mean dressed weight compared to those fed on all the other diets. Anti-nutritive factors present in the LB may have caused depressed feed intake and poor feed utilization leading to the reduced dressed weight.

The dressed weight of the broilers fed on the LB based diets followed the trend of feed intake, live weight and body weight gain. Broilers on the GG and CWP diets had comparable (P>0.05) mean dressed weight to those fed on the 0%LGM diet. This indicates that the two legumes can be used to substitute SBM without negatively affecting the dressed weight.

Dressed weight (%)

The mean dressed weight (%) for the broilers fed on different diets was, 77.97, 77.5, 72.32 and 74.2% for broilers fed GG, CWP, LB and 0%LGM diets respectively.

Table 3.2.7: Effects of legume type and levels on carcass performance of broiler chicken

Diet		[2]GG			[3]CWP			[4]LB			[5]SEM
% Level of legumes	[1]0%LGM	10%	20%	30%	10%	20%	30%	10%	20%	30%	
Mean dressed weight (g/bird)	1226.00^{bc}	1158.50^{bc}	1245.00^{bc}	1339.30^{bc}	1471.75^{c}	1105.50^{bc}	1045.30^{b}	1190.00^{bc}	955.35^{ab}	566.50^{a}	121.00
Dressing percentage (%)	74.20	83.71	79.09	71.12	81.74	76.01	75.26	75.45	71.63	69.87	8.96
Breast weight (%)	22.20	18.49	20.44	15.72	19.89	18.96	18.04	14.60	13.72	12.88	2.34
Drumstick (%)	4.89	5.46	4.96	4.47	4.73	5.14	4.47	4.95	3.54	3.89	0.56
Abdominal fat (%)	1.53	1.88	1.49	1.56	1.78	1.58	1.43	1.33	1.07	1.24	0.24
Gizzard (%)	1.80	2.53	1.89	1.75	1.78	2.30	1.50	2.35	1.68	2.31	0.25
Liver (%)	2.72	2.32	2.58	2.62	2.66	2.46	2.80	2.25	2.94	2.90	0.38
Pancreas (%)	0.30	0.31	0.32	0.35	0.30	0.33	0.30	0.27	0.35	0.43	0.04

Means within a row without superscripts/ with similar superscripts do not differ significantly (P>0.05).

[1]0%LGM - Diet with 0% of the selected legumes

[2]GG - Green gram

[3]CWP - Cowpea

[4]LB - Lablab bean

[5]SEM - Standard error of mean

Table 3.2.8 Effect of legume type on carcass performance of broiler chicken

	Type of legume				
	0%[1]LGM	[2]GG	[3]CWP	[4]LB	[5]SEM
Mean dressed weight (g/bird)	1226.00[a]	1248.00[a]	1208.00[a]	904.00[b]	100.30
Dressed weight (%)	74.20	77.97	77.50	72.32	2.93
Breast weight (%)	22.20[b]	18.22[ab]	18.96[ab]	13.74 [a]	2.38
Drumstick (%)	4.89	4.96	4.78	4.12	0.31
Abdominal fat (%)	1.53	1.64	1.60	1.21	0.24
Gizzard (%)	1.80	2.06	1.86	2.11	0.24
Liver (%)	2.72	2.51	2.64	2.70	0.20
Pancreas (%)	0.30	0.33	0.31	0.35	0.36

Means within a row without superscripts/with similar superscripts do not differ significantly ($P>0.05$)

[1]0%LGM - Diet with 0% of the selected legumes

[2]GG - Green gram

[3]CWP - Cowpea

[4]LB - Lablab bean

[5]SEM - Standard error of mean

Although the weights were not significantly different (P>0.05) from each other, broilers fed on GG tended to have higher dressed weight followed closely by those fed on CWP then those fed on the 0%LGM diet and the least were those on LB based diets.

Chakam *et al*. (2010) and Kur *et al*. (2014) did not find significant difference (P>0.05) on carcass yield when cooked or roasted CWP were added in broiler diets at levels of 10, 20, 30 and 15% respectively. Similar to the current study, Moawia (2015) also reported no significant differences (P>0.05) on dressed weight when decorticated LB was included at 5, 10 and 15% levels in broiler diets.

Breast weight (%)

Broilers fed on LB based diets had lower (P<0.05) breast weight (13.74%) when compared to those on 0%LGM (22.2%) but almost similar (P>0.05) to those on GG and CWP based diets (18.22 and 18.96% respectively). Eljack *et al*. (2009) reported no significant differences (P>0.05) when raw CWP were included up to 20% in broiler diets. Similar to the current study Abeke *et al*. (2008) reported significantly lower (P>0.05) breast weight of broiler finisher fed on 50% LB compared to the control diet.

The weight reported for LB fed broilers in the current study followed what was observed on weight gain which was significantly different from the 0%LGM diet. The low breast weight (%) for broilers on the LB based diets could have been due to the low feed intake and body weight reported for the broilers. Anti-nutritive factors reduced feed intake thereby lowering weight gain of broiler chicken (Aletor, 1993; Islam *et al*., 2001).

Abdominal fat (%)

Broilers fed on different legumes had the almost similar (P>0.05) abdominal fat weights of 1.64, 1.60, 1.53 and 1.21% for broilers fed on GG, CWP, LB and 0%LGM diets respectively. Broilers on the GG based diets had numerically higher amounts of fat although not significantly (P>0.05) higher compared to those on the other diets. Wiryawan *et al*. (1997) and Chakam *et al*. (2010) reported similar results to the current study where no significant effect (P>0.05) was reported on back fat of finisher pigs and abdominal fat of broilers fed on diets containing 10, 20 and 30% levels of GG respectively. Kana *et al*. (2012) also did not report any significant differences (P>0.05) when 20% CWP was included in diets of broiler chicken replacing SBM (0.89 and 0.77% for SBM and 20%CWP based diets respectively).

Drumstick weights (%)

The percentage weight of drumsticks of broilers fed on different legumes was almost similar (P>0.05) at 4.96, 4.78, 4.12 and 4.89% for the broilers on GG, CWP, LB and 0%LGM diets respectively. Eljack *et al*. (2009) reported no significant difference (P>0.05) in drumstick weight of broilers fed CWP based diets at 10, 20 and 30%.

Gizzard (%)

The gizzard weights for broilers fed on GG, CWP, LB and the 0%LGM diets were 2.01%, 1.86%, 2.11% and 1.80% respectively. Broilers fed on lablab bean had a numerically higher (P>0.05) gizzard weight, those fed on GG followed while those on CWP had the least. Eljack *et al*. (2009), Chakam *et al*. (2010) and Kana *et al.* (2012) reported no significant effect on gizzard weight when broiler chicken were fed diets containing LB and CWP based diets respectively at 10, 20 and 30% levels.

Liver weights (%)

Broilers fed on different diets had liver weights that were similar (P>0.05) at 2.51, 2.64, 2.70 and 2.72% for GG, CWP, LB and 0%LGM respectively. Broilers fed on LB had numerically higher weights compared to what was reported for CWP and GG. Similarly Wiryawan *et al*.

(1997) reported similar (P>0.05) weights of the liver of finisher pigs fed GG up to 30% level. Chakam *et al*. (2010) also reported no significant (P>0.05) difference in the weights of liver of broiler finishers fed different levels of cooked CWP. Abeke *et al*. (2008) reported results that were similar to the present study when LB was included in broiler rations at 10 and 20%. However Abeke *et al*. (2007a) reported significantly (P<0.05) higher liver weight of broilers fed on 50% LB.

Pancreas (%)

Broilers fed on the legume GG had a pancreas weight of 0.33 % which was almost similar to what was reported for CWP (0.31%), LB (0.35%) and the 0%LGM diet (0.30%). Broilers on LB diet had numerically higher pancreas weight. Similar to what was reported for GG, CWP and LB in this experiment, Wiryawan *et al*. (1997), Chakam *et al*. (2010) and Abeke *et al*. (2007a) did not observe any difference (P>0.05) on pancreas weights of broilers fed on GG, CWP and LB based diets respectively.

3.2.4.3 Cost - benefit analysis of inclusion of grain legumes in broiler chicken diets

The results of the cost benefit analysis of adding GG, CWP and LB in broiler chicken diets are presented in Table 3.2.9

Broilers fed on diets containing 10% CWP gave a profit of Ksh 247.35 /bird while those on the 0%LGM diet gave a profit of Ksh 242.55 /bird. The return from broilers on the 10% CWP based diets was therefore Ksh 4.8 more than that of the broilers on the 0%LGM diets. Broilers that were fed on 20 and 30% CWP and all levels of GG and LB gave lesser profits compared to those fed on the 0%LGM diet.

A profit of Ksh 220.75, 215.57 and 185.24/bird was reported for broilers fed on 10, 20 and 30% GG diets respectively.

Table 3.2.9: Cost - benefit analysis of inclusion of grain legumes in broiler diets

Diets	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Feed intake(kg/bird)										
Starter period	0.87	0.89	0.76	0.77	0.77	0.74	0.81	0.73	0.58	0.50
Finisher period	2.30	2.67	2.06	2.28	2.57	2.21	2.34	2.37	2.22	1.85
Cost of feed (Ksh/Kg)										
Starter	62.55	64.14	66.64	69.29	59.57	58.06	56.66	64.53	70.24	73.21
Finisher	56.75	58.86	61.30	62.02	55.17	53.35	51.97	60.75	65.29	68.38
Total	119.30	123.00	127.94	131.31	114.74	111.41	108.63	125.28	135.53	141.59
Live weight/ kg/ bird[1]	1.71	1.74	1.57	1.52	1.74	1.49	1.45	1.42	1.02	0.69
Sale of bird (at ksh/ 250kg)[2]	427.50	435.00	392.50	380.00	435.00	372.50	362.50	355.00	255.00	172.50
Cost of feed (Ksh/ bird)[3]										
Starter	54.42	57. 09	50.65	53.35	45.86	42.96	45.90	47.11	40.74	36.61
Finisher	130.53	157.16	126.28	141.41	141.79	117.90	122.22	143.98	144.94	126.50
Total	184.95	214.25	176.93	194.76	187.65	160.86	168.12	191.09	185.68	163.11
Return (Ksh/bird/diet)[4]	242.55	220.75	215.57	185.24	247.35	211.64	194.38	163.91	69.32	9.39
Cost benefit (Ksh/bird/diet)[5]	**0.00**	**-21.80**	**-26.98**	**-57.31**	**+4.80**	**-30.91**	**-48.17**	**-78.64**	**-173.23**	**-233.16**

[1] Live weight (kg) per bird at day 42; [2] Cost of selling 1kg live weight of broiler; [3] Cost of feed multiplied by amount consumed; [4]Profit per bird after the total cost of feed is deducted; [5]Comparative advantage of using the three legumes. T1= 0% LGM- Diet with 0% of the selected legumes; T2 = 10% Green gram; T3 = 20% Green gram; T4= 30% Green gram; T5 = 10% Cowpea; T6 = 20% Cowpea; T7 = 30% Cowpea; T8 = 10% Lablab bean; T9= 20% Lablab bean; T10 = 30% Lablab bean.

When compared to the profit from the broilers on the 0%LGM diet, this was a net loss of Ksh 21.8, 26.98 and 57.31/bird for broilers fed 10, 20 and 30% GG diets respectively. A loss of Ksh 30.91 and 48.17/bird was reported for broilers fed on diets containing 20 and 30% CWP respectively compared to those fed on the 0%LGM diet. Broilers that were fed on LB diets had the highest net loss when compared to those fed on the 0%LGM diet (Ksh 78.64, 173.23 and 233.16/bird) for broilers fed on diet containing 10, 20 and 30% LB respectively.

The net profit realized for the broilers fed on 10% CWP was as a result of better weight gain (1698g/bird) compared to those fed on the 0%LGM diet (1668g/bird). This may be due to better utilization of CWP by the broiler chicken due to fewer amounts of anti-nutritive factors present in the diet. Chakam *et al*. (2010) also reported net profits when broilers fed on 15% cooked CWP were compared to those fed on the 0%LGM diet.

Broilers fed on diets containing 20 and 30 % CWP had a net loss when compared to the broilers fed on the 0%LGM diet. Although the two diets were cheaper than the 0%LGM diet (Table 3.2.9), broilers on these diets had lower weight gains (1445, 1401g/bird respectively) and poor feed conversion (2.19, 2.11 respectively) compared to those fed on the 0%LGM diet (1668g/bird and 1.91 respectively) (Table 3.2.6). Similar to the current study Defang *et al*. (2008) reported a net loss when black common bean and CWP were included in broiler chicken diets.

The net loss reported for the broilers fed on GG diets compared to the broilers fed on 0%LGM diets was slightly less than what was reported for those fed on CWP and LB diets. The loss realized for broilers fed on 20 and 30% GG diets was as a result of low body weight gain (1527, 1475g/bird) compared to the 0%LGM diet (1668g/bird) while that of broilers fed 10% GG diet was as a result of poor conversion (2.10 vs 1.91) (Table 3.2.6) and high cost of the diet compared to the 0%LGM diet (Table 3.2.9).

Broilers fed on the LB based diets had the highest net loss compared to those fed on the 0%LGM diet. This could be explained by the fact that these broilers had very low weight gain (1380, 947, 648g/bird for 10, 20 and 30% LB diets respectively) and very poor feed conversion (2.25, 2.88, 3.65 for 10, 20 and 30% LB diets respectively) compared to 1668g/bird and 1.91 of the 0%LGM diet (Table 3.2.6). Similarly Abeke *et al*. (2007b) reported decreasing profit as the levels of LB were increased in diets of shika- brown pullets. The poor feed utilization by the broilers on the LB based diets could be due to presence of anti-nutritive factors that interfere with nutrient intake and utilization.

CHAPTER FOUR: GENERAL DISCUSSION

The purpose of this study was to evaluate the effect of dietary inclusion of PM, GG, CWP and LB on growth performance and carcass quality of broiler chicken. Experiment one was undertaken to determine the effect of replacing maize with pearl millet in broiler chicken diets on growth performance, carcass quality and economic performance of broiler chicken. Experiment two was carried out to evaluate the effect of varying dietary levels of GG, CWP and LB in PM-SBM diets on growth, carcass quality and economic performance of broiler chicken. This chapter aims at combining the results of the two experiments conducted with respect to the objectives.

Feed intake was not affected ($P>0.05$) by dietary inclusion of PM in experiment one. However, use of 30% GG, 20%LB and 30%LB in experiment two, resulted in a decline in feed intake ($P<0.05$). The decline may have been caused by presence of anti-nutritive factors in the legumes (Mubarak, 2005; Kalpanadevi and Mohan, 2013). Anti-nutritive factors especially tannins are bitter to taste hence reduce palatability of a feed resulting in reduced feed intake (Aletor, 1993). There was a clear trend on effect of level of legume inclusion on feed intake. A decline in feed intake with increased levels of all the legumes in the diets was observed. This may have been due to an increase in the amounts of tannins with increase in the level of legume in the diet. The decline was gradual in GG and CWP diets but was steep in LB based diets. This may have been due to a higher level of tannins in the grain legumes as reported in other studies by Sharma *et al*. (1991) in GG (2.16-2.73 mg/g), Iyayi *et al*.(1998) in CWP (3.6 mg/g) and Soetan, (2012) in LB (3.5- 4.7 mg/g) diets.

Higher ($P<0.05$) body weight gain was observed when PM was included in broiler chicken diets in experiment one. Adeola and Orban (1995) indicated that PM has a more balanced amino acid profile compared to maize. Higher amounts of analyzed crude protein and crude fat coupled with a more balanced amino acid profile in PM compared to maize grain may

have caused the higher weight gain. Amino acids are required in protein synthesis hence the rapid deposition of meat in the chicken. Oil has been shown to improve palatability of feeds in broiler chicken diets leading to better growth (Moran, 1986). Dietary inclusion of 10% GG and 10% CWP resulted in a higher ($P>0.05$) body weight gain compared to use of 0%LGM diet. Similar to what was observed for feed intake, there was a clear trend of decreasing weight gain with increased inclusion of the three legumes in the diet. Similarly the decline was slight for GG and CWP fed broilers but was more pronounced in the LB based diets. The decline may have been caused by increased levels of anti-nutritive factors in the diets. Anti-nutritive factors reduce feed intake, inhibit protein and energy metabolism, and affect feed conversion efficiency thereby depressing growth rate (Islam *et al*., 2002; Akanji *et al*., 2007).
Use of GG at all levels resulted in similar weight gain when compared to 0%LGM while inclusion of CWP above 10% level and LB at all levels resulted in a significant ($P<0.05$) reduction in weight gain. The performance of broilers on GG based diets compared to those on CWP and LB diets could have been due to lower amounts of anti-nutritive factors in GG compared to the other legumes. Robinson and Singh (2001) observed a lower amount of trypsin inhibitor activity in GG (1.9mg/g - 2.9mg/g) compared to CWP (3.1mg/g) and LB (3.8mg/g - 5.5mg/g). Trypsin inhibitors cause increased production of enzyme trypsin which results in hypertrophy and hyperplasia of the pancreas. This in turn leads to depressed growth through endogenous loss of amino acids used to manufacture the enzymes (Akanji *et al.*, 2007).

Feed conversion ratio was not affected by inclusion of PM in experiment one diets. In experiment two, inclusion of GG and CWP in the diets did not affect the FCR but inclusion of LB in the diet increased it. Inclusion of LB in the diet resulted in a poor feed conversion which worsened with increased LB levels. This may have been due to presence of anti-nutritive factors that affected feed intake and body weight gain therefore affecting FCR. Abeke *et al*. (2008a) also reported a poor FCR with increased levels of LB in the diet.

Green gram based feeds produced broilers with the highest live weight, weight gain, dressed weight and breast muscle weight. Those on CWP diets followed while those on the LB diets had the least weights. Apart from the low weights observed for broilers on the LB diets, these broilers had poor feather development probably due to the inhibitory effect of anti-nutritive factors on protein utilization (Akanji *et al*., 2012). Feathers are primarily made up of keratin which is protein (MacAlpine and Payne, 1977). Yellow coloration of the shanks, skin and the beaks of broilers on all the GG based diets was also observed. Color is the most important sensory quality that a consumer looks for when purchasing food (Saltmarsh, 2000). In Kenya consumers prefer broilers with yellow skins similar to the indigenous chicken. Inclusion of GG siftings in layers diet at 5-20% level was reported to improve the color of the yolk (Bien and Thieu, 2007).

Inclusion of PM in broiler chicken diets in experiment one and use of GG and CWP in experiment two had no effect (P>0.05) on the carcass parts studied (%); dressed weight, breast muscle, drumstick, abdominal fat, gizzard, liver and pancreas. However inclusion of LB in the diets of broiler chicken in experiment two resulted in a reduction in the mean dressed weight and breast weight (%). This may have been caused by the low feed intake of the broilers on LB based diets. All the other body parts (drumstick, abdominal fat, gizzard, liver and pancreas) were not affected by inclusion of LB in the diets.

Although the cost of producing PM diets in experiment one was higher (Ksh 119.30/kg) than that of producing a kilogram of maize based diet (Ksh 106.28/kg), broilers that were fed on PM diets resulted in a higher live weight at the end of 42 days compared to those fed maize based diets at 1.71kg/bird and 1.45kg/bird respectively. This translated to a profit of Ksh 242.55/bird for broilers fed on the PM diets which was Ksh 26. 46 higher than that of the broilers on the maize based diets (Ksh 216.09 /bird). The profit can be attributed to the higher body weight gain (1668 vs 1452g/bird) and better feed conversion (1.91 vs 1.97) for PM compared to maize based diets respectively.

In experiment two, broilers fed on all legumes at all levels apart from 10 %CWP resulted in less profits when compared to those on the 0%LGM diet. Broilers in the 10%CWP category had a net profit compared to those in the 0%LGM diet owing to the fact that CWP was relatively cheap and that the broilers had a higher body weight gain compared to the 0%LGM diet. Although broilers on the 10% GG diet had better weight gain compared to the 0%LGM, the high cost of GG increased the cost of producing the feed hence making it unprofitable. Broilers on 20% (GG and CWP), 30% (GG and CWP) and all levels of LB resulted in a net loss when compared to those fed on the 0%LGM diet. This may have been due to low body weight gain, higher feed conversion ratio and the high cost of green grams and lablab beans. The fact that lablab beans were expensive coupled with the fact that broilers fed on these diets had very low weight gains and poor feed conversion resulted in the net losses reported.

CHAPTER FIVE: CONCLUSIONS

Two studies were undertaken to determine the effects of complete replacement of maize with pearl millet and the effect of use of green grams, cowpeas and lablab beans at 0, 10, 20 and 30% levels on growth performance and carcass quality of broiler chicken. The following were conclusions from the two studies.

1. Pearl millet can completely replace maize in broiler chicken diets without negatively affecting growth performance and carcass quality. Broilers fed pearl millet diets had a higher body weight gain, similar feed intake, feed conversion ratio and carcass parts weights compared to those fed maize based diets.
2. Performance in terms of feed intake, body weight gain and live weight declined as the levels of the legumes were increased in the diet.
3. Green grams are a satisfactory feed ingredient and can be included in broiler chicken diets up to 30% level of inclusion without significantly ($P>0.05$) affecting body weight gain, feed conversion ratio and carcass performance.
4. Cowpeas can be added in broiler chicken diets up to 10% level since more inclusion results in reduction in body weight gain.
5. Use of lablab bean resulted in reduction in body weight gain therefore its use in the diets of broiler chicken at 10% levels or above should be discouraged.
6. Inclusion of GG and CWP at 10% levels resulted in higher body weight gain when compared to the broilers on the 0%LGM diet.
7. Green gram based feeds produced broilers with the highest body weight gain, live weight, dressed weight, drumstick weight and the best FCR followed by CWP fed broilers and lastly by the Lablab fed broilers.

8. Green gram use resulted in production of broilers with a distinct yellow coloration of the shanks and skin. This would mean more profits from these broilers since consumers prefer them over the white colored ones.
9. Pearl millet as a replacement of maize and 10% CWP as a substitute for SBM can be used in broiler chicken diets resulting in more profits.

RECOMMENDATIONS

From these studies, it is recommended that;

1. There is need to investigate the anti-nutritive factors which may have negatively affected the broiler chicken performance.
2. In future, studies involving cowpeas and lablab on broiler chicken performance should use treated beans to reduce the effect of anti-nutritive factors that affect growth of the broilers.
3. A follow up study should be conducted to find out the actual pigments responsible for the yellow coloration on the shanks and carcass of the broiler chicken fed GG diets.
4. Broilers fed on a 30%GG diet should be sold at 5-6 weeks of age.
5. Farmers should be encouraged to grow more legume grains to reduce their cost.

REFERENCES

Abdelgani A.A., Abdel A., Elamin K.M., Dafalla K.Y., Malik H.E.E. and Dousa B.M. (2013). Effect of dietary cowpea (*Vigna unguiculata*) seeds on the performance of broiler chicks. Wayamba Journal of Animal Science **5**: 678-684.

Abeke F.O., Ogundipe S.O., Sekoni A.A., Dafwang I.I., Adeyinka I.A., Oni O.O. and Abeke A. (2008). Effect of dietary levels of cooked *lablab purpureus* beans on the performance of broiler chickens. American Journal of Food Technology **3**(1): 42-49.

Abeke F.O., Ogundipe S.O., Oladele S., Sekoni A.A., Dafwang I.I., Adeyinka I.A., Oni O.O. and Abeke A. (2007a). Effect of duration of cooking of *Lablab purpureus* beans on the performance, organ weight and haematological parameters of shika-brown pullet chicks. Journal of Biological Sciences **7**(3): 562-565.

Abeke F.O., Ogundipe S.O., Sekoni A.A., Dafwang I.I., Adeyinka I.A., Oni O.O. and Abeke A. (2007b). Growth and subsequent egg production performance of shika-brown pullets fed graded levels of cooked *Lablab purpureus* beans. Pakistan. Journal of Biological Sciences **10**(7): 1056-1061.

Adeola O. and Orban J.I. (1995). Chemical composition and nutrient digestibility of pearl millet (*Pennisetum glaucum*) fed to growing pigs. Journal of Cereal Science **22**: 177-184.

Adeola O., Rogler J.C. and Sullivan T.W. (1994). Metabolism and nutrition: pearl millet in diets of White Pekin ducks. Poultry Science **73**: 425-435.

Adeyemi O.A., Adekoya J.A and Sobayo R.A. (2012). Performance of broiler chickens fed diets containing cassava leaf meal: blood meal mix as replacement for soybean meal. Revista Científica Udo Agricola **12**(1): 212-219.

Afiukwa C.A., Ogah O., Ibiam U.A., Edeogu C.O. and Aja P.M. (2012). Characterization of cowpea cultivars for variations in seed contents of some antinutritional factors (ANFs). Continental Journal of Food Science and Technology **6**(1): 25-34.

Agugo U.A. and Onimawo I.A. (2009). Heat treatment on the nutritional value of mungbean. Electronic Journal of Environmental, Agricultural and Food Chemistry **8**(10): 924-930.

Agugo B.A.C. (2003). Introducing mungbean into the southeastern Nigeria's humid forest; Overview of potentials. In the proceedings of 37th Annual Conference of the Agricultural Society of Nigerian held at Calabar, 301-309.

Akanji A.M., Adebiyi A.O., Adebowale O.S., Fasina O. and Ogungbesan A.M. (2012). Performance characteristics and haematological studies of broiler chickens fed cow pea based diets. Journal of Agriculture and Environment for International Development **4**: 79-85.

Akanji A.M., Ologhobo A.D. and Emiola I.A. (2007). Utilization of some raw tropical legumes in diets of exotic adult cockerels. Journal of Animal and Veterinary Advances **6** (4): 485-489.

Aletor V.A. (1993). Allelochemicals in plant foods and feeding Stuffs. Part I. Nutritional, Biochemical and Physiopathological aspects in animal production. Veterinary and Human Toxicology **35**(1): 57-67.

Aletor V.A. and Fetuga B.L. (1987). Pancreatic and intestinal amylase (EC 3.2.1.1) in the rat fed haemagglutinin extract: Evidence of impaired dietary starch utilization. Journal of Animimal Physiolology and Animal Nutrition **57**(3): 113-117.

Ali-khan S.T. and Youngs C.G. (1973). Variation in protein in field peas. Canadian Journal of Plant Science **53**: 37-41.

Alledrege J. (1994). Effects of condensed tannins on browsers and grazers: Qualitative and Quantitative defense. Colorado State University, Fortcollins, Colorado, 805-823.

Allen L.H. and Davis, C.A. (2013). Legumes. Elsevier **2**: 120-126.

Amaefule K.U. and Osuagwu F.M. (2005). Performance of Pullet chicks fed graded levels of Raw Bambarra groundnut (*Vigna subterranean* (L.) Verdc) offal diets as replacement for Soybean meal and Maize. Livestock Research for Rural Development **17**: 5-10.

Amato S.V. and Forrester R.R. (1995). Evaluation of pearl millet as a feed ingredient for broiler rations. Applied Genetics **117**: 489-497.

Amerah A.M., Ravindran V. and Lentle R.G. (2009). Influence of insoluble fibre and whole wheat inclusion on the performance, digestive tract development and ileal microbiota profile of broiler chickens. British Poultry Science **50**: 366-375.

Amini K. and Ruiz-Feria C.A. (2007). Evaluation of pearl millet and flaxseed effects on egg production and n-3 fatty acid content. British Poultry Science **48(**6): 661-668.

Anaeto M. and Adighibe L.C. (2010). Cassava root meal as substitute for maize in layers ration. Brazillian Journal of poultry Science **13**(2): 153-156.

Andi M.A. (2012). Effects of additional DL-methionine in broiler starter diet on blood lipids and abdominal fat. African Journal of Biotechnology **11**: 7579-7581.

Andrews D.J. and Kumar K.A. (1992). Pearl Millet for food, feed and forage. Advances in agronomy. Academic Press Inc., ed. Donald L. Sparks, San Diego, CA, pp 90-128.

Anwar F., Latif S., Przybylski R., Sultana B. and Ashraf M. (2007). Chemical composition and antioxidant activity of seeds of different cultivars of mungbean. Journal of Clinical Investigation **117**(9): 2486-2495.

AOAC (2002). Official methods of analysis of AOAC International, 17th Ed., Revision I, Gaithersburg, M. D, USA, Official Method 930.15, 920.35, 962.09, 942.05, 973.18, 2002.04, 994.12, 968.06.

Apata D.F. and Ologhobo A.D. (1997). Trypsin inhibitor and other anti-nutritional factors in tropical legume seeds. Tropical Science **37**: 52-59.

Austic R.E. and Nesheim M.C. (1990). The feed ingredients in: Poultry production. Lea and Febiger, Philadelphia, PA.

Aveling T. (2000). Cowpea Pathology Research. Pretoria South Africa, pp. 1-7.

Awada S.H., Hady A., Hassan A.B., Ali I. and Babiker E.E. (2005). Antinutritional factors content and availability of protein, starch and mineral of maize (*Zea mays* Linnaus) and lentil (*Lens culinaris*) as influenced by domestic processing. Journal of Food Technology **3**(4): 523-528.

Back D.W., Goldman M.J., Fisch J.E., Ochs R.S. and Goodridge A.G. (1986). The fatty acid synthase gene in avian liver. Two mRNAs are expressed and regulated in parallel by feeding, primarily at the level of transcription. Journal of Biological Chemistry **261**: 4190-4197.

Bamgbose A.M., Ogunbenro S.D., Obasohan E.E., Aruna M.B., Oteku I.T., Igene U.F., Otoikhian C.S.O. and Imasuen J.A. (2004). Replacement value of maize offal/cashew nut for maize. Proceedings of 29th Annual Conference of Nigerian Society for animal Production (NSAP), March 21st – 25th Usman Danfodio University, Sokoto, Nigeria. pp. 219-221.

Bashar Y.A., Abubakar A. and Ukpele J. (2012). Pearl millet as an alternative to maize or sorghum in the diets of broilers in Sokoto, Nigeria. International Journal of Applied Agricultural and Apicultural Research **8**(1): 1-8.

Bau H., Vilaume C., Nicolas J.P. and Jean L.M. (1997). Effect of germination on chemical composition, biochemical constituents and antinutritional factors of Soya Bean (*Glycine max*) Seeds. Journal of Science and food Agriculture **73**: 1-9.

Baurhoo N., Baurhoo B., Mustafa A.F. and Zhao X. (2011). Comparison of corn- and Canadian pearl millet-based diets on performance, digestibility, villus morphology, and digestive microbial populations in broiler chickens. Poultry Science **90**: 579-586.

Bawa G.S., Tegbe T.S.B., Ogundipe S.O., Dafwang I.I. and Abu E.A. (2003). The effect of duration of cooking lablab seeds on the level of some antinutritional factors. Proceedings of the 28th Annual Conference of the Nigerian Society for Animal Production (NSAP), 16th to 20th March, I. A. R and T, Obafemi Awolowo University, Ibadan, Nigeria.

Benabdeljelil K. and Arbaoui M.I. (1994). Effects of enzyme supplementation of barley-based diets on hen performance and egg quality. Animal Feed Science and Technology **48**: 325-334.

Berri C., Besnard J. and Relandeau C. (2008). Increasing dietary lysine increases final pH and decreases drip loss of broiler breast meat. Poultry Science **87**: 480-484.

Bhatty N., Gilani A.H. and Nagra S.A. (2000). Nutritional value of mungbean (*Vigna radiata*) as effected by cooking and supplementation. International Journal of Food Science and Nutrition **51**(3): 169-174.

Bien Le. D. and Thieu P.C. (2008). Laying performance of egyptian hens fed graded levels of mung bean (*Phaseolus aureus*) offal as replacement for soybean meal and maize. Proceedings MEKARN regional conference 2007: matching livestock systems with available resources (Editors: Reg Preston and Brian Ogle), Halong Bay, Vietnam, 25-28 November 2007. http://www.mekarn.org/prohan/bien.htm

Blair R. (2008). Nutrition and feeding of organic poultry. CAB International, ISBN 978-1-84593-406-4, Oxfordshire, England. www.researchgate.net/.../240523240_**Nutrition_and_Feeding**

Brake J.D., Brann D.E. and Griffey C.A. (1997). Barley without enzyme supplementation in broiler grower and finisher diets. Journal of Applied Poultry Resources **6**: 422-431.

Brody S. (1945). Bioenergetics and growth. Reinhold Pub.Corp, New York.

Burton G.W., Wallace A.T. and Rachie K.O. (1972). Chemical composition and nutritive value of pearl millet (*Pennisetum typhoides* (Burm.) Stapf and E. C. Hubbard grain. Crop Science **12**: 187.

Byerlee D. and Eicher C.K. (1997). Africa's emerging maize revolution. Lynne Rienner Publishers.

Chakam V.P., Téguia A. and Tchoumboue J. (2010). Performance of finisher broiler chickens as affected by different proportions of cooked cowpeas (*Vigna unguiculata*) in the grower-finisher diet. African Journal of Food, Agriculture, Nutrition and Development **10**(4): 2427-2438.

Cheva-Isarakul B. and Tangtaweewipat S. (1993). Sesame meal as soybean meal substitute in poultry diets. 11. Laying hen. Asian- Australasian Journal of Animal Sciences **6**(2): 253-258.

Chianu J., Vanlauwe B., Mahasi J.M., Katungi E., Akech C., Mairura F.S., Chianu J.N. and Sanginga N. (2008). Soybean situation and Outlook analysis: The case of Kenya. www.iwmigmia.org/what-we-do/mip/pro**jec**ts/.../rso-sbean-kenya.pdf

Choct M. (2006). Enzymes for the feed industry: past, present and future. World’s Poultry Science Journal **62**: 5-15.

Choct M. (1997). Feed enzymes: current and future applications. Proceedings of the 11th Alltech Asia-Pacific Lecture Tour, Melbourne, Australia, pp. 73-81.

Choi J., Song J., Choi Y.M., Jang D.J., Kim E., Kim, I. and Chee K.M. (2006). Daidzein modulations of apolipoprotein B and fatty acid synthase mRNA expression in chick liver vary depending on dietary protein levels. Asian- Australasian Journal of Animal Sciences **19**: 236-244.

Ciurescu G. (2009). Efficiency of soybean meal replacement by rapeseed meal and /or canola seeds in commercial layer diets. Archiva Zootechnica **12**(1): 27.33.

Clement I.M., Kwari I.D., Igwebuike J., Nkama I., Mohammed I.D. and Hamaker B. (2010). Performance and economics of production of broiler chickens fed sorghum or millet as replacement for maize in the semi-arid zone of Nigeria. Agriculture and Biology Journal of North America **1**: 321-325.

Cober E.R., Cianzion S.R., Pantalone V.R and Rajcan I. (2009). Soybeans, in oil crops, J. Vollmann and Rajcan, Editors. pp, 57-90.

Coertze A.F. and Venter S. (1996). A.3 - Cowpeas. Indigenous seed crops, pp. 1-5. Agricultural Research Council.

Collin A., Malheiros R.D., Moraes V.M.B., Van As. P., Darras V.M., Taouis M., Decuypere E. and Buyse J. (2003). Effects of dietary macronutrient content on energy metabolism and uncoupling protein mRNA expression in broiler chickens. British Journal of Nutrition **90**: 261-269.

Collins V.P., Cantor A.H., Pescatore A.J., Straw M.L. and Ford M.J. (1997). Pearl millet in layer diets enhances egg yolk n-3 fatty acids. Poultry Science **76**: 326-330.

Collins V.P., Cantor A.H., Pescatore A.J., Straw M.L. and Ford M.J. (1995). Effect of pearl millet in laying hen diets on egg fatty acids. Poultry Science **74**(1): 4.

Cowienson A.J. (2005). Factors that affect the nutritional value of maize for broilers. Animal Feed Science and Technology **119**: 293-305.

Creswell D.C. (1981). Nutritional evaluation of mungbeans (*Phaseolus aureus*) for young broiler chickens. Poultry Science **60**(8): 1905-1909.

Dada S.A.O., Atanda L.A. and Alabi B.E. (2000). Utilisation of Leucaena leaf meal as a protein supplement in broiler finisher ration. Nigerian Journal of Animal Production **27**: 40-44.

Davis A.J., Dale N.M. and Ferreira F.J. (2003). Pearl millets as an alternative feed ingredient in broiler diets. Journal of Applied Poultry Resource **12**: 137-144.

Defang H.F., Téguia A., Awah-Ndukum J., Kenfack A., Ngoula F. and Metuge F. (2008). Performance and carcass characteristics of broilers fed boiled cowpea (*Vigna unguiculata* L Walp) and or black common bean (*Phaseolus vulgaris*) meal diets. African Journal of Biotechnology **7**(9): 1351-1356.

Deka K.R. and Sarkar C.R. (1990). Nutrient composition and antinutritional factors of *Dolichos lablab L*. seeds. Food Chemistry **38**: 239-246.

De-Pach Y.M., Mbugua P.N., Gachuiri C.K. and Kabuage L.W. (2012). Effect of feed enzymes and energy level on broiler chicken (*Gallus domesticus*) performance in Kenya. MSc Thesis Univeristy of Nairobi.

Doerge D.R. and Sheehan D.M. (2002). Goitrogenic and estrogenic activity of soy Isoflavones. Environmental Health Perspectives **110**(3): 349-353.

Dousa M.B., Khadiga A. Abdel Atti. and Elawad S.M. (2011). Inclusion of some raw legume grains as broiler chicks concentrates. International Journal of Poultry Science **10**: 393-396.

Eeckhout W. and De Paepe M. (1994). Total phosphorus, phytate-phosphorus and phytase activity in plant feedstuffs. Animal Feed Science and Technology **47**: 19–29.

Eljack B.H., Fadlalla I.M.T. and Ibrahim M.T. (2009). The effect of feeding cowpea (*Vigna unguiculata*) on broiler chick's performance and some carcass quality measurements. Assiut Veterinary Medical Journal **56:** 124.

Emmerson D. A. (1997). Commercial approaches to genetic selection for growth and feed conversion in domestic poultry. Poultry Science **76**(8), 1121-1125.

Endres J.G. (2001). Protein quality and human nutrition, in Soy protein products: characteristics, nutritional aspects, and utilization. Revised and expanded edition, J.G. Endres, Editor, AOCS, pp10-19.

Ernst R.A., Vohra P., Kratzer F.H. and Ibanga O. (1994). A comparison of feeding corn oats and barley on the growth of white leghorn chickens, gastrointestinal weights of males and sexual maturity of females. Journal of Applied Poultry Resources **3**: 253-260.

Esonu B.O., Iheukwumere F.C., Iwuji T.C., Akanu N. and Nwugo O.H. (2003). Evaluation of *Microdermis puberula* leaf meal as feed ingredient in broiler starter diets. Nigeria Journal of Animal Production **30**: 3-8.

Fan H.P., Xie M., Wang W.W., Hou S.S, and Huang W. (2008). Effects of dietary energy on growth performance and carcass quality of white growing pekin ducks from two to six weeks of age. Poultry Science **87**: 1162-1164.

Fancher B.I., Jensen L.S., Smith R.L. and Hanna W.W. (1987). Metabolizable energy content of pearl millet**.** Poultry Science **66**: 1693-1696.

FAO (2012). FAOSTAT, production
http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor.

FAO (2011). FAOSTAT. http://faostat.fao.org.

Fuller H. (1981). Formulating broiler feed for hot weather use. In: Poult. Digest Butterworth. Nottingham, pp. 321-323.

Gakuya D. W., Mbugua P. N., Mwaniki S. M., Kiama S. G., Muchemi G. M., and Njuguna A. (2014). Effect of supplementation of *Moringa oleifera* (LAM) Leaf Meal in layer chicken feed. International Journal of Poultry Science **13**(7), 379-384.

Garcia A.R. and Dale N.M. (2006). Feeding of unground pearl millet to laying hens. Journal of Applied Poultry Resource **15**: 574–578.

Gatel F. (1994). Protein quality of legume seeds for non ruminant animals: a literature review. Animal Feed Science and Technology **45**: 317-348.

Gatlin D.M.III, Barrows F.T., Braown P., Dabrowski K., Gaylord T.G., Hardy R.W., Herman E., Hu G., Krogdahl A., Nelson R., Overturf K., Rust M., Sealy W., Skonberg D., Souza E.J., Stone D., Wilson R and Wurtele E. (2007). Expanding utilization of sustainable plant products in aquafeeds: a review. Aquaculture Research **38**: 551-579.

Ghadge V.N., Upase B.T and Paatil P.V. (2009). Effect of replacing groundnut cake and soybean meal on performance of broilers. Veterinary World **2**(5): 183-184.

Gopala K.A.G., Prabhakar J.V. and Aitzetmuller K. (1997). Tocopherol and fatty acid composition of some Indian pulses. Journal of the American Oil Chemists' Society **74**: 1603-1606.

Graham P.H. and Vance C.P. (2003). Legumes: Importance and Constraints to Greater Use. Plant Physiology **131**(3): 872-877.

Grisoni M.L., Uzu G., Larbier M. and Geraert P.A. (1991). Effect of dietary lysine on lipogenesis in broilers. Reproduction Nutrition Development **31**: 683-690.

Hafeni S., Irvin D.T.M. and Petrus P.N. (2013). Performance of broiler chickens fed pearl millet as an energy source and *acacia karroo* leaf meal as an additive. http://hdl.handle.net/11070/872

Hedley C. (2001). Carbohydrates in legume and grain legume seeds. Editor: Hedley, C.L. CAB International.

Hetland H. and Svihus B. (2007). Inclusion of dust bathing materials affects nutrient digestion and gut physiology of layers. Poultry Science **16**: 22-26.

Hidalgo M.A., Davis A.J., Dale N.M. and Dozier W.A. (2004). Use of whole pearl millet in broiler diets. Journal of Applied Poultry Resources **13**: 229-234.

Ibe E.A., Ongudipe S.O., Duru S. and Makinde O.J. (2014). Growth Performance and carcass characteristics of broiler chicken fed two varieties of each of guinea corn and millet as replacements for dietary maize. World Journal of life sciences and medical research **3**(2): 46-52.

Ibitoye E.B., Olorede B.R., Jimoh A.A. and Abubakar H. (2012). Comparative performance and organ relative weight of broiler chickens fed three sources of energy diet. Journal of Animal Production Advances **2**(5): 233-238.

Indriani A. **and Murwani R. (2005)**. Serum lipid profile of broilers given *Scurrula oortiana* extracts as an alternative to in-feed chlorotetracycline. Proceeding National Seminar on Food Safety of Animal Product. Jogjakarta, pp 145-158.

Ishaaya I. and Birk Y. (1965). Soybean saponins. IV. The effect of proteins on the inhibitory activity of soybean saponins on certain enzymes. Journal of Food Science **30**(1): 118-120.

Islam M.S., Awaral M.A. and Rahman M.H. (2002). Evaluation of toxic effects of country bean (*Lablab purpureus*) seed meal as dietary protein supplementation in broiler feed. Bangladesh veterinarian **17**(1): 33-36.

Iyayi E.A., Kluth H. and Rodehutscord M. (2008). Effect of heat treatment on antinutrients and precaecal crude protein digestibility in broilers of four tropical crop seeds. International Journal of Food Science and Technology **43:** 610–616.

Jiang Z., Ahn D.U., Ladner L. and Sim J.S. (1992). Influence of feeding full- fat flax and sunflower seeds on internal and sensory qualities of eggs. Poultry Science **71**: 378-382.

Jin E., Polle J. E., Hong K. L., Sang M. H. and Chang, M. (2003). Xanthophylls in microalgae: From biosynthesis to biotechnological mass production and application. Journal of microbiology and biotechnology, 13(2), 165-174.

Joseph J.K. and Abolaji J. (1997). Effects of replacing maize with graded levels of cooked Nigerial mango- seed kernels (*Mangifera indica)* on the performance, carcass yield and meat quality of broiler chickens, Bioresource technology **61**(1): 99-102.

Jurgens H.M. (1969). Animal Feeding and Nutrition. 6^{th} ed. Edited by Hafez, E.S.E and I, Adyer. Washington State University, Pullman, Washington, pp. 15-16.

Kalpanadevi V. and Mohan V.R. (2013). Nutritional and anti nutritional assessment of under utilized legume D. lablab var. vulgaris L. Bangladesh Journal of Scientific and Industrial Research **48**(2): 119-130.

Kamatchi K.B., Tresina S.P., Mohan V.R. and Vadivel V. (2010). Nutrient and chemical evaluation of raw seeds of five varieties of *Lablab purpureus* (L.) Sweet. Advances in Bioresearch **1(**1): 44-53.

Kana J.R., Teguia A. and Fomekong A. (2012). Effect of substituting soybean meal with cowpea (*Vigna unguiculata* WAL) supplemented with natural plant charcoals in broiler diet on growth performances and carcass characteristics. Iranian Journal of Applied Animal Science **2**(4): 377-381.

KEBS (Kenya Bureau of Standards) (2009). Kenya standard specifications for compounded poultry feeds. KS 62: 2009.

Khalil A.A. (2006). Nutritional improvement of Egyptian breed of mungbean by probiotic Lactobacilli. African Journal of Biotechnology **5:** 206-212.

Kingori A.M., Wachira A.M. and Tuitoek J.K. (2010). Indigenous chicken production in Kenya: A review. International Journal of Poultry Science **9**(4): 309-316.

Kinyua M.G., Orwa D., Kimani E. and Kamotho G. (2008). Survey of Dolichos Bean (*Lablab purpureus*) Production Systems, Utilization, Marketing and the Collection and Characterization of Germplasm in Kenya. Proceedings of the International Dolichos meeting, Arusha, Tanzania, 8th March 2008.

Kumar A.M., Reddy V.R., Reddy P.V. and Reddy R.S. (1991). Utilization of pearl millet (*Pennisetum typhoides*) for egg production. Poultry Science **32**: 463-469.

Kunyanga C.N. and Imungi J.K. (2010). Quality characteristics and acceptability of bread produced with supplementation of *Dolichos lablab* beans. Food Science and Technology Research **16**(6): 593-598.

Kur A.T., Abdel Atti K.A., Dousa B.M., Elagib H.A., Malik H.E. and Elamin K.M. (2014). Effect of treated cowpea seeds on broiler chicken. Global Journal of Animal Scientific Research **1**(1): 58-65.

Kwari I.D., Igwebuike J.U., Shuaibu H., Titimaand S.I. and Raji A.O. (2014). Growth and carcass characteristics of broiler chickens fed Maize, Sorghum, millet and their combinations in the semi arid zone of Nigeria. International Journal of science and Nature **5**(2): 240-245.

Lambrides C.J. and Godwin I.D. (2006). Mungbean. In: Chittarajan, K., Genome Mapping and Molecular Breeding in Plants **3**: 69-90.

Lawrence B.V., Adeola O. and Rogler J.C. (1995). Nutrient digestibility and growth performance of pigs fed pearl millet as a replacement for corn. Journal of Animal Science **73**: 2026-2032.

Ledér I. (2004). Sorghum and millet in cultivated plants, primarily as food sources. Encyclopedia of Life Support Systems (EOLSS), Developed under the Auspices of the UNESCO, Eolss Publishers, Oxford, UK,[http://www. eolss. net].

Lee D. and Hanna W. (2002). Pearl millet for grain. Extension Bulletin 1216. Athens GA: University of Georgia.

Leeson S. and Summers J.D. (2009). Commercial poultry nutrition. Nottingham University Press. http://www.razeghi.ir/index2.php?option=com_docman&task=doc_view&gid=29&Itemid=51.

Leeson S. (2000). Is feed efficiency still a useful measure of broiler performance. http://www.omafra.gov.on.ca/english/livestock/poultry/facts/efficiency.htm

Leeson S., Atteh J.O. and Summers J.D. (1987). The replacement value of canola meal for soybean meal in poultry diets. Canadian Journal of Animal. Science **67**:151-158.

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

Liener I.E. (1989). Anti nutritional factors in legume seeds: State of art. Recent advances of research in Anti nutritional factors in Legume seeds. Huisman, J, Van der Poel, T.F.B. and Liener, I.E, ed. PUDOC, Wageningen the Netherlands, pp. 6-13.

Lu L., Ji C., Luo X.G., Liu B. and Yu S.X. (2006). The effect of supplemental manganese in broiler diets on abdominal fat deposition and meat quality. Animal Feed Science Technology **129**: 49-59.

MacAlpine R. and Payne C.C. (1997). Hydrolyzed feather protein as a source of amino acids for broilers. British Poultry Science **18**: 265-273.

Maia F.M.M., Oliveira J.T.A., Matos M.R.T., Moreira R.A. and Vasconcelos I.M. (2000). Proximate composition, amino acid content and haemagglutinating and trypsin-inhibiting activities of some Brazilian *Vigna unguiculata* (L) Walp cultivars. Journal of the Science of Food and Agriculture **80**(4): 453-458.

Mal B., Padulosi S. and Ravi S.B. (2010). Minor millets in South Asia; Learnings from IFAD-NUS project in India and Nepal. Maccarese, Rome, Italy: Biodervisity Intl and Chennai, India: M. S. Swarninathan Research Foundation, pp. 1-185.

Mangat B.K., Maiti R.K. and Kharval I.S. (1999). Pearl Millet Biology. In Khairwal I.S., Rai K.N., Andrews D.J. and Harinarayana G. 1999. Pearl Millet Breeding. Science publishers, Inc. USA.

Manwar S.J. and Mandal A.B. (2009). Effect of high moisture storage of pearl millet (*Pennisetum typhoides*) with or without feed enzymes on growth and nutrient utilization in broiler chickens. Animal Science Journal **80**: 438-445.

Mariana C.J., Contiero C.J., de Lima B., Lovaglio R.B. and Monti R. (2008). Characterization of a feather degrading of *Bacillus amyloliquefaviens* protease: A new strain. World Journal of Agricultural Science **14**(5): 648-656.

Masoudi A., Bajarpour M., Chaji M., Eslami E. and Mirzadeh K.H. (2010). Economic value of date pits replaced with maize in broiler chicken diets. Journal of Animal and Veterinary Advances **9**(11): 1578-1581.

Maundu P.M., Ngugi G.W. and Kabuye C.H.S. (1999). *Lablab purpureus* In: Traditional food plants of Kenya. English Press Ltd. Nairobi, Kenya pp154-155.

McDonald P., Edwards R.A., Greehalgh J.F.D. and Morgan C.A. (2002). Animal Nutrition. 6th ed Pearson Education limited. United Kingdom, pp 572-573.

McNab J.M and Boorman K.N. (2002). Poultry feedstuffs, supply, composition and Nutritive value. Poultry science symposium series 26: 65.

Medugu C.I., Kwari I.D., Igwebuike J., Nkama I., Mohammed I.D. and Hamaker B. (2010). Performance and economics of production of broiler chickens fed sorghum or millet as replacement for maize in the semi-arid zone of Nigeria. Agriculture & Biology Journal of North America **1**(3): 9321.

Mehri M., Pourreza J. and Sadeghi S. (2010). Replacing maize with Pearl millet in laying hens'diets. Tropical Animal Health Production **42**: 439-444.

Micha R., Wallace S. K. and Mozaffarian D. (2010). Red and processed meat consumption and risk of incident coronary heart disease, stroke, and diabetes mellitus a systematic review and meta-analysis. Circulation **121**(21): 2271-2283.

Miller H.M. and Holmes J.H.G. (1992). Grain legumes for broiler production. Proc Austral Poultry Science Symposium, Sidney, pp 38-45.

MOA (Ministry of Agriculture). (2010). Economic Review of Agriculture.

MOA (Ministry of Agriculture). (2005). Annual report. Ministry of Agriculture Headquarters, Kilimo house, Nairobi, pp. 90.

Moawia R. (2015). Effect of dietary Hyacinth Bean (*Lablab purpureus*) on broiler chicks performance (Doctoral dissertation). http://khartoumspace.uofk.edu:8080/bitstream/handle/123456789/8203/Effect%20of%20Dietary%20Hyacinth%20Bean%20%28Lablab%20purpureus%29%20on.pdf?sequence=1

Mohammed K.H.A., Toson M.A., Hasanien H.H.M., Soliman M.AH. and El-Nager S.H.M. (2010). Effect of barley replacement and enzyme supplementation on performance and egg quality of laying hens. Egypt Poultry Science **30**: 731-745.

MoLD (Ministry of Livestock Development). (2009). Annual reports on poultry production in Kenya. A paper presented in Nairobi-Kenya, Nov.23-27/2009.

MoLD (Ministry of Livestock Development). (2008). National Livestock Development. A paper presented in Nairobi-Kenya, Session paper No 2 – May 2008.

MoLFD (Ministry of Livestock and Fisheries Development). (**2007).** Animal Production Annual Report, Nairobi, Kenya.

Moran E.T. Jr. (1986). Variation in body composition of Poultry. Proceedings of the Nutrition Society **45**: 101-109.

Morrison F.B. (1948). A handbook for the student and stockman. The morrison publishing company, New York, pp 31-32.

Mubarak A.E. (2005). Nutritional composition and antinutritional factors of mungbean seeds (*Phaseolus aureus*) as affected by some home traditional processes. Journal of Food Chemistry **89**: 489-495.

Murphy A.M. and Colucci P.E. (1999). A tropical forage solution to poor quality ruminant diets: a review of *Lablab purpureus*. Livestock Research for Rural Development **11** (2): 16.

Murwani R. (2008). Effect of Corn or Sorghum in combination with soybean meal or MungBean on The Titre Antibody to NDV vaccine in Broiler Chickens. International Journal of Poultry Science **7**(5): 497-503.

Muthamia J.G.N. and Kanampiu F.K. (1996). On-farm cowpea evaluation in the marginal areas of eastern Kenya. In: Fungoh P.O. and G.C.O. Mbadi (eds.). Proceedings of the 5th KARI Scientific Conference. KARI, Nairobi, Kenya. pp. 677-685.

Nasr J. and Kheiri F. (2011). Effect of different lysine levels on Arian broiler performances. Italian Journal of Animal Science **10**: 170-174.

National Coordinating Agency for Population and Development (NCAPD). (2010). RAPID Population and Development. Nairobi, Kenya: National Coordinating Agency for Population and Development. http://www.healthpolicyinitiative.com/Publications/Documents/1095_1_Kenya_booklet_3_31_10_sglepg_LOW_RES_PDF_for_INTERNET_acc.pdf.

Newkirk R. (2010). Soybean: Feed Industry Guide. 1st edition, Canadian International Grains Institute. cigi.ca/wp-content/.../12/2010-Soybean-Feed-Industry-Guide.pdf.

NRC (National Research Council). (2006). Lost Crops of Africa. Vegetables, Volume II: The National Academies Press, Washington, D.C.

NRC (National Research Council). (1996). Pearl millet. In: Lost Crops of Africa. Volume 1: Grains. National Academy Press, Washington DC, USA, pp, 77-126.

NRC (**National Research Council). (1994).** Nutrients requirements of domestic animals. nutrient requirements of poultry. 9th edition, National Academy Press Washington.

Nyoro J.K., Ayieko M. and Muyanga M. (2007). The compatibility of trade policy with domestic policy interventions affecting the grains sector in Kenya. In FAO Workshop on Trade and Policy for Food Products Conducive to Development in Eastern Africa, Rome. www.researchgate.net/.../237789199_The_Compatibility_of_

Obilana A.B. (2003). Overview: importance of millets in Africa. In: Belton P.S.,Taylor J.R.N., editors. Proceeding of the Workshop on the Proteins of Sorghum and Millets: Enhancing Nutritional and Functional Properties for Africa. 2–4 April 2003. Pretoria, South Africa. Available from <http://www.afripro.org.uk>.

Ojewola G.S. and Oyim S. (2006). Comparative evaluation of maize, sorghum and millet in growing cockerel's ration. Agricultural Journal **1**(3): 176-179.

Ologhobo A.D., Apata D.F. and Akinpelu O. (1993). Toxicity of raw lima bean (*Phaseolus lunatus L*) and lima bean fraction of growing chicks. British Poultry Science **34**(3): 505-522.

Oluwatosin O.B. (1999). Genotype x environment influence on cowpea (*Vigna unguiculata* (L) Walp) anti nutritional factors: 1-trypsin inhibitors, tannins, phytic acid and haemagglutinin. Journal of the Science of Food and Agriculture **79**(2): 265-272.

Onifade A.A. (1998). A review: Potential for biotechnological application of keratin- grading microorganisms and their enzymes for nutritional improvement of feathers and other keratin as livestock feed resource. Bioresource Technology **66**: 1-11.

Pal M., Brahmachary R. and Ghosh M. (2010). Comparative studies on physicochemical and 34 biochemical characteristics of scented and non-scented strains of mungbeans (*Vigna radiata*) 35 of Indian origin. Legume Research **33**: 1-9.

Panda A.K., Raju M.V.L.N., Rama S.V.R., Lavanya G., Reddy E.P.K. and Sunder G.S. (2010). Replacement of normal maize with quality protein maize on performance, immune response and carcass characteristics of broiler chickens. Journal of Animal Science **23**(12): 1626-1631.

Parsons C.M., Zhang Y. and Araba M. (2000). Nutritional evaluation of soybean meals varying in oligosaccharide content. Poultry Science **79**(8): 1127-1131.

Pengelley B.C. and Maass B.L. (2001). *Lablab purpureus* (L.) Sweet – diversity, potential use and determination of a core collection of this multi-purpose tropical legume. Genetic Resources and Crop Evolution **48**: 261-272.

Pereira P.A.A., Del Peloso M.J., Da Costa J.G.C., Ferreira C.M. and Yokoyama L.P. (2001). Beans Product: Perspectives for Production, Consumption and Genetic Improvement. Paper presented at the Cowpea Research National Meeting. Embrapa Rice and Beans. Teresina, PIAUÍ, Brazil.

Pesti G.M., Bakalli R.I., Driver J.P., Sterling L.E. Hall and Bell E.M. (2003). Comparison of peanut meal and soybean meal as protein supplements for laying hens. Poultry Science **82**: 1274-1280.

Poncet V., Lamy F., Devos K., Gale M., Sarr A. and Robert T. (2000). Genetic control of domestication traits in pearl millet (*Pennisetum glaucum* L, Poaceae). Theoretical and Applied Genetics **100**:147–159.

Pond W.G., Church D.C. and Pond K.R. (1995). Basic Animal Nutrition and Feeding. John Wiley and sons Inc, New York.

Rabie M.H. and Szilagyi M. (1998). Effects of L-carnitine supplementation of diets differing in energy levels on performance, abdominal fat content, and yield and composition of edible meat of broilers. British Journal of Nutrition **80**: 391-400.

Ragab H.I., Kijora C., Abdel Ati K.A. and Danier J. (2010). Effect of traditional processing on the nutritional value of legumes seeds produced in Sudan for poultry feeding. International Journal of Poultry Science **9**: 198- 204.

Raghavan V. (2001). Pigmentation in broilers. Feed Mix **9**: 3.

Rama Rao S.V., Raju M.V.L.N., Reddy M.R. and Panda A.K. (2004). Utilization of graded levels of finger millet (*Eleusine coracana*) in place of yellow maize in commercial broiler chicken diets. Asian Australasian Journal of Animal Science **18**: 80-84.

Rama Rao S.V., Reddy M.R., Praharaj N.K. and Shyamsunder G. (2000). Laying performance of broiler breeder chickens fed various millets or broken rice as a source of energy at a constant nutrient intake. Tropical Animal Health and Production **32**: 329-338.

Ramakrishna V., Jhansi Rani P. and Ramakrishna R. (2008). Changes in anti nutritional factors in Indian bean (*Dolichos lablab* L.) seeds during germination and their behavior during cooking Nutrition and Food Science **38**(1): 6-14.

Rao S.V.R., Raju M.V.L.N., Reddy M.R. and Panda A.K. (2004). Replacement of yellow maize with pearl millet (*Pennisetum typhoides*), foxtail millet (*Setaria italica*) or finger millet (*Eleusine coracana*) in broiler chicken diets containing supplemental enzymes. Asian Australasian Journal of Animal Science **17**(6): 836-842.

Ravindran V. and Blair R., (1992). Feed resources for poultry production in Asia and the Pacific. II. Plant protein sources. World's Poultry Science Journal **48**: 205-231.

Reddy A.R., Reddy V.R., Rao P.P., Reddy K.G., Reddy B.V., Ramachandraiah D. and Rao C.L.N. (2005). Performance of layers on sorghum-based poultry feed rations. International Sorghum and Millets Newsletter, 46, 75-79. oar.icrisat.org/1233/1/ISMN-46_75-79_2005.pdf

Reza M.S. Yahya E.N. and Naser M.S. (2008). Replacement of different levels of rapeseed meal with soybean on broiler performance. Asian Journal of Animal Veterinary Advances **3**(5): 278-285.

Robinson D. and Singh D.N. (2001). Alternative protein sources for hens. Queensland poultry research and development center Ann-Clin Biochem. pp 6-24.

Rosenberg H.R., Rohdenburg E.L. and Eckert R.E. (1960). Multiple amino acid supplementation of white corn meal. Journal of Nutrition **72**: 415-422.

Salami R.I. and Odunsi A.A. (2003). Evaluation of processed peel meals as substitutes for maize in the diets of layers. International Journal of Poultry Science **2**(2): 112-116.

Salami R.T. and Boorman K.N. (1999). Crude protein requirement of growing cockerels by the diet dilution technique. Tropical Animal Science **1**: 63-72.

Salimath V.P. and Tharanathan R.N. (1992). Carbohydrates of field bean (*Dolichos lablab*). Cereal Chemistry **59**: 430-435.

Saltmarsh M. (2000). Essential guide to food additives. Edited, Leatherhead Food RA Publishing. pp 1-32.

Sandberg A.S. (2002). Bioavailability of minerals in legumes. British Journal of Nutrition **88**(3): S281-S285.

Sanginga N., Dashiell K., Diels J., Vanlauwe B., Lyasse O., Carsky R., Tarawali S., Asafo-Adjei B., Menkir A., Schulz S., Singh B., Chikoye D., Keatinge D. and Ortiz R. (2003). Sustainable resource management coupled to resilient germplasm to provide new intensive cereal–grain–legume–livestock systems in the dry Savanna. Agriculture ecosystems and Environment **100**: 305-314.

Sarwatt S.V., Ketule A.M. and Lugendo A.J.H. (1991). Effects of substituting Dolichos bean meal with soya bean on the performance of broiler chickens. Livestock Research for Rural Development **3**(3): 59-64.

Scanes G.C., Brant G. and Ensminger M.E. (2004). Poultry Science. 4th ed. Pearson Prentice hall, New Jersey.

Sharma N.K., Sapkota M., Sah R., Sharma M.P., Creswell D. and Sharma N. (2012). Performance and carcass characteristics of broilers under diets supplemented with whole grains. Nepal Journal of Science and Technology **13**: 21-28.

Sharma A.K., Bakhshi A.K. and Varma M.M. (1991). Proximate composition and nutritional quality of some improved varieties of mungbean (*Vigna radiata*). Legume Research **14**(4): 197-200.

Shewry P.R. and Tatham A.S. (1999). The characteristics, structures and evolutionary relationships of prolamins. In: Seed Proteins (Eds. P. R. Shewry and R. Casey) Kluwer Academic Publishers, Dordrecht. pp 11-33.

Shi S.R., Lu J., Tong H.B., Zou J.M. and Wang K.H. (2012). Effects of graded replacement of soybean meal by sunflower seed meal in laying hen diets on hen performance, egg quality, egg fatty acid composition and cholesterol content. Journal of Applied Poultry Research **21**: 367-374.

Shivashankar G., Kulkarni R.S., Shashidhar H.E. and Mahishi D.M. (1993). Improvement of field bean. Advances in Horticultural Science **5**: 277-286.

Siddhuraju P., Makkar H.P.S. and Becker K. (2002). The effect of ionising radiation on anti nutritional factors and the nutritional value of plant materials with reference to human and animal food. Food Chemistry **78**: 187-205.

Singh P. and Raghuvanshi R.S. (2012). Finger millet for food and nutritional security. African Journal of Food Science **6** (4): 77-84.

Singh D.N, Nagle T.A.D. and Trappet P.C. (2009). Chicken meat industry – Broiler performance on pearl millet based diets. RIRDC Publication NO 09/134, RIRDC project No DAQ – 337A. https://rirdc.infoservices.com.au/downloads/09-134.

Singh B.B. and Emechebe A.M. (1997). Advances in research on cowpea, Striga and Alectra pp 215-224.

Sinurat A.P., Purwadaria T., Ketaren P.P. and Pasaribu T. (2014). Substitutions of soybean meal with enriched palm kernel meal in laying hens diet. JITV **19**(3): 184-192.

Sittiya J. and Yamauchi K. (2014). Effects of replacing corn with whole grain paddy rice in laying diets on egg production performance. Journal of Advanced Agricultural Technologies **1**: 1-4.

Slack J.M.W. (1995). Biology of the pancreas. Development **121**: 1569-1580.

Smits C.H.M. and Annison G. (1996). Non-starch polysaccharides in broiler nutrition-towards a physiologically valid approach to their determination. World's Poultry Science Journal **52**: 203-221.

Soetan K.O. (2012). Comparative evaluation of phytochemicals in the raw and aqueous crude extracts from seeds of three *Lablab purpureus* varieties. African Journal of Plant Science **6**(15): 410-415.

Subramanian and Metta (2000). Sorghum Grain for Poultry Feed, http://www.icrisat.org/text/research/grep/homepage/sgmm/chapter14.htm.

Takahashi K. and Akiba Y. (1995). Effect of methionine supplementation on lipogenesis and lipolysis in broiler chickens. Journal of Poultry Science **32**: 99-106.

Tanaka K., Ohyani S. and Shigeno K. (1983). Effect of increasing dietary energy on hepatic lipogenesis in growing chicks. II. Increasing energy by fat or protein supplementation. Poultry Science 62: 452-458.

Tangtaweewipat S. and Cheva-Isarakul B. (1992). Sesame meal as soybean meal substitute in poultry diets 2. Laying hen. Journal of Agriculture (Thailand). www.ajas.info/journal/view.php?number=18803

Téguia A. and Fon Fru S. (2007). The growth performances of broiler chickens as affected by diets containing common bean (*Phaseolus vulgaris*) treated by different methods. Tropical Animal Health and Production **39**: 405-410.

Téguia A. and Beynen A.C. (2005). Alternative feedstuffs for broilers in Cameroon. Livestock Research for Rural Development **17**(3).

Tessseraud S., Larbier M., Chagneau A.M. and Geraert P.A. (1992). Effects of dietary lysine on muscle protein turnover in growing chickens. Reproduction Nutrition Development **75**: 853-865.

Tinsley R.L. (2009). Assessing the soybean value chain analysis in Kenya. CNFA farmer to farmer program, November- December. Colorado State University, Fort Collins, Colorado. lamar.colostate.edu/~rtinsley/SoybeanKenya.pdf.

Tomooka N., Lairungreang C., Nakeeraks P., Egawa Y. and Thavarasook C. (1992). Center of genetic diversity and dissemination pathways in mungbean deduced from seed protein electrophoresis. Theoretical and Applied Genetics **83**(3): 289-293.

Tornekar A.P., Munde V.K. and Kokane S.S. (2009). Effect of replacing maize with Bajra (Pearl Millet) on the performance of broilers. Veterinary World **8**: 310-312.

Torres T.R., Ludke M do C.M.M., Ludke J.V., Santos M.J.B. dos., Lima M.R. and Santos P.A. dos. (2013). Performance of broilers fed during 21 days on mash or pellet diets containing whole or ground pearl millet grains. Brazilian Journal of Poultry Science **15**(4): 371-378.

Tshovhote N.J., Nesmruni A.E., Raphulu T. and Gous R.M. (2003). The chemical composition, energy and amino acid digestibility of cowpeas used in poultry nutrition. South African Journal of Animal Science **33**(1): 65.

Tulasi S.L., Rajashekher A.R., Raghunadha Reddy G., Prasad V.L.K., Raju M.V.L.N., Rao C.L.N., Belum V.S.R., Rao P.P. and Ramachandraiah D. (2004). Performance of broilers on sorghum based diets. International Sorghum and Millets Newsletter **45**: 37-40

United States Department of Agriculture (USDA) (2011). Foreign Agriculture Service, Global 37 Agricultural Information Network (GAIN). 38http://gain.fas.usda.gov/Lists/Advanced%20Search/AllItems.aspx.

Van Eys J.E., Offner A. and Bach A. (2004). Manual of quality analyses for soybean products in the feed industry. American Soybean Association, Brussels, Belgium.

Vieira S.L. and Angel C.R. (2012). Optimizing broiler performance using different amino acid density diets: What are the limits? The Journal of Applied Poultry Research **21**(1) 149-155.

Waller A. (2007). Take a fresh look at broiler nutrition. Poultry International, September 2007, 12-13.

Wang T.L., Domoney C., Cliff L., Casey R. and Grusak M.A. (2003). Can we improve the nutritional quality of legume seeds? Plant physiology **131**: 886-891.

Watson L. and Dallwitz M. J. (1992). The grass genera of the world. CAB international. **1038**: 512-513.

Wayne B. (2013). Prospects to enhance pearl millet production and its uptake by the poultry Industry. RIRDC Publication No 12/135 downloaded from https://rirdc.infoservices.com.au/downloads/12-135.

Whittemore C.T. (1988). Elements of pig science. John Wiley and Sons Inc, New York.

Willis S. (2003). The use of soybean meal and full-fat soybean meal by the animal feed industry. 12th Australian Soybean Conference http://www.australianoilseeds.com/__data/assets/file/0019/1198/Sarah_Willis-The_Use_of_Soybean_Meal_and_Full_Fat_Soybean_Meal_by_the_Animal_Feed_Industry.pdf.

Wiryawan K.G., Miller I.H.M. and Holmes J.H.G. (1997). Mungbeans (*Phaseolus aureus*) for finishing pigs Animal Feed Science Technology **66**: 297-303.

Yalçin S., Özkul H., Özkan S, Gous R., Yaşa I. and Babacanoğlu E. (2010). Effect of dietary protein regime on meat quality traits and carcass nutrient content of broilers from two commercial genotypes. British Poultry Science **51**: 621-628.

Yang N. and Jiang R.S. (2005). Recent advances in breeding for quality chickens. World Poultry Science Journal **61**: 373-381.

Yoshiki Y., Kudou S. and Okubo K. (1998). Relationship between chemical structures and biological activities of triterpenoid saponins from soybean (review). Bioscience Biotechnology and Biochemistry **62:** 2291-2299.

Yunusu Y., Doma U.D., Zahraddeen D., Umar A. and Abubakar S.B. (2014). Carcass and gut characteristics of broiler chicken fed different energy sources. International Journal of Poultry Science **13**(9): 525-529.

LIST OF APPENDICES

EXPERIMENT ONE

APPENDIX1.1: ANALYSIS OF VARIANCE FOR BROILER CHICK FEED INTAKE (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	1	228299	228299	5.09	0.065
Residual	6	269166	44861		
Total	7	497465			

No significant difference was observed (P>0.05)

APPENDIX 1.2: ANALYSIS OF VARIANCE FOR BROILER CHICK BODY WEIGHT GAIN (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	1	92855	92855	12.93	0.011
Residual	6	43093	7182		
Total	7	135948			

Significant difference was observed (P<0.05)

APPENDIX 1.3: ANALYSIS OF VARIANCE FOR BROILER CHICK FCR (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	1	0.00708	0.00708	0.12	0.739
Residual	6	0.34985	0.05831		
Total	7	0.35693			

No significant difference was observed (P>0.05)

APPENDIX 1.4: ANALYSIS OF VARIANCE FOR BROILER CHICK DRESSED WEIGHT (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	1	0.5	0.5	0	0.97
Residual	6	1986.8	331.1		
Total	7	1987.3			

No significance difference was observed (P>0.05)

APPENDIX 1.5: ANALYSIS OF VARIANCE FOR BROILER CHICK BREAST WEIGHT (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	1	49.76	49.76	4.42	0.08
Residual	6	67.48	11.25		
Total	7	117.24			

No significant difference was observed ($P>0.05$)

APPENDIX 1.6: ANALYSIS OF VARIANCE FOR BROILER CHICK DRUMSTICK WEIGHT (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	1	0.211	0.211	0.16	0.7
Residual	6	7.757	1.293		
Total	7	7.968			

No significant difference was observed (P>0.05)

APPENDIX 1.7: ANALYSIS OF VARIANCE FOR BROILER CHICK ABDOMINAL FAT WEIGHT (%) (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	1	0.0463	0.0463	0.17	0.691
Residual	6	1.5907	0.2651		
Total	7	1.637			

No significant difference was observed (P>0.05)

APPENDIX 1.8: ANALYSIS OF VARIANCE FOR BROILER CHICK GIZZARD WEIGHT (%) (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	1	0.2811	0.2811	1.49	0.268
Residual	6	1.1312	0.1885		
Total	7	1.4123			

No significant difference was observed (P>0.05)

APPENDIX 1.9: ANALYSIS OF VARIANCE FOR BROILER CHICK LIVER WEIGHT (%) (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	1	0.0072	0.0072	0.01	0.909
Residual	6	3.0474	0.5079		
Total	7	3.0546			

No significant difference was observed (P>0.05)

APPENDIX 1.10: ANALYSIS OF VARIANCE FOR BROILER CHICK PANCREASE WEIGHT (%) (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treatment	1	0.00324	0.00324	0.88	0.383
Residual	6	0.02199	0.00367		
Total	7	0.02523			

No significant difference was observed (P>0.05)

EXPERIMENT TWO

APPENDIX 2.1: ANALYSIS OF VARIANCE FOR BROILER CHICK FEED INTAKE (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Legume	2	935827	467913	22.05	<.001
Level	3	2559869	853290	40.21	<.001
Legume*Level	6	541726	90288	4.25	0.002
Residual	36	763997	21222		
Total	47	4801419			

Legume, level and legume by level interactions were significant ($P<0.05$)

APPENDIX 2.2: ANALYSIS OF VARIANCE FOR BROILER BODY WEIGHT GAIN (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Legume	2	1761552	880776	152.48	<.001
Level	3	1930821	643607	111.42	<.001
Legume*Level	6	894537	149089	25.81	<.001
Residual	36	207947	5776		
Total	47	4794857			

Legume, level and legume by level interactions were significant (P<0.05)

APPENDIX 2.3: ANALYSIS OF VARIANCE FOR BROILER CHICK FCR (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Legume	2	4.59527	2.29763	71.34	<.001
Level	3	2.92587	0.97529	30.28	<.001
Legume*Level	6	4.40503	0.73417	22.79	<.001
Residual	36	1.15952	0.03221		
Total	47	13.0857			

Legume, level and legume by level interactions were significant ($P<0.05$)

APPENDIX 2.4: ANALYSIS OF VARIANCE FOR BROILER CHICK DRESSED WEIGHT (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Legume	2	635629.	317814.	5.43	0.009
Level	3	1117742.	372581.	6.37	0.001
Legume*Level	6	481300	80217	1.37	0.253
Residual	36	2106658.	58518.		
Total	47	4341328.			

Legume and levels were significant (P<0.05), while legume by level interactions were not significant (P>0.05)

APPENDIX 2.5: ANALYSIS OF VARIANCE FOR BROILER CHICK DRESSED WEIGHT % (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Legume	2	177.2	88.6	0.27	0.763
Level	3	457.2	152.4	0.47	0.706
Legume*Level	6	123.5	20.6	0.06	0.999
Residual	36	11700.5	325		
Total	47	12458.5			

Legume, levels and legume by level interactions were not significant (P>0.05)

APPENDIX 2.6: ANALYSIS OF VARIANCE FOR BROILER CHICK BREAST WEIGHT (%) (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Legume	2	143.92	71.96	3.18	0.053
Level	3	282.51	94.17	4.16	0.012
Legume*Level	6	69.16	11.53	0.51	0.797
Residual	36	814.03	22.61		
Total	47	1309.62			

Level was significantly different (P<0.05) while legume and legume by level interactions were not significantly different (P>0.05)

APPENDIX 2.7: ANALYSIS OF VARIANCE FOR BROILER CHICK DRUMSTICK WEIGHT (%) (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Legume	2	3.522	1.761	1.39	0.263
Level	3	4.277	1.426	1.12	0.353
Legume*Level	6	4.703	0.784	0.62	0.715
Residual	36	45.74	1.271		
Total	47	58.242			

Legume, levels and legume by level interactions were not significant (P>0.05)

APPENDIX 2.8: ANALYSIS OF VARIANCE FOR BROILER CHICK ABDOMINAL FAT WEIGHT (%) (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Legume	2	1.014	0.507	2.21	0.124
Level	3	0.6059	0.202	0.88	0.46
Legume*Level	6	0.4864	0.0811	0.35	0.903
Residual	36	8.2543	0.2293		
Total	47	10.3606			

Legume, levels and legume by level interactions were not significant (P>0.05)

APPENDIX 2.9: ANALYSIS OF VARIANCE FOR BROILER CHICK GIZZARD WEIGHT (%) (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Legume	2	0.3218	0.1609	0.67	0.519
Level	3	1.259	0.4197	1.74	0.176
Legume*Level	6	3.082	0.5137	2.13	0.073
Residual	36	8.6753	0.241		
Total	47	13.338			

Legume, levels and legume by level interactions were not significant (P>0.05)

APPENDIX 2.10: ANALYSIS OF VARIANCE FOR BROILER CHICK LIVER WEIGHT (%) (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Legume	2	0.1747	0.0874	0.15	0.861
Level	3	0.9278	0.3093	0.53	0.664
Legume*Level	6	0.8719	0.1453	0.25	0.956
Residual	36	20.9776	0.5827		
Total	47	22.9521			

Legume, levels and legume by level interactions were not significant (P>0.05)

APPENDIX 2.11: ANALYSIS OF VARIANCE FOR BROILER CHICK PANCREAS WEIGHT (%) (0-42 DAYS)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Legume	2	0.00672	0.00336	0.64	0.533
Level	3	0.03449	0.0115	2.19	0.106
Legume*Level	6	0.03335	0.00556	1.06	0.405
Residual	36	0.18902	0.00525		
Total	47	0.26358			

Legume, levels and legume by level interactions were not significant (P>0.05)

APPENDIX 2.12: COST OF FEED INGREDIENTS (KSH) AT THE TIME OF THE EXPERIMENT

Ingredient	Cost of ingredient Ksh/kg
Maize	35
Pearl millet	45
Soybean meal	70
Green gram	75
Cowpea	35
Lablab bean	80
Fishmeal	120
Meat and bone meal	30
Berger fat	250
Limestone	8
DCP	75
Vitamin mineral premix	360
Common salt	20
Methionine	650
Lysine	250