EVALUATION OF INCLUSION LEVELS OF MILLED MATURE PODS OF *Prosopis juliflora (*MATHENGE*)* IN BROILER FINISHER DIETS

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DECLARATION AND RECOMMENDATION

This thesis is my original work developed as a requirement for the partial fulfilment of Master of Science degree, in Animal Science (Nutrition option) and has not been presented before for a degree in any other university.

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RECOMMENDATION

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DEDICATION

To Waitituh Mukuna, Nyokabi, Awino, Mukunah and Wanja.

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ABSTRACT

A study was conducted at Tatton Agricultural Park (Egerton University) to determine inclusion levels and effects of milled mature pods of *Prosopis juliflora* on feed intake (FI), growth performance, feed conversion ratio (FCR), dressing % and weights of internal organs (liver, gizzard and heart) of finishing broilers. The nutrient composition of the pods was also determined. Experimental diets were formulated using milled mature Prosopis pods (MMPP) at varying levels and offered to broilers in two separate experiments (experiment 2 and 3) conducted from the 29th to 56th days. In experiment 2, 120, 29 day old broilers (Arbor Acres strain) weighing 0.82 ±0.09 kg were used in a randomized complete block design (RCBD). Each treatment had 20 broilers, offered six experimental diets T1 (0% MMPP, control), T2 (20% MMPP), T3 (40% MMPP), T4 (60%, MMPP), T5 (80% MMPP) and T6 (100 %, MMPP). In experiment 3, 80 broilers (Arbor Acres strain) 29 days old weighing 0.82 ±0.08 kg were used in a randomized complete block design (RCBD). Each treatment had 20 broilers offered four experimental diets, T1 (0% MMPP, control), T2 (10% MMPP), T3 (20% MMPP) and T4 (30% MMPP). The results showed MMPP had CP of 11.4% and gross energy of 17.489 MJ/kg feed. In experiment 2, the ADFI was higher ($P<0.05$) in T1 and T2, than the rest of the treatments. Final live body weight was higher ($P<0.05$) in T1 and T2, than the rest of the treatments. The FCR for T1-T4, were similar ($P>0.05$), but significantly different ($P<0.05$) from T5 and T6. The dressing %, liver and gizzard weights were similar ($P>0.05$), for T1-T3, but different ($P<0.05$) for T4-T6. Heart weight for T1 was different ($P<0.05$) from the other treatments. For experiment 3, the ADFI were higher ($P<0.05$) in T1and T2 than T3-T4. Final live body weights were similar ($P>0.05$) for T1-T3. FCR was similar ($P>0.05$) among the treatments. The dressing % and gizzard and proventriculus weights were similar ($P>0.05$) among all treatments. Liver weight for T1 was different ($P<0.05$) from the other treatments. Heart weights for T1 and T2 were different ($P<0.05$) from T3 and T4. Therefore it is concluded that MMPP can substitute 20 % of broiler finisher diets, without affecting (feed intake, weight gain and internal organs weights).

Key words: Mature pods of Prosopis, broiler finisher diets, feed intake, final weight

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADF	Acid Detergent Fibre
ADFI	Average daily feed intake
ASAL	Arid and Semi arid lands
BW	Body weight
C	Celsius
CBFD	Compounded Broiler Finisher diet.
CF	Crude Fibre
CGM	Corn gluten meal
CT	Condensed Tannins
DCW	Dressed Carcass Weight
DFI	Daily feed intake
DM	Dry Matter
EE	Ether Extract
FCR	Feed Conversion Ratio
FI	Feed intake
FWt	Final live body weight
GDP	Gross Domestic Product
GE	Gross Energy
IBD	Infectious Bursal disease
MDG	Millennium Development Goals.
ME	Metabolizable Energy
MJ	Mega Joules
MMPP	milled mature Prosopis pods
NCD	New Castle Disease
NDF	Neutral Detergent Fibre.
NFE	Nitrogen Free Extract
NRC	National Research council
SBM	Soybean Meal
TEP	Total Extractible Phenolics
TET	Total Extractible Tannins.

CHAPTER ONE

INTRODUCTION

1.1. Background

In most countries in Sub-Sahara Africa, agricultural development is key to the achievement of the first Millennium Development Goal (MDG) of eradicating extreme poverty and hunger. Agriculture is the economic base for the majority of the rural populations and constitutes a key economic sector (Gitau *et al.,* 2008). In Kenya, agriculture is the largest productive sector of the economy and is expected to provide the impetus in the realization of vision 2030, which is Kenya's economic development blue print for the next 20 years (RoK, 2007). It is the principal sector in the Kenyan economy accounting for about 24% of the GDP (RoK, 2007). The sector is the largest contributor of foreign exchange through export earnings and provides employment and livelihood to a majority of the population. It is estimated that 75% of the population depend on the sector either directly or indirectly (Noah and Waithaka, 2005). The sector is dynamic, it achieved an average growth of 5.2% in 2005 and 7.6% in 2007 (MoA, 2007).

Livestock sub-sector is an important part of Kenya's national economy, comprising of dairy and beef production, hides and skins, poultry, goats and sheep, fish farming, rabbit production and other emerging livestock (MoLFD, 2006). It accounts for up to 10% of the GDP (Kiptarus 2005; DGBSIR, 2009). Kenyan poultry population is estimated at 30 million birds of which 75% is indigenous, 8% layers, 14% broilers, 1% breeding stock and 2% all others not chicken (Mifugo news, 2009). Poultry produce 22,000 metric tonnes (MT) of meat and 1.3 billion eggs annually. Commercial poultry consist of hybrid layers and broilers, mainly kept at the periphery of main towns due to the availability of market for the finished products and easy sourcing of day old chicks (Kiptarus, 2005; Mifugo news, 2009).

Despite the significant contribution to the national economy and household incomes, the poultry sub-sector in Kenya experiences technical, economic and institutional challenges. Some of the main constraints to increased poultry production have been identified as; inadequate quantity and quality of feeds due to unreliable sources of raw materials and lack of proper enforcement of quality standards (RoK, 2008); poorly developed markets and unreliable market outlets, poor access to day old chicks, and poor disease control due to high veterinary costs (MoLFD, 2006; RoK, 2007; Kembe *et al.*, 2008).

The poultry industry in Kenya is vibrant, and is second largest after dairy. It is the largest consumer of livestock commercial feeds, having grown from 50% consumption of commercial livestock feeds produced in 2000 (Radull, 2000) to 60-70% in 2007 (Nyaga, 2007). The use of agricultural and agro-industrial by products in the formulation of poultry feeds results in fluctuation in quantity, quality and prices of the manufactured feeds which is a problem to small scale farmers (Ngunyen and Preston, 1997; Radull, 2000; Nyaga, 2007), because their supply depends on rainfall which is not always reliable. Consequently, there has been much interest in recent years in exploring alternative feedstuffs because of rising costs of conventional dietary ingredients. The large non-conventional feed resources from available agro-forestry trees, such as *Leucena leucocephala* (Leucena) and *Manihot esculenta* (cassava) have been explored and studied (Tewe, 1992; Chauynarong *et al.*, 2009). Recently, attention has been turned to other agro forestry trees/legumes such as *Prosopis juliflora,* which are not fully utilized due to lack of information on their nutritive value and levels of inclusion in feeds (Sawe *et al.,* 1998).

Prosopis juliflora is readily available in the arid and semi-arid lands of Kenya. It can be used as feed supplement in broiler feed manufacture, thus increased returns for households living near Prosopis forests (Piesenick *et al.,* 2006). Harvesting of Prosopis pods will contribute to the control of the weed and thereby reduce its spread in the ASAL areas (Aboud *et al.,* 2005; Choge *et al.,* 2007; Farm Africa, 2008). However the presence of anti-nutritive factors such as tannins (Abdulrazak *et al.*1999) in Prosopis could hinder the digestion and utilization of Prosopis, while the high sugar content of 13% (Choge *et al.*, 2007) and 35% (TV- South programme, 2009) could make it hygroscopic and render milling and incorporation into feeds a challenge. This study was therefore conducted to evaluate the feed intake, weight gain, FCR and internal organs weights of broiler chicken offered diets with graded levels of milled mature pods *Prosopis juliflora* during the finisher phase.

1.2 Statement of the Problem.

Poultry feeds are mainly compounded from cereals and agro-industrial by-products. These ingredients are also food for man. The competition for food between man and non-ruminant livestock impacts negatively on the quality, quantity and prices of animal feeds. These are the major constraints in the development of poultry industry in Kenya. Therefore, poultry stakeholders are in need of alternative, locally available feed resources that have little/no competition between man and livestock, are available in all seasons (dry and wet) and cost-effective. Prosopis pods have been identified as an alternative feed resource but are not being utilized in broiler feeds production because they have not been evaluated. The knowledge of their nutritive value will be useful in their utilization in formulation of commercial broiler diets. This would consequently stabilize the quality, quantity and possibly lower the prices of broiler feeds. It would on the other hand improve the profit margin from broiler production; make broiler meat more available and affordable.

1.3 Objectives

Broad objective

To determine the appropriate inclusion level of mature pods of *Prosopis juliflora* in broiler finisher diets

Specific objectives

1. To determine the nutritive composition of mature Prosopis pods from Marigat, Baringo County (Kenya).

2. To determine the effect of replacing compounded broiler finisher diet (CBFD) with graded levels of milled mature Prosopis pods (MMPP) on feed intake, final live body weight, feed conversion ratio, dressing percentage and internal organs weight of broiler chicken.

3. To determine the effect of replacing maize in the compounded broiler finisher diet (CBFD) with graded levels of MMPP on feed intake, final live body weight and feed conversion ratio, dressing percentage and internal organs weights of broiler chicken.

Hypothesis

1. There is no difference between the proximate composition of MMPP and that of CBFD.

2. Replacing CBFD with graded levels of MMPP (weight to weight) has no effect on feed intake, final live body weight, feed conversion ratio, dressing percentage, liver, gizzard and heart weights of broiler chicken.

3. Replacing maize in the compounded broiler finisher diet (CBFD) with graded levels of MMPP has no effect on feed intake, weight gain, feed conversion ratio, dressing percentage, liver, gizzard and heart weights of broiler chicken.

1.4 Justification

Cereal based broiler feeds available in the market are expensive, especially for small-scale poultry producers. This is due to the competition with human beings for the cereals. Poultry farmers therefore, need cheaper feeds to reduce production costs and increase returns. The pods of *Prosopis juliflora* are available throughout the year (wet and dry seasons) and are potential energy and protein sources in poultry feeds. The use of locally available raw materials, such as the pods of *Prosopis juliflora*, as ingredients in broiler feed formulation is expected to improve the availability of broiler feeds throughout the year, as well as reduce the feeding cost of broilers. The use of Prosopis pods is therefore expected to contribute significantly to availability of feeds for growing broilers and improve the feed conversion ratios (FCR). Higher and sustainable broiler growth arising from affordable and available feeds would result in, increased incomes to the households keeping broilers and improved national food security. In addition, the households in areas where Prosopis is available will have employment creation through the collection and sale of the pods, economic empowerment and income diversification of these communities. The evaluation of the broiler performance fed on Prosopis based diets will contribute knowledge to the use levels of Prosopis pods in commercial broiler finisher feeds.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of Kenya's Poultry Industry

Livestock production is an important part of Kenya's national economy and more so in the subsistence and semi-commercial smallholder farming systems, dominated by resource poor farm households (Lanyasunya *et al.,* 2005; IFAD, 2006). Livestock sector accounts for up to 10% of the GDP (Kiptarus, 2005; DGBSIR, 2009) and 6% of Agricultural exports (RoK, 2007) and makes over 30% of farm gate value of agricultural commodities (Kiptarus, 2005). The sector contributes 90% of employment opportunities and accounts for 95% of family incomes in the ASAL, (MoLD-Strategic Plan, 2008) which comprises 84% of Kenyan total land mass (RoK, 2007). The sector comprises of a mixture of large and small-scale farmers as well as self-help groups (Radull, 2000) keeping dairy cattle, beef cattle, poultry, goats and sheep, fish, rabbits and emerging livestock e.g. shrimps, quails and snails.

Poultry is the largest livestock species worldwide **(**FAO, 2000), providing more than 30% of all animal protein consumption (Permin & Pedersen, 2000). Poultry production is dynamic, growing from 25.8 million chicken in 2003 (Kiptarus, 2005) to 28 million birds by 2006 (MoLFD, 2006). Kenyan poultry population is estimated at 30 million (Mifugo news, 2009). Of this population, indigenous chicken comprises of 75%, exotic layers 8%, exotic broilers 14%, exotic breeding stock 1% and 2% all others birds that are not chicken (MoLFD, 2006), They produce 22,000 MT of meat and 1.3 billion eggs annually. According to Oparanya (2009), the overall poultry population in 2009 was 31.8 million, with indigenous chicken comprising 84%. There was therefore an increase in population over the years with indigenous chicken performing better than other poultry.

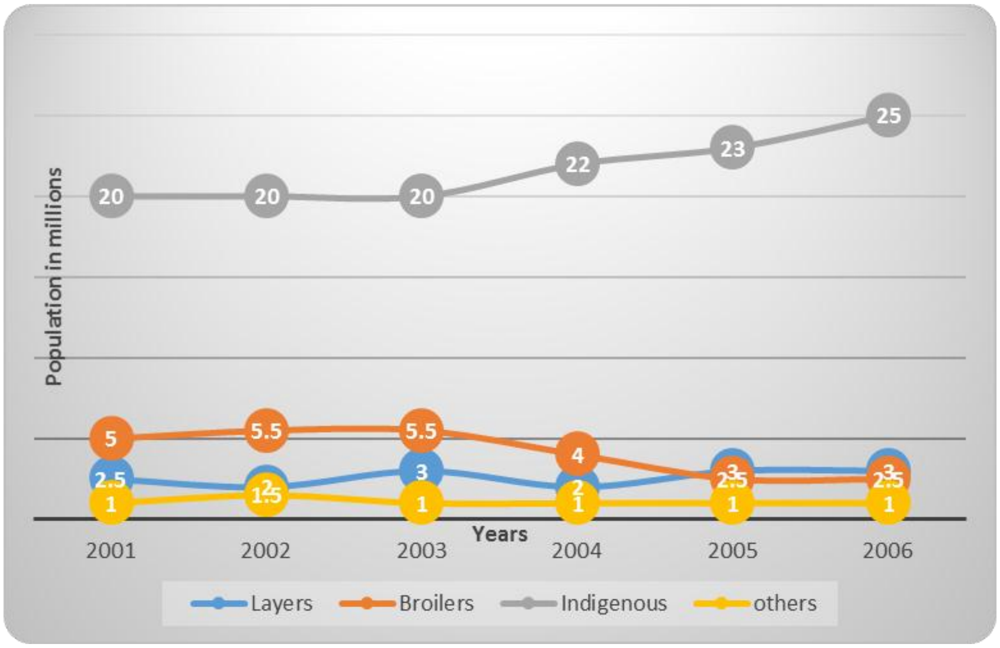

Figure 1. The population of various types of chickens in Kenya:
Source: FAO (2007)

Exotic poultry population has been dropping over the years with a rise in indigenous poultry population. Indigenous chicken production in Kenya has been on the rise due to low capital investment, availability of market and ready acquisition of the inputs (MoLFD, 2006). This could be due to the challenges facing the exotic poultry production, requirement of high capital and management skills. Most poultry producers are therefore turning to indigenous poultry production, that require less management skills and capital investment, highly flexible and less space requirement (King'ori *et al.,* 2010). The government has also been promoting commercial indigenous poultry production, to improve nutritional situation and standards of living of the rural population. King'ori *et al.* (2010) reported that eggs and chicken meat contribute to the protein nutrition of the rural population thus alleviating malnutrition. Commercial poultry consist of hybrid exotic layers and broilers in batches of 100-1000, kept at the periphery of main towns due to the availability of market for the products and easy acquisition of inputs and day old chicks (Kiptarus, 2005; MoLFD, 2006; Nyaga, 2007). Day old chicks both layers and broilers are supplied by private farms namely; Kenchick, Muguku, Kenbrid and other small hatcheries

(MoLFD, 2004). According to Nyaga (2007), the exotic breeds for egg production are: Shaver, Starcross, Isa brown and Ross; whereas breeds for broiler production are Arbor Acres, Hybro, Cobb and Hypeco. The indigenous chicken ecotypes are frizzled feathered, naked neck, barred feathered, mauve feathered, black feathered and dwarf size birds.

2.2 Poultry Production Systems in Kenya

The production systems are classified into traditional and intensive, based on scale of production, function, breed types, husbandry and productivity (Malanga, 2008). Traditional poultry production is often described as a low input/low output system (Mwalusanya *et al.*, 2002), where poultry flocks of 10-20 birds are released and left to scavenge (birds are left to look for what nature offers) around the homestead during daytime, (Duguma *et al.*, 2006; Malanga, 2008) . In addition, they may be given kitchen leftovers and other types of offal. The flock comprises of birds of different species and varying ages (Sonaiya and Swan, 2004), disease control system is almost non-existent and disease outbreaks such as NCD is quite common and can sometimes wipe out whole flock in a village (Business Daily, 2007). Intensive commercial systems on the other hand are costly, labour intensive and sophisticated in terms of housing, feeding and disease control (Sonaiya and Swan, 2004; Malanga, 2008). Nevertheless, the output is high i.e. 280 - 320 eggs per hen/year and 35 - 40 days needed to get broilers to their slaughter weight (Okitoi *et al.*, 2006). In contrast to the traditional poultry production, intensive commercial poultry industry is concentrated in few big farms with large flock sizes, and many small-scale farmers that keep an average of 500 layers or broilers (Kiptarus, 2005).

2.3 Benefits of Keeping Poultry

Apart from the contribution to the country's GDP, the sub-sector earns the country substantial foreign exchange through export of eggs, meat and day old chicks (Kiptarus, 2005). Poultry are generally reared for eggs, meat, feathers, cash generation and social-cultural practices such as offering sacrifices, entertainment and prestige (Tadelle *et al.*, 2003; Sonaiya and Swan, 2004). Other non marketed benefits of poultry are provision of manure, poultry waste for ruminant feed and asset storage or financing. Poultry play the function of insurance; farmers can sell poultry in the case of a family emergency or for education costs (Sonaiya and Swan, 2004). The benefits of poultry do not, however, stop at the farm gate. There are substantial employment opportunities in egg and meat marketing and services related to general poultry production including, provision of feeds, veterinary care and extension services (RoK, 2007).

2.4 Challenges of poultry production in Kenya

Some of the main constraints to increased poultry production in Kenya are poor management practices, inadequate quantity and quality of feeds, high veterinary costs, pests and diseases, poor infrastructure and limited extension services (Zemmelink *et al.*, 1999; Badubi *et al.,* 2004; Kiptarus 2005; MoLFD 2006; ROK 2007 and Kembe *et al.*, 2008). Poultry productivity is also constrained by, lack of organized markets, inadequate markets and marketing infrastructure, limited application of technology and access to affordable credit. Sonaiya and Swan (2004) noted that Small-scale producers are constrained by poor access to markets, goods and services; having weak institutions and lack of skills, knowledge and appropriate technologies. Adene (1996) and Chanie *et al.* (2009) reported Newcastle disease (NCD), Gumboro/Infectious Bursal disease (IBD), Mareks disease (MD), Fowl typhoid, Cholera, Mycoplasmosis and Coccidiosis as the major diseases predominant in commercial poultry in most African countries, with NCD being the most deadly (Guèye, 1999; Okitoi *et al.,* 2006). The Business daily, (2007) of Kenya reported IBD and NCD wiped out more than 80% of the indigenous chicken population in the year due to lack of proper disease control measures. Awan *et al.* (1994) also reported Newcastle disease as the major constraint to poultry production throughout the world, besides other constraints such as predation and climatic extremes. Nyaga *et al.* (1979) reported fowl pox as being common in most laying flocks in Kenya, although it might not cause deaths the loss in production in terms of reduced laying percentage and high Feed Conversion ratio (FCR) is significant. However, total confinement, maintenance and improvement of cleaning and disinfection procedures, production according to an "all in - all out" principle, and extensive prophylactic use of vaccines and drugs has reduced the significance of diseases in modern commercial poultry production.

2.5. Voluntary feed intake and feed conversion ratio in poultry

Voluntary feed intake is also termed the desired feed intake (Emmans and Fisher, 1986) and is that which will allow the potential FCR to be attained (Ferket and Garnat, 2006). The growth of an animal is at least partly determined by feed availability and intake. Fisher (1984) reported that even a slight restriction of feed intake might affect the FCR of broiler chicks adversely and therefore to improve flock feed intake, environmental and immunological stressors must be checked as they constitute the greatest feed intake regulation (Ferket and Garnat, 2006). Cheng *et al.* (1997) demonstrated that temperature affected feed intake in broilers. The optimum temperatures for broiler production is between 26-29 ^{o} C, temperatures below or above reduces feed intake and the feed consumed is used for temperature regulation, warming the body and heat dissipation. As temperatures go beyond 29^{0} C feed intake is reduced and birds control their feed intake to normalize energy intake (Leeson *et al.,* 1996) resulting in increased feed intake as dietary energy reduces (Ferket and Garnat, 2006). Animal's rate of feed intake is largely dependent on the genetic ability of the animal (Denbow, 1994; Silverstein *et al.,* 2001; and Richards, 2003). The amount of feed an animal takes is proportional to its genetic ability to grow, such that the faster growing animals have higher feed intake rate (Ferket and Garnat 2006) and therefore faster growth. Further, Ebrahimi *et al.* (2010) demonstrated that particle size and feed form affected feed intake and feed intake was highest in pelleted feed leading to high abdominal fat. High feed intake automatically leads to high energy intake which probably caused abdominal fat deposition. Also Raju *et al.* (2004) reported an increase in abdominal fat of broilers as dietary energy levels increased

Feed conversion ratio (FCR) is the ratio of the feed taken over the weight gained over a specific period. It is the amount of feed taken by the animal that actually translates to weight gain. Quality of feed in terms of protein, energy, minerals, vitamins, water and their balance, promotes voluntary feed intake which translates to a good FCR. The lower the FCR value, the better the efficiency of converting feed taken into weight. The higher the intake, the lower the ratio unless it is affected by, animal genetics, feed quality, diseases and other stressors in the animal environment that reduce weight gain. FCR remains one of the most important traits in commercial animal breeding programmes, as feed represents 60 to 70% of the cost of raising an animal to market weight (Bottje *et al.,* 2002). Animal breeders would therefore want to breed animals with the best FCR to ensure maximum profits to livestock keepers.

2.6 Energy intake in poultry

The energy intake refers to the calories that are taken in by the chicken through its feed. The amount of energy in feedstuffs is normally expressed in units of Metabolizable energy (ME) per unit weight. The ME refers to feed energy that is available to the bird for maintenance of vital functions, growth and the production of meat and eggs. Birds eat to satisfy their energy requirements (Renner, 1964; Ferket and Garnat, 2006). Therefore, increasing the concentration of energy in the diet will result in a decrease in intake, and vice versa, as long as intake is not limited by problems of bulk, texture, inaccessibility, palatability, nutrient imbalance etc. Studies done by Cheng *et al.* (1997) showed that energy is a limiting nutrient in poultry. Birds fed low ME MJ /kg feed consumed more feed and had high FCR. When slightly higher ME, than the recommendations of the NRC i.e.13.598 MJ/Kg feed, was provided to broilers, they improved skeletal muscles, feed conversion and protein utilization (Cheng *et al.,* 1997) and therefore better weight gain. Leeson *et al.* (1996) reported a decrease in carcass fat deposition as energy intake is decreased.

2.7 Protein intake in poultry

In contrast to energy, feeding higher levels of CP, more than the NRC recommendations does not compensate for lower ME provision (Cheng *et al.,* 1997) leading to poor FCR. Instead, the excess protein is broken down to provide energy and in the process producing uric acid. Lopez and Leeson (1994) and Junqueira *et al.* (2006), found that provision of high crude protein 20% to older broiler breeders and molted laying birds didn't improve general performance and fertility of the eggs. According to Tamin *et al.* (1999) high protein diets, up to 25.1% CP could limit adverse effects of high ambient temperatures of up to 32^{o}C, but the effect was low and modifying dietary protein supply didn't help broilers withstand hot conditions. Tamin *et al.* (2000) further confirmed that though increasing dietary protein to 28-33% improved broiler performance and carcass characteristics; the effect was low as compared to the benefits. Therefore increasing the CP levels is not only expensive but also the return is not equivalent to the increase in performance. Walsh and Brake, (1997) and Hudson *et al.* (2000) also suggested that the recommended CP level by the NRC is important for breeder broilers during rearing to improve egg production and reduce floor eggs as the fertility of broilers is affected by genetics of the chicken and CP content of the feed. Provision of optimum level of protein and balance of amino acids and energy as recommended by the NRC is therefore important for proper development of poultry during growth, throughout rearing and production.

2.8 Nutrient requirement of growing broiler chicken 0-8 weeks

Animal performance is majorly influenced by genotype and nutrition. Available feed nutrients support animals' maintenance, growth, production and reproductive requirements. Growing broiler nutrient requirement is partitioned for maintenance and growth. Maintenance is considered the most important. When there is scarcity of nutrients, partitioning of nutrients is such that the limited nutrients are directed to maintenance to allow for animal survival, leading to retarded growth. Growing animals, especially broilers, therefore have to be given enough nutrients for maintenance and growth to prevent retarded growth. The recommended nutrient content of diets for growing broilers ensures maximum utilization at various stages of growth. The nutrients needed for maintenance and growth takes into account the desired body weight and FCR. According to NRC (1984), the weekly nutrient requirement for growing broilers changes daily due to daily changes in body weights as shown in Table 1.

Table 1. Weekly Nutrient Requirement for growing broiler chicken from 0-8 weeks

	0-3 weeks	4-6 weeks	7-8 weeks
Energy base ME MJ/Kg feed	13.388	13.388	13.388
Protein %	23	20	18
Body Weight (grammes)	40-540	541-1500	1501-2300
Feed consumption (grammes)	0-320	321-840	841-1100
Cumulative average feed consumption by 8 weeks			5000 g

Source: NRC, 1984

2.9 Overview of *Prosopis juliflora* in Kenya

2.9.1 Agro-forestry trees

Agro-forestry practices are crucial for improvement of livelihoods and sustainable management of natural resources and the environment in East African region. They play an important role in sustainable agriculture considering the fact that the region encompasses ten of the world's poorest countries. High value tree crops support rural economies and health of people by providing income opportunities, food and nutritional security and help in conservation of the environment. They could also provide leafy fodder and pods for livestock feed (Sawe *et al.*, 1998; Paterson *et al.*, 1998; Abdulrazak *et al.*, 1999) as the nutritional value especially for protein is high (16-25)% with high digestibility (Paterson *et al.*, 1998). They provide fodder throughout all seasons, especially during the dry season (Anttila, 1993). Agro- forestry trees also provide fuel wood and erosion protection for denuded areas (Aboud *et al.*, 2005).

2.9.2 Forages and Legumes and Anti-nutritive Factors

Gutteridge and Shelton (1994) reported that various anti- nutritive factors present in forage legumes reduce bio-availability of the present nutrients to livestock, especially non ruminants. These factors are, among others; tannins, mimosine, coumarin and trypsin inhibiting factor. Analysis of *Prosopis juliflora* pods and leaves by Abdulrazak *et al.* (1999) showed condensed tannins rather than total extractable Phenolics have a depressive effect on gas production, which could be due to inability of rumen micro-organisms to attach to condensed tannins for degradation and recommended further research for incorporation of tree leaves in livestock feeds. However, Makkar (2003) found that tannins have beneficial properties in livestock feeding and up to 4% in the diet promotes rumen bypass thus allowing high quality protein to be digested in the small intestines. Studies by Ambula *et al.* (2003) showed that feeding laying birds' sorghum with high level tannin did not affect their performance, while Barry *et al.* (1986) and Naurato *et al.* (1999) demonstrated that a group of peptides present in human and monkey saliva acts as defence against dietary tannins, suggesting that poultry may also have such peptides.

Table 2. Nutrient composition of various Agro-forestry /legume trees

	%DM	%CP	%NDF	%ADF	%Ash	%EE	%TEP	%TET	Source
Sesbania sesban	90	22.73	25.78	23.74	6.17	1.70	2.35	0.60	Wambui *et al.*, 2006
Calliandra calothyrsus	92	18.88	30.78	21.49	5.29	4.70	5.23	3.85	Wambui *et al.*, 2006
Acacia nilotica	91.8	13.5	22.7	20.7	3.5	1.7	-	-	Sawe *et al.*, 1998
Leucena leucocephala	-	19.72	38.64	34.4	5.92	-	-	-	Walker 2012
Gliricidia sepium	43.3	24.6	45.8	24.5	16.45	3.55	-	-	Foroughbakhc *et al.*, 2012

TEP-= Total extractable Phenolics; TET= Total extractible tannins

2.9.3 Prosopis juliflora in Kenya

Prosopis juliflora is an invasive plant species, introduced deliberately or accidentally to different parts of the world and can cause important economic, environmental and social losses (Anderson, 2005). It was introduced to eastern Africa in the 1970s through collaborative projects involving local governments and outside agencies (Aboud *et al.*, 2005). It is a moderately sized tree or shrub-like in some situations and has root nodules that can absorb nitrogen from the atmosphere, and thus the species may supplement soil fertility in some instances (Bhojvaid and Timmer, 1998; Aboud *et al.,* 2005). Figure 2 shows the distribution of *Prosopis Juliflora* in Kenya. Prosopis tree, commonly known as ‘mathenge’ in Kenya, is widely distributed in semi-arid and arid counties of Baringo, Tana River, Garissa and Mandera. Prosopis species grow in array of environments and are not restricted by soil type, pH, salinity or fertility and are therefore used in the rehabilitation of deserts and saline lands, for shelter belts and sand dune stabilization (Anderson, 2005).

2.9.4 Negative attributes of Prosopis

Studies have shown that Prosopis is an invasive plant species and can directly or indirectly affect the food security of local residents. In areas where it spreads, it can destroy natural pasture, displace native trees, and reduce grazing potential of rangelands (Admasu, 2008). They compete for and reduce productivity of croplands. The invasion of Prosopis has caused considerable decline in livestock production and productivity due to the loss of dry season grazing areas to Prosopis plants. Palatable indigenous pasture species have all reduced (Mwangi and Swallow 2005; Admasu, 2008). Mwangi and Swallow (2005) reported facial contortions, rumen compaction and constipation in livestock, disfiguration of livestock gums and tooth decay, possibly due to high sugar content. These problems can be reduced by proper processing and incorporation of Prosopis pods in livestock feeds at levels optimum for production.

2.9.5 Benefits and Uses of Prosopis

Prosopis can be used as firewood, charcoal, building materials, floor tiles, furniture, and handicrafts. Other uses involving non-wood products include processing as feed for livestock (Anttila *et al.,* 1993; Farm Africa 2008; Admasu, 2008). Increase in milk production and lower FCRs of animals fed Prosopis pods have been reported (Mahgoub *et al.,* 2005), with the use of up to 20% inclusion being beneficial in goats. It is also used as human food; beverage and processed food (Mwangi and Swallow, 2005; Choge *et al.,* 2007), possible medicinal values, gum production, tannin extraction (Aboud *et al*., 2005; Perera *et al.*, 2005), and wind breaks of Agricultural crops (Mwangi and Swallow, 2005)

Aboud *et al*. (2005), Perera *et al.* (2005) and Choge *et al.* (2007) found that complete eradication of established Prosopis is virtually impossible; therefore better ways of utilizing and managing Prosopis will control its spread. This includes promotion of how *Prosopis juliflora* products could be best harvested and used. In other developing countries economic value has been added to some types of Prosopis products, and this involves comprehensive efforts incorporating product certification and marketing (Farm Africa, 2008, Admasu, 2008). King'ori *et al.* (2011) in a review suggested that appropriate technologies and management strategies are necessary for sustainable utilization of Prosopis in Kenya.

2.9.6 Nutritional value of Prosopis pods and leaves

Chemical analysis of Prosopis pods showed that they are high in sugars, carbohydrates and protein (Anttila *et al.*, 1993). They have CP content of 16.2 %, CF 22%, EE 3.4%, Ash 4.5% and NFE 54.1%. Pods from the species of Algarobia genus, which includes common weedy species in Africa, contain 7- 22% protein but the fruits of *P. juliflora* contain 15.95 % CP, 30 - 75% carbohydrates, 11-35% crude fibre, 1 - 6% fat and 3 - 6% ash. The variation is dependent on season and the environment (Oduol *et al.,* 1986). Talpada, (1985) showed that nearly all the essential amino acids are present, with higher content of polyunsaturated fatty acids at 1.06g/100g DM as compared to saturated at 0.56g/100g DM (Choge *et al.*, 2007). Analysis by Choge *et al.* (2007) found the Kenyan Prosopis (Baringo type) with 16.2% CP which was comparable to the findings by Abdulrazak *et al.*, (1999), total sugars 13%, carbohydrate 69%, energy value 15.3 MJ/Kg sample, CF 47.8%, fat 2.12 % and ash 6%. Table 3 and 4 show chemical composition of various species of Prosopis the world over.

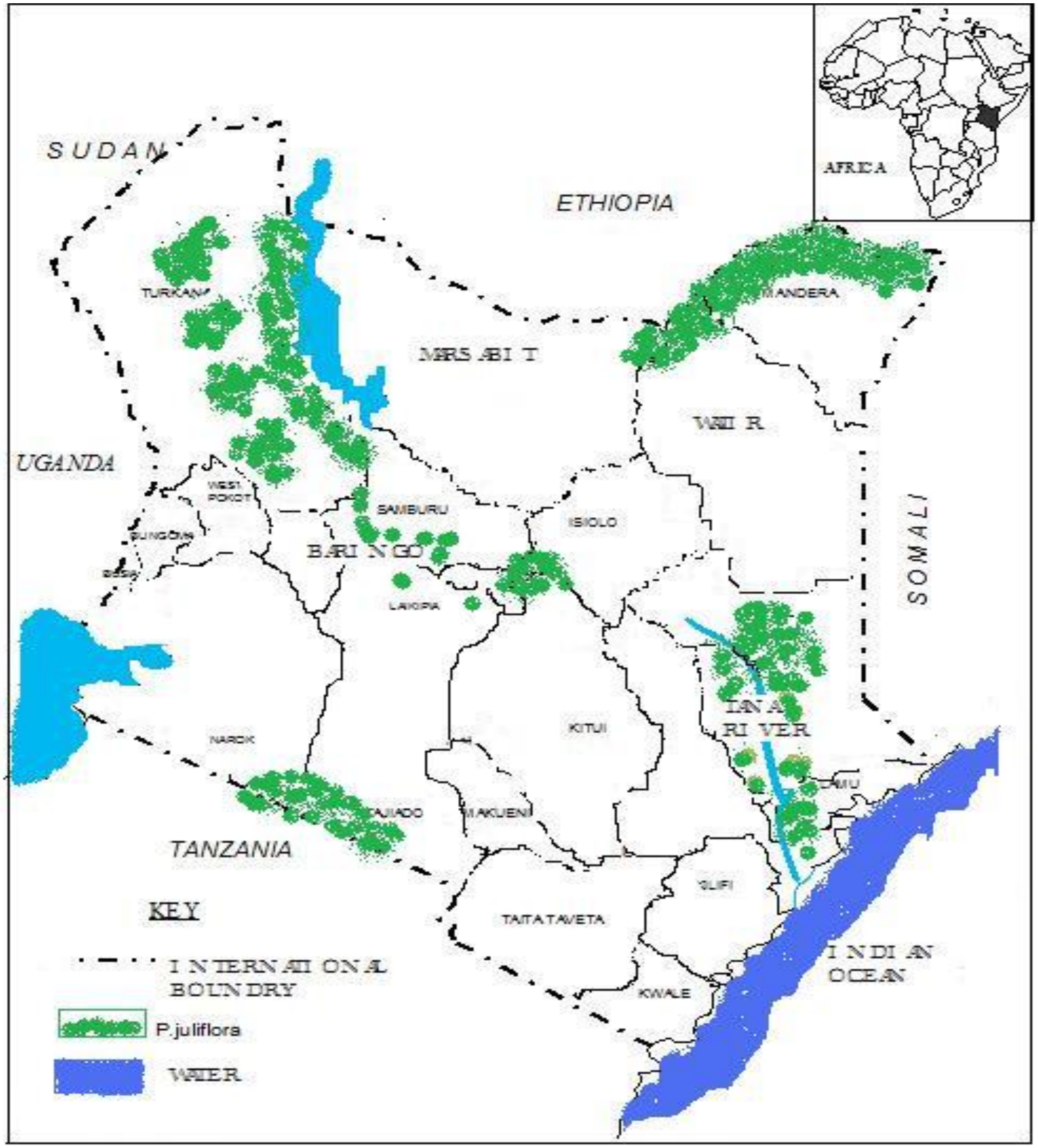

Figure 2. Distribution of *P. juliflora* in Kenya

Source: Sirmah (2009)

Table 3. Chemical composition of Prosopis leaves and pods.

Plant part	%DM	%CP	%CF	%NDF	%ADF	%Fat	%Ash	Source
Leaves of P. chilensis	95.2	32.2	18.5	-	-	4.1	12.6	Omer and Sakina., 2011
Pods of P. chilensis	93.9	12.5	27.5	-	-	2.5	4.9	Omer and Sakina., 2011
Pods of P. juliflora	-	16.3		44.8	36.2	-	-	Abdulrazak *et al.*, 1999
Pods (flour) of P. juliflora	93.6	16.2	47.8	-	-	-	6.0	Choge *et al.*, 2007
Raw seed meal of P. africana	96.1	22.6	6.9	-	-	-	4.0	Yusuf *et al.*, 2008
Decorticated fermented seed meal of P. africana	94.3	42.5	4.9	-	-	-	8.1	Yusuf *et al.*, 2008
Leaves of P. juliflora	-	18.5	-	27.1	18.2	-	-	Abdulrazak *et al.*, 1999
Pods of P. julifora	-	12.5	25	-	-	2-3	-	Del valle *et al.*, 1983
Kernels of P. juliflora	-	38	9	-	-	3	-	Del valle *et al.*, 1983

Table 4: Phenolics and tannin composition of Kenyan *Prosopis juliflora* leaves and pods

Plant part	TEPmg/ gDM	TETmg/ gDM	CTmg/ gDM
Pods	37.6	25.5	1.2
Leaves	16.2	13.3	15.4

TEP = Total extractable phenolics; TET = Total extractible tannins; CT = Condensed tannins.
Source: Abdulrazak *et al.* (1999)

2.9.7 Limitations of use of *Prosopis juliflora* pods as broiler feed

Abdulrazak *et al.* (1999) reported condensed tannins to have a depressive effect on gas production. This could be due to decrease in degradability, hence reduced bio-availability of the nutrients present in Prosopis. In practical poultry nutrition, hydrolysable tannins are easily absorbed through the intestinal walls and can therefore cause actual damage to the internal organs as compared to the condensed tannins, which are not absorbed. However, Bhatta *et al.* (2005) found that effects of tannins in Prosopis can be reduced by treatment with poly-ethylene glycol (PEG) to improve performance in kids. Yusuf *et al.* (2008) and Mahgoub *et al.* (2005) suggested 20% inclusion level for broilers and goats as optimum for not affecting and improvement in performance respectively. Choge *et al*. (2007) reported high sugar content, up to 13%, that could render it hygroscopic making milling and incorporation into the feed a challenge. However, this property could improve the pelleting qualities and reduce dustiness of feed preparation with Prosopis.

CHAPTER THREE

NUTRIENT COMPOSITION OF *Prosopis juliflora* PODS FROM BARINGO COUNTY, KENYA

3.1 Materials and Methods

3.1.1 Preparation of Dry Mature Pods of Prosopis

Prosopis juliflora dry mature pods were obtained from Marigat Sub County in Baringo County. Marigat is located at latitude 0^0 20’N and longitude 35^0 57’E Kenya (FAO, 1992). It is about 1500m above sea level with a mean annual rainfall of 600-800mm with weak bimodal peaks recorded from March- May and June-August. Soils are mainly clay loams with alluvial deposits derived from tertiary / quaternary volcanic and pyroclastic rock sediments that have been weathered and eroded from the uplands. They contain high levels of P, K, Ca and Mg and low levels of N and C. They range from acidic to slightly alkaline (Mwangi and Swallow 2005).The pods were collected from the ground after the trees were shaken for the pods to drop. Spoilt and mouldy pods were discarded and clean pods were put in gunny bags and transported to Kays Premium Feeds in Nakuru town where they were milled to pass through a 5mm sieve according to the procedure by (Choge *et al.*, 2006). The milled mature Prosopis pods (MMPP) were then used in the formulation of the experimental diets fed at different inclusion levels in the feeding trials (see Chapter 4 and 5).

3.1.2 Study Site

The study was conducted at Animal Science Laboratories, Egerton University. Egerton is located at latitude 0º 23’S and longitude 35º 57’E, 2,238m above sea level, with mean daily temperature of 21ºC. There is bimodal rainfall pattern (March to May and June to September) with a mean annual rainfall of 900 - 1,020mm. The study was conducted in May 2011. The mean room temperature was 20-25 º C

3.1.3 Proximate analysis

The Proximate composition [dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE) and ash)] of *Prosopis juliflora* pods were determined using the standard procedures of the Association of Official Analytical Chemists (AOAC, 1990). Neutral detergent fibre (NDF) and Acid detergent fibre (ADF) were done according to Van Soest *et al.* (1991). Gross energy (GE) was determined using e2K combustion calorimeter (www.cal2k.com, South Africa). Total extractable tannins (TEP) were determined as described by Abdulrazak and Fujihara (1999). Sample was prepared and sent to Novus laboratories in the United States for Amino acid profile, Metabolizable energy and mineral determination using the standard procedures of the Association of Official Analytical Chemists (AOAC, 2006).

3.1.4 Data analysis

Data obtained from proximate analysis in duplicates were summarized in excel spreadsheet and descriptive statistics done.

3.2. Results

3.2.1. Nutrient composition

The results of the proximate analysis are given in Tables 5, 6 and 7.

Table 5. Mineral composition of mature pods of *Prosopis juliflora* from Marigat in Baringo County, Kenya

Mineral	Mg/g of DM in pods
Ca	2.43
P	1.35
K	17.82
Na	0.10
Mg	0.81

Ca = calcium; P = Phosphorus; K = Potassium; Na = Sodium; Mg = Magnesium.

Table 6. Amino acid profile, Metabolizable Energy and polyphenols of mature pods of *Prosopis juliflora* from Marigat in Baringo County, Kenya

Parameter	Mg/g DM in Pods
Essential AA	
Lysine	3.6
Methionine	10
Leucine	6.2
Isoleucine	3.0
Cystine	1.0
Phenylanine	2.7
Tyrosine	0.22
Threonine	0.32
Tryptophan	0.72
Valine	5.0
Non Essential AA	
Alanine	3.3
Arginine	4.7
Glycine	3.42
Histidine	1.62
Proline	9.72
Serine	2.34
Polyphenols	5.31
ME MJ/Kg sample	12.791

AA = Amino acids; ME = Metabolizable energy

Table 7. Nutrient composition and Gross energy value of mature pods *Prosopis juliflora* from Marigat in Baringo County, Kenya

Nutrient	%DM
DM	90.3
CP	11.4
CF	17.7
EE	2.8
Ash	2.7
NDF	25.3
ADF	15.4
GE	17.489

DM = dry matte; CP = crude protein; CF = crude fibre; EE = ether extract; NDF = neutral detergent fibre; ADF = acid detergent fibre; GE = Gross energy/MJ Kg feed.

3.3 Discussion

Total nutrients in a feed (carbohydrates, proteins and fats) are expressed as organic matter and yields gross energy. When they are readily digestible, they are called digestible nutrients. These nutrients can only be useful to the animal when they are available for digestion and assimilation into the animal's body for production, growth and reproduction. Therefore, for an animal to benefit from feeds taken, feed factors that prevent intake, digestion and assimilation should be minimal. The Gross energy content of MMPP was 17.489MJ/Kg sample, which was higher than 15.3MJ/Kg sample reported by Choge *et al.,* (2007). According to NRC (1984), the ME content of maize at 13.8 MJ/Kg is slightly higher than MMPP of 12.8 MJ/Kg but higher than most cereal based milling by-products (Maize germ and wheat bran) of about 11 MJ/Kg DM. MMPP can possibly be used as energy source in poultry feed.

The DM content of MMPP in this study of 90.3% was lower than values reported in literature by Choge *et al*. (2007) and Omer and Sakina (2011) of 93.6% and 93.9%, respectively. However Koech *et al.* (2010) and Girma *et al.* (2011) reported lower values of 88.4% and 89.15% respectively. This difference could be due to harvesting stage/degree of maturity and season which determines the DM content in the pod of Prosopis plant. Ribaski (2012) reported that silvopastural practices such as weeding, grazing and more spacing between plants affects the DM content of Prosopis plants, leading to higher total DM production. These factors could have possibly affected the DM content of MMPP because the pods were harvested in areas where there was no control and management. There was therefore no organized spacing.

The 11.4% CP of MMPP (Table 1) was much lower than those in earlier studies by Abdulrazak *et al*. (1999), Choge *et al*. (2007), Koech *et al.* (2010) and Girma *et al.* (2011) of 16.3%, 16.2%, 18.5% and 15.43 %, respectively. The high values reported by the above researchers could have been due to different silvopastural practises which affected the total DM production and CP content of the pods (Ribaski, 2012). The CP content in MMPP was lower than the requirement for broilers (Table 1). The use of MMPP as a feed ingredient for broiler is therefore possible only with supplementation of protein sources as it is composed mainly of carbohydrate, 69% (Choge *et al*., 2007). The CP content of maize is (8-12) % (NRC 1984) which is low compared to 11.4% of MMPP. The CP content of other cereal based milling by-product e.g maize germ and wheat bran is about 15% (NRC 1984), which is still lower than CP requirements for broilers (Table 1). The CP content of oil seed milling by products and fish meals is above 40%. Supplementation with oil seed milling by- products and fish meal is therefore recommended to improve the CP content of broiler feeds with MMPP.

In this study, the ether extract (EE) of 2.8% for MMPP was at variance with results of Girma *et al.* (2011) who recorded 6.1%, but similar to the results by Del Valle *et al.* (1983) and Omer and Sakina (2011) who reported 2-3% and 2.5%, respectively. Choge *et al.* (2007) reported a lower EE of 2.18%, which could explain their low value of gross energy (15.300 MJ/Kg) compared to the value of 17.489 MJ/Kg in this study. Choge *et al.* (2007) reported a higher figure of CP, which could have translated to low levels of EE. Oduol *et al.* (1986) reported that season affected the proximate composition of Prosopis pods. Harvesting time and season possibly influenced the EE content and therefore altered proximate composition of MMPP. According to Choge *et al.* (2007), polyunsaturated fatty acid content of MMPP was 1.06g/100g DM as compared to saturated at 0.56g/100g DM. Improvement of meat quality is a function of animal nutrition, food science and human nutrition (Pisulewski, 2005). Unsaturated fatty acids undergo oxidation on exposure to oxygen (Wood *et al.,* 2002) in animal feed or animal products leading to rancidity in feeds and poor shelf life and colour change in meats (Wood *et al.,* 2002). Linoleic acid is derived entirely from the diet (Wood *et al.*, 2008). It passes through the pig's stomach unchanged and is then absorbed into the blood stream in the small intestine and incorporated from there into tissues. Linoleic acid which forms major component of unsaturated fatty acids in MMPP (Choge *et al.,* 2007), will therefore be present in the carcass which will lead to poor keeping quality. However rancidity effect in feeds and poultry products in MMPP compounded broiler diets can be minimised by use of vitamin E and antioxidants as Ethoxyquin, when feed is stored for at most 30 days in sealed containers away from light (Khan *et al.,* 2001).

The 17.7% CF is within the range of 16.9-18.99 % reported by other researchers like Rao and Reddy (1983), Talpada and Shukla, (1988) and Reddy *et al.* (1990). These values are, however, higher than the 14.6% reported by Girma *et al.* (2011). The high CF values will limit the level of inclusion into poultry diets, with total CF content of the diets below 5%. However for higher inclusion, xylam and phytase enzymes could reduce the effects of high fibre, improve performance of broilers and reduce feed cost (Mariam *et al.,* 2013). Yusuf *et al.* (2008) reported improvement in nutritional value and reduction in the ant nutritional contents of decorticated fermented Prosopis seed meal on fermentation. Fermentation possibly reduced the effect of anti-nutrients in Prosopis. Treatment of MMPP through fermentation and / or incorporation of enzymes in feeds compounded with MMPP is necessary for maximum utilization of the pods. The NDF content of 25.3% MMPP was closer to values reported by Andrade-Montemayor *et al.* (2009) of 26.45% but lower than 29.8% and 29.0% reported by Batista *et al.* (2002) and Ahmed *et al.* (2012) respectively. The ADF content of 15.4% for MMPP was slightly lower than values of 16.19% and 17.2% reported by Andrade-Montemayor *et al.* (2009) and Batista *et al.* (2002), respectively. The major fractions of CF are NDF and ADF (Andrade-Montemayor *et al.,* 2009), their high values will limit utilization and inclusion of MMPP into broiler feeds.

The calcium content of 2.43mg/g DM for MMPP was similar to 2.31mg/g DM reported by Girma *et al.* (2011) but lower than values reported by Koech *et al.* (2010) and Abdulrazak *et al.*

(1999) of 5.2mg/g DM and 5.1mg/g DM respectively. The Phosphorus content of 1.35mg/g DM, for MMPP was comparable to 1.36mg/g DM, reported by Abdulrazak *et al.* (1999) but lower than 1.78mg/g DM and 2.64mg/g DM reported by Girma *et al.* (2011) and Koech *et al.* (2010) respectively. The Sodium content of 0.11mg/g DM for MMPP was lower than 0.19mg/g DM reported by Choge *et al.* (2007). According to NRC, (1994), calcium requirement for finishing broilers is 0.9% in the diet with a Ca: P ratio of (1.5-2): 1. However studies by Driver *et al.* (2005) indicate values 0f 0.625% to be optimum. Further Angel, (2013) in a review reported that calcium and phosphorus availability should be measured as digestible not total calcium or phosphorus and suggested that effects of calcium source on availability of phosphorus and vice versa should be known when feeds are compounded. Calcium and phosphorus in MMPP is inadequate in compounding broiler diets, therefore readily available sources of digestible calcium as Dicalcium phosphate (DCP) should be used in formulation of such diets.

The MMPP had TEP value of 80mg/g DM which was higher than 35.5g/Kg DM reported by Abdulrazak *et al.* (1999). Hughes, (2011) reported condensed tannin value of 1% in poultry diets to have no adverse effects on broiler performance. However Qiyu, and Guanghai, (2012) reported maximum total tannin value of 0.64 %. The total tannins present in feed formulations with MMPP should therefore contain a maximum of 1% active ingredient of tannins. According to Kyarisiima *et al.* (2004) there was improvement in nutritional value of high tannin sorghum and improvement of performance of broilers fed high tannin sorghum treated with wood ash extracts as compared to untreated high tannin sorghum. Treatment of MMPP could possibly reduce the tannins content and therefore digestibility of broiler diets with MMPP formulations.

According to NRC (1994), the first and second limiting amino acid in poultry in grain based diets are methionine and lysine, respectively. Broiler requirement for methionine and lysine during the finishing phase is 0.35% and 1.0% respectively. However, Dozier *et al.* (2008), reported that as broilers are bred for faster growth, so does their requirement for CP and amino acids especially methionine, which increases to 0.65%. In this study the methionine and lysine content of the MMPP was 0.1% and 0.4%, respectively. It is therefore necessary to incorporate methionine and lysine when using Prosopis pods in formulating broiler finisher diets.

3.4. Conclusion

Milled mature pods had high ME value, though low compared to maize but higher than other cereals and milling by products. It could therefore be used as a broiler feed ingredient. However the CF and tannin content was high, which can interfere with feed intake and digestion in poultry. Treatment could possibly reduce the effects of high TEP and fibre content and improve broiler performance. CP content is lower than broiler requirement (Table 1) during the finishing phase, it is therefore important to incorporate high protein feed ingredient especially of animal origin as they have good quantities of the essential amino acids. Minerals like Calcium and Phosphorus must be incorporated as their content in MMPP are inadequate for finishing broilers

CHAPTER FOUR

PERFORMANCE OF BROILER CHICKEN FED ON FINISHER DIETS PARTIALLY OR WHOLLY REPLACED WITH MILLED MATURE *Prosopis juliflora* PODS

4.1 Introduction

The supply of adequate, good quality and cost effective poultry feeds has been a major challenge in tropical countries, including Kenya (Radull, 2000). This has been due to reliance on agro-industrial by products as poultry feed ingredients whose availability is dependent on rainfall. Consequently, there has been interest in recent years to explore non-conventional feed ingredients. There exists diverse non-conventional feed resources, such as products from trees, which are not effectively utilized due to lack of information on their nutritive values which is useful in determining their inclusion levels (Sawe *et al.*, 1998).

Attempts to increase poultry production therefore, need to focus on the use of non-conventional poultry feed ingredients such as pods, which will reduce feed costs and ensure constant supply of good quality feeds throughout the year. *Prosopis juliflora,* commonly known as 'Mathenge' in Kenya, is widely available in the arid and semi-arid lands of Kenya (Fig. 2). Prosopis species grow in array of environments and are not restricted by soil type, pH, salinity or fertility and are therefore used in the rehabilitation of deserts, saline lands and shelter belts, and sand dune stabilization (Anderson, 2005). The pods of Prosopis can potentially be used in formulation of poultry feeds, such as broiler diets, thus providing income for households living near Prosopis forests (Piesenick *et al.,* 2006). In Nigeria and Ethiopia, use of Prosopis pods reduced feed costs without compromising broiler performance and quality of the meat (Yusuf *et al.* 2008; Girma *et al.* 2011)). In Kenya similar benefits are anticipated from the use of Prosopis pods. Therefore, the aim of this experiment was to determine the performance of broiler chicken offered finisher diets partially or wholly replaced with MMPP.

4.2 Materials and Methods

4.2.1 Study site

The study was conducted in the Poultry Research Unit, Tatton Agricultural Park, Egerton University. The Park is located at latitude 0º 23'S and longitude 35º 57'E, 2,238m above sea level, with mean daily temperature of 21°C. There is bimodal rainfall pattern (March to May and June to September) with a mean annual rainfall of 900 - 1,020mm. The study was conducted between May and June 2011. The mean room temperature was 20-25 ° C

4.2.2 Animals and housing

One hundred and fifty day old broilers (Arbor Acres strain) of mixed sexes were bought from Kenchic Ltd. They were brooded together in Nakuru East Su County using a charcoal stove for three weeks. They were offered commercial broiler starter feed during the starter period. Amintotal®, a multi vitamin was administered in clean water from day 1-5. Vaccinations were done at day old (hatchery), 10th, 14th, 21st and 26th day for Mareks, NCD, IBD/ Gumboro, IBD/ Gumboro and NCD respectively. On the 27th day they were transported to Tatton Agricultural Park, Egerton University and offered the control diet (Table 8). On day 29, one hundred and twenty broilers, 60 cockerels and 60 pullets with an initial weight of 0.82 ±0.09 Kgs were selected for the study. There were 20 broilers per treatment with each treatment having 10 birds. On the seventh week, an anthelminthic, (Ascarex®) was administered in drinking water for one day followed by an antibiotic/ coccidiostat (amidiostat®) combined with multivitamin (Amintotal®) for 5 days. The chicks were housed in pens (ten chicks per pen) measuring about 5M^2, that were well ventilated and lighting provided 24 hours. The pens were initially cleaned with liquid soap, disinfected using (omnicide®) and about 10cm thick of wood shavings put as bedding.

4.2.3 Dietary treatments

Mature pods of *Prosopis juliflora* obtained from Marigat Sub County in Baringo County, (Kenya) was used in the study. Marigat is located at latitude 0^0 23'N longitude 35^0 59'E and is about 1500m above sea level with a mean annual rainfall of 600-800mm. The pods were collected from the ground after the trees were shaken and spoilt and mouldy pods were discarded. The pods were put in gunny bags and transported to Kays Premium feeds (Nakuru). Milling of whole pod was done according to the procedure described by Choge *et al.* (2006) and flour passed through a 5mm sieve. The MMPP were then used in formulation of the experimental diets after analysis (Table 9).

The dietary treatments offered to the broilers are shown in Tables 8 and 9. Table 8 presents the compounded broiler finisher diet used as the control diet while Table 9 presents the six experimental diets used in the different treatments of the study.

Table 8. Composition of the compounded broiler finisher diet (CBFD) T1

Ingredient	% in diet
Maize	35
Maize Germ	30
C.G.meal	13
Fish meal	10
CSC	10
DCP	1.25
Iodized salt	0.25
Vit premix	0.5
Totals	100
Calculated CP (%)	22.38
Calculated ME (MJ/kg)	13.706
Calculated CF (%)	2.73

C.G.meal = Corn gluten meal; DCP = Dicalcium phosphate; CF = crude fibre; CP = Crude protein; ME = Metabolizable energy MJ/Kg feed; CSC = Cotton seed cake; Vitamin premix provided the following per kg of diet: Vit. A = 10,000 IU; Vit. D = 2000 IU; Vit. E = 5mg; Vit.K = 2mg; Riboflavin = 4.20mg; Nicotinic acid = 20mg; Vit. B = 0.01mg; Pantothenic acid = 5mg; Folic acid = 0.5mg; Choline = 3mg; Mg = 56mg; Fe = 20mg; Cu = 10mg; Zn = 50mg; Co = 125mg and Iodine = 0.08mg

Table 9. Composition of the six experimental diets based on MMPP inclusion

Treatment/ diets	% MMPP	% CBFD (Control) diet
T1(Control)	0	100
T2	20	80
T3	40	60
T4	60	40
T5	80	20
T6	100	0

MMPP = Milled Mature Prosopis Pods; (CBFD) = Compounded broiler finisher diet (Control) (Table 8)

4.2.4 Nutrient Composition

Analysis of the nutrient composition of the experimental diets was done as described in Chapter 3 (see Section 3.2.2).

4.2.5 Experimental Procedure and Design

A feeding trial was carried out using one hundred and twenty, 29 day old Arbor Acres broilers in a randomized complete block design (RCBD). The broilers were randomly allocated the 6 diets with 2 replicates (10 birds/ replicate) per treatment. Blocking was done based on sex. Each experimental unit had 10 birds with similar body weights. The dietary treatments were offered *ad libitum* by giving a weighed amount of the respective diets (Table 9) once a day at 0900 hours. Voluntary feed intake was estimated as the difference between the amount of each diet offered and that left on daily basis. Weight gain of the broilers was monitored by weighing them weekly at 0900 hours before morning feeding. Feed Conversion ratio was calculated as feed intake divided by weight gain over the 28 days experimental period.

At the end of the experiment, on their 56th day, three birds per pen with body weight similar to average pen weight were selected and kept overnight (12 hours) in pens with drinking water only. They were weighed the next day, slaughtered by cutting individual bird's neck. Feathers were removed manually using heated water at about (60-70) ^{o} C. The neck, head, heart, gizzard plus proventriculus and liver were removed. The liver, heart and gizzard plus proventriculus were each weighed separately and the carcass dressing percentage calculated as weight of dressed carcass divided by the weight of live bird expressed as a percentage.

4. 2. 6 Data analysis and Statistical models

Statistical Analysis

Data from the experiment was subjected to Analysis of Variance (ANOVA) using the general linear model (GLM) of SAS software (Statistical Analysis Systems 2002) with the model containing treatment effect on the parameters measured. Differences between treatment means were separated using Tukey's Range Procedure (HSD).

Average daily feed intake

The following statistical model: $\mathbf{Y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}}$ was adapted,

Where; Y_{ij} = Feed intake (g day^{-1}); μ= is the overall mean;

α_i = is effect of the treatment diet (i = 1…6); β_j= effect of jth sex, (j=1,2);

ε_{ij} = is the error term associated with the observation.

Final live body weight

The following statistical model: $\mathbf{Y_{ij} = \mu + \alpha_i + \beta_j + \beta (X_{ij} - X) + \varepsilon_{ij}}$ was adapted,

Where; Y_{ij} = Final live body weight (Kg); μ= is the overall mean;

α_i = is effect of the treatment diet (i = 1…6); β_j= effect of jth sex, (j=1,2);

β= Regression coefficient of Y_{ij} on X_{ij} (Initial body weight);

X_{ij} = Measurement of covariate corresponding to Yij.

ε_{ij} = is the error term associated with the observation.

Feed conversion Ratio

The following statistical model: $\mathbf{Y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}}$ was adapted,

Where; Yij = FCR; μ= is the overall mean; α_i = is effect of the treatment diet (i = 1…6);

β_j= effect of jth sex, (j=1,2);ε_{ij} = is the error term associated with the observation.

Dressed carcass percentage and internal organ weights

The following statistical model: $\mathbf{Y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}}$ was adapted,

Where; Yij = dressing percentage/organ weight. μ= is the overall mean;

$\boldsymbol{\alpha_i}$ = is effect of the treatment diet (i = 1,…..6); β_j= effect of jth sex, (j=1,2);

ε_{ij} = is the error term associated with the observation.

4.3 Results

4.3.1 Nutrient composition of the diets

The nutrient composition of the diets used in the experiment is presented in Table 10. The diet 100% MMPP had the highest DM, CF and TEP but the lowest CP, EE, NDF, ash, phosphorus and calcium. As the composition of MMPP in diet increased, CP, EE, phosphorus and calcium decreased, whereas CF and TEP increased.

Table 10. Nutrient composition of the finisher diets offered to the broilers

	%DM	%CP	%CF	%EE	%NDF	%ADF	%Ash	TEP	%P	%Ca
T1	88.5	19.5	6.1	5.3	46	18.2	7.1	35	0.83	1.22
T2	88.5	18.5	8.6	4.4	71	26	11.5	45	0.72	0.91
T3	89	16.8	10.1	3.1	65	16.4	8.0	60	0.44	0.73
T4	88	14.4	13.4	4.0	60	30.7	7.0	65	0.42	0.67
T5	88	12.2	15.8	2.7	67.8	14.4	7.1	65	0.35	0.54
T6	90.3	11.4	17.7	2.8	41.2	25	2.7	80	0.15	0.27

DM = dry matter; CP = crude protein; CF = crude fibre; EE = ether extract; NDF = neutral detergent fibre; ADF = acid detergent fibre; TEP = total extractible phenolics mg/g of DM; P = phosphorus; Ca = calcium. Treatments: T1 = (Control, 0% MMPP); T2 = (20% MMPP); T3 = (40% MMPP); T4 = (60% MMPP); T5 = (80% MMPP); T6 = (100% Prosopis); MMPP = milled mature Prosopis pods.

4.3.2 Analysis of variance of the broiler performance

Table 11 presents the ANOVA of the performance of the broilers. There was significant difference (P<0.05) on all the parameters measured.

Table 11. Analysis of variance of performance of finishing broilers subjected to various inclusion levels of MMPP in the diet

Source of variation	df	ADFI	Final wt	ADG	Liver wt	Heart wt	G + PV wt	FCR	Dressing %
		g							
Treatment	5	167*	1283*	29*	33*	9.8*	47*	9.6*	62*

* Significant at (P<0.05); G + PV = gizzard + proventriculus weight.

4.3.2.1 Feed intake, final live body weight and feed conversion ratio of broilers

Table 12 presents average daily feed intake (ADFI), average daily gains (ADG), initial and final live body weights and feed conversion ratio (FCR) of the broilers. The ADFI and ADG decreased with increased levels of MPP in diet whereas FCR increased with increased MPP in diet. The control group had the highest final live body weight.

Table 12. Performance of broilers offered finisher diets with increasing levels of MMPP

Parameter	T1/Control	T2	T3	T4	T5	T6	SEM
ADFI (g/day)	220^{a}	229^{a}	166^{b}	120^{c}	116^{c}	87^{c}	2.99
Initial Wt (g)	980	925	701	717	682	926	25.59
Final Wt (g)	1999^{a}	1692^{ac}	1295^{c}	1072^{bc}	915^{b}	630^{d}	23.32
FCR	3.73^{a}	5.24^{a}	7.63^{a}	10.07^{a}	31.18^{b}	-11.4^{d}	1.71
ADG (g/day)	60^{a}	45^{b}	23^{c}	12^{cd}	4.1^{d}	-0.01^{d}	0.93

Figures within a row with similar superscripts are not significantly different (P>0.05); ADFI = Average Daily Feed Intake; FCR = Feed Conversion Ratio; ADG = Average Daily Gains; SEM Standard Error of the Mean; T1 = (0% MMPP); T2 = (20% MMPP); T3 = (40% MMPP); T4 = (60% MMPP); T5 = (80% MMPP); T6 = (100% MMPP); MMPP = milled mature Prosopis pods.

The ADFI of T2 (20% MMPP) and T1 (control) were similar (P>0.05) but significantly different (P<0.05) from the rest of the treatments. Increasing the level of MMPP beyond 20% decreased ADFI. Treatments 4, 5 and 6 had similar (P>0.05) ADFI. As the proportion of MMPP increased in the diet, the droppings became wet. Beyond 20% inclusion the wetness was directly proportional to level of MMPP in diet. Consequently, water intake increased as the inclusion of MMPP in the diet increased, until the feed intake reduced due to high levels of MMPP in the diet.

Birds consuming 100% MMPP (T6) survived for only two weeks after which deaths were observed, therefore, experimental observations were recorded for two weeks. The birds showed signs of weakness, were unable to feed and had severe weight loss. Feed intake for T6 was generally low throughout the 2 week experimental period with an ADFI of 94g. The birds showed signs of starvation from the second day followed by depression of feed intake as the days progressed. On the 14th day of the experiment 30% of the birds (T6) were unable to move and another 30% were dead. The recumbent birds were slaughtered on the 15th day. The 40% remaining birds were offered the Control diet and put under observation. Half of these birds were able to grow and gain some weight but they did not have compensatory growth. The other half died despite the *ad libitum* feeding of the control diet.

Initial body weights were used as covariates in the analysis. The final live body weight of the birds ranged between 915-1999g (Table 11). The group offered T1 0% MMPP had the highest final live body weight (1999g), while the group on 100% MMPP had the lowest weight (630g). The weight gain decreased as Prosopis inclusion in the diet increased. The final live body weight for T1 and T2 were similar (P>0.05) but different (P<0.05) from T3, T4, T5 and T6. Final live body weight of T2, T3 and T4, were similar (P>0.05) but different (P<0.05) from T5 and T6. Final live body weight for T4 and T5 were similar (P>0.05). ADG of T1 was significantly different (P<0.05) from the rest of the treatments. Treatment six (T6) was significantly different (P<0.05) from the other treatments and had the lowest final live body weight.

Feed conversion ratio (FCR) ranged between 3.73 to negative 11.44 (Table 12). The group offered T1 (Control) had the lowest FCR at 3.73, while the group offered T5 had the highest FCR. The group offered T6 had negative 11.44 due to weight loss during the experimental period. FCR increased as the inclusion of MMPP in diet was increased. The first 4 treatments had similar FCR (P>0.05), but different from T5 (P<0.05).

4.3.2.2 Dressed carcass weight, internal organs weights and gross pathological changes of broilers

The dressed carcass percentage and internal organ (heart, liver and gizzard and proventriculus) weights of broilers fed on increasing levels of MMPP and slaughtered at the age of 56 days are presented in Table 13.

Table 13. Dressing percentage and internal organ weights of broilers offered on increasing levels of (MMPP)

Parameter	T1	T2	T3	T4	T5	T6	SEM
Dressing (%)	68^{a}	68^{a}	62^{ab}	62^{ab}	60^{b}	53^{cb}	0.50
Liver wt (g)	53^{a}	50^{a}	30^{ab}	25^{b}	22^{b}	20^{b}	0.91
Heart wt (g)	23^{a}	10^{b}	10^{b}	7^{c}	5^{c}	3.5^{c}	0.42
Gizzard and proventriculus wt (g)	70^{a}	68^{a}	45^{ad}	33^{d}	30^{d}	35^{d}	2.01

Figures within a row with different superscripts are significantly different at $P<0.05$; SEM = Standard Error of the Mean; Treatments: T1 = (0% MMPP); T2 = (20% MMPP); T3 = (40% MMPP); T4 = (60% MMPP); T5 = (80% MMPP); T6= (100% MMPP); MMPP= milled mature Prosopis pods.

Dressed carcass %, liver and gizzard and proventriculus weights decreased with increased amount of MMPP in the diet. The dressing % of T1, T2, T3 and T4 were similar ($P>0.05$), but different ($P<0.05$) from T5 and T6, while T5 and T6 were similar ($P>0.05$). T3, T4 and T5 were similar ($P>0.05$), and T5 and T6 were similar ($P>0.05$). With increasing level of MMPP replacing CBFD, the dressing percentage decreased, with complete replacement of CBFD with MMPP resulting in the lowest dressing percentage.

The average liver weight was in the range of 20- 53g decreasing with increasing amount of MMPP in the diet, (Table 13). Average liver weight of T1, T2 and T3 were similar ($P>0.05$), but different ($P<0.05$) from T4, T5 and T6. The weight for T3, T4, T5, and T6, were similar ($P>0.05$).

The average heart weight was in the range of 3.5-23g. Heart weight decreased as inclusion of MMPP increased in the diet, with T6 having the lowest weight. The heart weight of T1 was higher ($P<0.05$) compared to other treatments and decreased by almost 50% in T2 and T4 compared to T1. Heart weight of T1 was different ($P<0.05$) from the other treatments and T2 and T3 were similar ($P>0.05$). Treatments T4, T5 and T6 had similar ($P>0.05$) heart weights.

The average gizzard and proventriculus weight was in the range of 35- 70g (Table 13). Average gizzard and proventriculus weight of the broilers decreased with increasing levels of MMPP in the diet. Gizzard and proventriculus weights decreased by 50% in T6 compared to T1 that were offered CBFD with no MMPP added. T1 and T2 had similar (P>0.05) weights but different (P<0.05) from T3, T4, T5 andT6. Treatment T2 and T3 had similar (P>0.05) weights. Treatments T4, T5 and T6 had similar (P>0.05) weights.

4.4 Discussion

4.4.1 Feed intake, final live body weight and feed conversion ratio of broilers

In this study, MMPP inclusion of up to 20% had similar (P>0.05) effect on ADFI (Table 12). This is in agreement with observations by Yusuf *et al*. (2008) and Girma *et al.* (2011), who reported 20% inclusion of decorticated fermented Prosopis seed meal and MMPP respectively to broilers did not affect FI. Beyond 20% MMPP inclusion, feed intake decreased, with 100% inclusion recording the lowest intake. The feed intake was indirectly proportional to the amount of MMPP in the diet. This in agreement with Girma *et al.* (2011) who reported that at 30% inclusion of ground mature pods in broiler diets there was decreased feed intake.

The inclusion of 20% MMPP in the compounded broiler finisher diet (CBFD) resulted in numerically higher ADFI though not significantly different (P<0.05) from the control (T1) 0% MMPP (Table 12). This could be due to birds eating more to satisfy their nutritional requirements for maintenance and growth. It could also imply that moderate levels of fibre in broiler diets do not affect feed intake or the dilution effect of the nutrient content of the diet led to increased intake. Mateos *et al.* (2012) reported that fibre inclusion in broiler diets acted as a diluent and increased intake. Further, Omar (2000) reported that increasing the amount of fibre in broiler diets increased feed intake. The fibre content of T2 was 8.6 % (Table 10) which was higher than the recommended fibre levels (maximum of 5 %) in broiler diets. This study showed increased levels of TEP as the amount of MMPP in the diet increased (Table 10). Nyachoti *et al.* (1996) reported an increase in feed intake when high tannin sorghum was offered to broilers, suggesting that increase in feed intake in T2 (20% MMPP) could also be due to increase in tannin levels compared to control. Mateos *et al.* (2012) reported an increase in broiler growth rate when 3% fibre was in cooperated into broiler diets with low fibre levels due to better gizzard function with an increase in gastro duodenal refluxes that facilitated contact between digestive enzymes and nutrients. Omar, (2000) and Raza *et al.* (2009) reported an increase in feed intake as level of fibre is increased up to 5%, after which there was decrease in feed intake. Increase in FI as level of tannins increased could be due to birds taking more to meet their nutritional requirements as enzymes form protein complexes creating limited nutrient availability. However, King'ori *et al.* (2011) in a review on use of Prosopis as a feed resource reported underutilization of both leaves and pods as feed for non-ruminants and pre-ruminant stages of ruminant livestock due to high level of CF and NDF. Further, Del valle *et al.* (1983) reported heat labile anti nutritional factors such as trypsin inhibitor and hemaglutinin, in Prosopis pods depress feed intake. The increase in FI when CF and tannins levels increased in T2 could possibly be due to dilution effect and formation of tannin protein complexes respectively. The birds therefore took more feed to satisfy their nutritional requirements, until the CF and tannins depressed FI. The decrease in feed intake as MMPP was increased beyond 20% could be due to increase in the fibre content of the diet and/or presence of other anti-nutritional factors such as tannins, trypsin inhibitor, lectins, alkaloids and saponins that depress feed intake (Ortega-Nieblas, 1996).

Increased inclusion of Prosopis in the diet increased moist sticky droppings. This created sanitation problem, with addition of new bedding done daily in those pens to prevent occurrence of diseases like chronic respiratory diseases, salmonellosis and coccidiosis. As the birds consumed more Prosopis in the diet, their water consumption increased. This was possibly for elimination of the insoluble non starch polysaccharides such as galactomannans (Cruz Alcedo, 1999) present in Prosopis and also to rehydrate the birds due to water lost in the wet droppings. This is in line with findings by Bhatt *et al.* (1991) and Girma *et al.* (2011) that high viscosity in the gut contents caused by insoluble non starch polysaccharides led to increased water intake resulting in wet sticky droppings.

Weight gain in livestock is a function of majorly, genetics, environment and feeding. The balance of the above must be right to realize the full potential of an animal in terms of weight gain. The final live body weight in the study was inversely proportional to the level of MMPP in the diet (Table 12). The final live body weight for T1 and T2 were similar (P>0.05). This is in agreement with observations by Yusuf *et al*. (2008) and Girma *et al.* (2011), where 20% inclusion of Prosopis in broiler diets did not interfere with growth. The high numerical feed intake at 20% MMPP inclusion did not translate into higher weight gain. This shows that the birds actually took more to satisfy their maintenance and growth requirements, possibly some nutrients taken in were not efficiently utilized for weight gain due to feed factors affecting efficient feed utilization as CF and tannins. Inclusion of more than 20% MMPP in the feed could have prevented bioavailability of nutrients from the feed, hence no proportionate growth. Mateos *et al.* (2012) reported that increased weight due to intake of moderate fibre levels of 3% in broiler diets depended on level, source and type of diet. This is in agreement with Girma *et al.* (2011) who recorded reduced weight gain at 30% *Prosopis juliflora* pods inclusion. Similar findings have been recorded in this study, where there was reduction in weight gained as level of MMPP in diet was increased beyond 20%.

Inclusion of 100% MMPP in the diet of the broilers had a depressive effect on weight gain (Table 12). The weight loss was possibly due to the presence of anti-nutritive factors such as trypsin inhibitor and saponins (Mateos *et al.* 2012). Increased MMPP in the diet could have caused increased level of TEP which is an anti-nutritive factor probably causing the depressed intake thus reduced weight gain by binding enzymes and forming enzyme tannin complexes. The weight loss experienced showed that over the two weeks that birds were offered 100% MMPP, they used their body reserves to sustain themselves since feed intake did not meet their maintenance and growth requirements. There was no compensatory growth when these birds were offered control diet over the next two weeks, possibly the birds body system of absorption and metabolism could have been interfered with or the feeding time of two weeks was short (Acheampong-Boateng *et al.,* 2012). Similar results have been reported by Yu and Robinson (1992) in a review and Lee and Leeson (2001) in a feeding trial; where feed restriction beyond 4 days in broilers during the finishing phase didn't result in compensatory growth. Fontana *et al*. (1993) recommended that diets used in compensatory growth should have special composition, with Santoso *et al*. (1995) suggesting diets of (21-35) % CP to realize compensatory growth in birds that had previous feed restriction. The CP content for T1 (control/ no MMPP) was 19.5% in this study. Previous studies by Vohra *et al.* (1966) showed that tannins do interfere with Gastro Intestinal Tract (GIT) absorption and secretory activities and above 4% inclusion led to high mortality, sloughing of mucosa of oesophagus, subcutaneous oedema and crop thickening. Compensatory growth could have been impossible in the current study due to impairment of the GIT functions and/ or low CP content of the T1.

The FCR increased as MMPP was increased in the diet. This is in agreement with studies done by Yusuf *et al.* (2008) who demonstrated that FCR was similar ($P>0.05$) in broilers offered decorticated fermented Prosopis seed meal at 30% inclusion and the control that had no Prosopis meal. The ADG decreased as the inclusion of MMPP was increased and ADG was highest in T1 ($P<0.05$) compared to all the other treatments. However, studies done by Girma *et al.* (2011) showed that daily gain in diets with up to 20% inclusion was similar to the control. These findings demonstrate that treatment of Prosopis improved the availability of the nutrients thus a better FCR at a higher inclusion.

4.4.2 Dressed carcass percentage, internal organs weights, and gross pathological changes of broilers

In this study inclusion of up to 20% MMPP did not affect dressing percentage of broiler carcasses. Dressed carcass percentage decreased with increased inclusion of MMPP beyond 20% in the diet with drastic reduction in dressing percentage beyond 60% inclusion (Table 13). This is in agreement with Yusuf *et al.* (2008), Girma *et al.* (2011) and Yusuf *et al.* (2013), who reported MMPP inclusion in broiler diets up to 30% did not affect dressing percentage.

The present study showed that heart weight of the birds decreased as supplemental MMPP increased in the diet (Table 13). This is at variance with studies done by Yusuf *et al.* (2008) and Yusuf *et al.* (2013), who reported that up to 30% inclusion of Prosopis fermented seed meal, the heart weights were same as control. Also, the observations in the present study where liver weights of the birds decreased as the level of MMPP increased in the diet (Table 13). This is at variance with studies done by Yusuf *et al.* (2008) and Yusuf *et al.* (2013), who reported that up to 30% inclusion of Prosopis fermented seed meal, the liver weights were same as control. The reports from nutritive analysis indicate that fermentation improved the nutritional content of the seeds when compared to the untreated ones.

There was a reduction in the weight of gizzard and proventriculus as the MMPP was increased in the diet, although the difference was not significant (P>0.05) for T1, T2 and T3 (Table 13). The gizzard and proventriculus size and weights for T4, T5 and T6 were similar (P>0.05) although the weight for T6 was numerically higher than T4 and T5. The reduced gizzard and proventriculus weights recorded could have been due to the reduced FI and final live body weights recorded as MMPP inclusion increased. The percentage reduction in dressed weight gain was higher than percentage reduction in gizzard and proventriculus weight as MMPP increased in the diets. Girma *et al.* (2011) reported an increase in crop and oesophagus weight in the highest inclusion of MMPP (30%) while Yusuf *et al.* (2008) recorded an increase in gizzard and proventriculus weights as Prosopis seed meal replaced soya bean meal. Similarly Oladije (2012) recorded a linear increase in gizzard and proventriculus weight as inclusion of fibre from cocoyam was increased in broiler diets. Hypertrophy of the gizzard and pro-ventriculus shows some form of adaptation to highest level of fibre (100% MMPP).

In this study, there were no gross pathological changes observed on the dressed carcass and the internal organs of the slaughtered birds. The carcass and internal organs showed signs of reduced size and weight but looked normal with reduced adipose tissue deposition as level of inclusion of MMPP increased (Table 13). The birds offered (100% MMPP) T6 had the lowest FI, final live body weight, no adipose tissue deposition and emaciated.

4.3 Conclusion

MMPP can potentially be used in the formulation of broiler finisher diets. From the results of this study, an inclusion level of 20% MMPP appears to be the optimum. This level of replacement has no adverse effect on ADFI, final live body weight, FCR, liver, gizzard weights and dressing percentage.

CHAPTER FIVE

PERFORMANCE OF BROILER CHICKEN, FED ON DIETS WITH *Prosopis juliflora* MILLED MATURE PODS (MMPP) PARTIALLY REPLACING MAIZE

5.1 Introduction

Poultry feed are mainly compounded from maize and milling by-products as part of the ingredients to provide energy. Maize is mainly used because it has high Metabolizable energy. However 87% of Kenyans consume maize as a dietary staple food at an average intake of 400gm per person per day (Mbithi, and Huyleenbroeck 2000) and (Shephard, 2008). According to Oparanya (2009) census, Kenyan human population was estimated at forty million people by 2009 with an annual growth rate of (2-3) %. There is therefore competition between humans and Livestock. Mbithi, and Huyleenbroeck (2000) further reported that about 3% of total maize produced in Kenya is used as livestock feed and there are variations in the use depending on the production which is dependent on rainfall. The area planted with maize seem to have reached a stagnation due to population pressure (Mbithi and Huyleenbroeck 2000), therefore intensification of production should be used to increase production per unit area. Standard newspaper (2014) reported Maize lethal necrosis disease (MLND) to cause reduction in maize production by 30% in 2014. Ways of reducing the disease will be to stop planting of maize for seasons, dress the seeds with insecticide and fungicide. This will cause high prices of maize in subsequent years as there will be scarcity. Consequently poultry farmers, have experienced and are expected to experience high feed prices and fluctuation in quality and quantity during the dry season and following years of inadequate rainfall. Inadequate supply of feed ingredients compromises quality of available feeds leading to poor growth rate, low egg production and hatchability, susceptibility to diseases and increased feed prices. This lowers the profitability of poultry production. Therefore, there is need to evaluate locally available alternative feed resources that are available all year round, with little or no competition with man and affordable. The pods of *Prosopis juliflora* is a locally available feed resource with no competition with man.The aim of this experiment was to evaluate the performance of broiler chicken offered CBFD with MMPP partially replacing maize.

5.2 Materials and Methods

5.2.1 Study site

The study was conducted at Poultry Research Unit of Tatton Agricultural Park, Egerton University. The Park is located at latitude 0^{o} 23’S and longitude 35^{o} 57’E, 2,238m above sea level, with mean daily temperature of 21^{o}C. The area receives bimodal rainfall pattern (March to May and June to September) with a mean annual rainfall of 900 - 1,020mm. The study was conducted between June and July 2011. The mean room temperature was 20-25^{o} C.

5.2.2 Animals and housing

One hundred day old broilers (Arbor Acres strain) comprising of mixed sexes were bought from Kenchick Ltd. They were brooded together in Nakuru Municipality using a charcoal stove for three weeks and offered commercial broiler starter feed. Amintotal®, a multi vitamin was administered in clean water from day 1-5. Vaccinations were done at, day- old, 10th, 14th, 21st and 26th day for Mareks (at hatchery), NCD, IBD/ Gumboro, IBD/ Gumboro, and NCD respectively. On the 27th day they were transported to Tatton Agricultural Park, Egerton University and offered the control diet (CBFD). On day 29, eighty broilers, 40 cockerels and 40 pullets with an initial weight of 0.82 ±0.08 Kgs were selected for the study. There were 20 broilers per treatment. On the seventh week, an anthelminthic, (Ascarex®) was administered in drinking water for one day followed by an antibiotic/ coccidiostat (amidiostat®) combined with multivitamin (Amintotal®) for 5 days. The chicks were housed in pens (ten chicks per pen) measuring about $5M^{2}$, that were well ventilated and lighting provided 24 hours. The pens were initially cleaned with liquid soap, disinfected using (omnicide®) and about 10cm thick of wood shavings put as bedding.

5.2.3 Dietary treatments.

Mature Prosopis pods obtained from Marigat Sub County in Baringo County (Kenya) were used in the study. Marigat is located at latitude 0^{0} 23’N longitude 35^{0} 59’E and is about 1500m above sea level with a mean annual rainfall of 600-800mm. The dried pods were collected from the ground after the trees were shaken and any spoilt or mouldy pods were discarded. The pods were put in gunny bags and transported to Kays Premium feeds in Nakuru town for milling. Milling of whole pod was done according to the procedure described by Choge *et al.* (2006) and passed through a 5mm sieve. The composition of the Compounded Broiler finisher diet (CBFD) used in the study is as presented in Table 8 (Chapter 4, section 4.2.3).

The dietary treatments were compounded as shown in Table 14. The percentage of maize in the compounded broiler finisher diet Table 8 (Chapter 4, section 4.2.3) was replaced (weight for weight) with increasing levels of MMPP.

Table 14. Composition of the experimental diets indicating replacement of maize with (MMPP)

Ingredient	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Maize	35	25	15	5
MMPP	0	10	20	30
Maize Germ	30	30	30	30
C.G.meal	13	13	13	13
Fish meal	10	10	10	10
CSC	10	10	10	10
DCP	1.25	1.25	1.25	1.25
Iodized salt	0.25	0.25	0.25	0.25
Vit premix	0.5	0.5	0.5	0.5
Totals	100	100	100	100
Calculated CP (%)	22.38	22.72	23.06	23.4
Calculated ME (MJ/kg)	13.706	13.099	12.366	11.696
Calculated CF (%)	2.73	4.4	6.07	7.74

C.G.meal = Corn gluten meal; DCP = Dicalcium phosphate; CF = crude fibre; CP = Crude protein; ME = Metabolizable energy MJ/Kg feed; CSC = Cotton seed cake; MMPP = Milled mature Prosopis pods; Vitamin premix provided the following per kg of diet: Vit. A = 10,000 IU; Vit. D = 2000 IU; Vit. E = 5mg; Vit.K = 2mg; Riboflavin = 4.20mg; Nicotinic acid = 20mg; Vit. B = 0.01mg; Pantothenic acid = 5mg; Folic acid = 0.5mg; Choline = 3mg; Mg = 56mg; Fe = 20mg; Cu = 10mg; Zn = 50mg; Co = 125mg and Iodine = 0.08mg.

5.2.4 Nutrient Composition

Analysis of nutrient composition of the experimental diets was done as described in Chapter 3 (Section 3.2.2).

5.2.5 Experimental Procedure and Design

A feeding trial was conducted using eighty, 29 day old Abor Acres broilers in a randomized complete block design. The broilers were randomly allocated the 4 test diets with 2 replicates (10 birds/ replicate) per treatment. Blocking was done based on sex. Each experimental unit had 10 birds with similar body weights. The dietary treatments were offered *ad libitum* by giving a weighed amount of the respective diets (Table 13) once a day at 0900 hours. Voluntary feed intake was estimated as the difference between the amount of each diet offered and that left over on daily basis. Weight gain of the broilers was monitored by weighing them weekly at 0900 hours before morning feeding. Feed conversion ratio was calculated as feed intake divided by weight gain over the 28 days experimental period.

At the end of the experiment, three birds per pen with body weight similar to average pen weight were selected and kept overnight (12 hours) in pens with drinking water only. They were weighed the next day, slaughtered by cutting each bird's neck individually and feathers removed manually using boiled water at (60-70) ^{o} C. The neck, head, heart, gizzard and proventriculus and liver were removed. The liver, heart and gizzard and proventriculus were each weighed separately and carcass dressing percentage calculated as weight of dressed carcass divided by weight of live bird expressed as a percentage.

5.2.6 Data analysis and Statistical models

Statistical Analysis

Data from the experiment was subjected to Analysis of Variance (ANOVA) using the general linear model (GLM) of SAS software (Statistical Analysis Systems 2002) with the model containing treatment effects on the parameters measured. Differences between treatment means were separated using Tukey's Range Procedure (HSD).

Average daily feed intake

The following statistical model: $\mathbf{Y_{ij}= \mu + \alpha_i + \beta_j+ \varepsilon_{ij}}$ was used,

Where; Yij = Feed intake (g day^{-1}); μ= is the overall mean;

α_i = is effect of the treatment diet ($i = 1…4$); β_j= effect of jth sex, ($j=1,2$);

ε_{ij} = is the error term associated with the observation.

Final live body weight

The following statistical model: $\mathbf{Y_{ij}= \mu + \alpha_i + \beta_j+ \beta (X_{ij} – X) + \varepsilon_{ij}}$ was used,

Where; Yij = Final live body weight (Kg); μ= is the overall mean;

α_i = is effect of the treatment diet (i = 1…4); β_j= effect of jth sex, (j=1,2);

β= Regression coefficient of Y_{ij} on X_{ij} (Initial body weight); X_{ij} = Measurement of covariate corresponding to Yij.

ε_{ij} = is the error term associated with the observation.

Feed Conversion Ratio

The following statistical model: $\mathbf{Y_{ij}= \mu + \alpha_i + \beta_j+ \varepsilon_{ij}}$ was used,

Where; Yij = FCR; μ= is the overall mean; α_i = is effect of the treatment diet (i = 1…4);

β_j= effect of jth sex, (j=1,2); ε_{ij} = is the error term associated with the observation.

Dressed carcass percentage and internal organs weights.

The following statistical model: $\mathbf{Y_{ij}= \mu + \alpha_i + \beta_j+ \varepsilon_{ij}}$ was used,

Where; Yij = dressing percentage/organ weight. μ= is the overall mean;

$\boldsymbol{\alpha_i}$ = is effect of the treatment diet (i = 1,…..4); β_j= effect of jth sex, (j=1,2);

ε_{ij} = is the error term associated with the observation.

5.3 Results

5.3.1 Nutrient composition of the broiler diets

The nutrient composition of the diets used in the experiment is presented in Table 15. The diet with 30% MMPP contained the highest CF and TEP but the lowest CP and calcium. As the composition of MMPP in diet increased, CP, phosphorus and calcium decreased, whereas CF and TEP increased.

Table 15. Nutrient composition of the finisher diets offered to broilers

	%DM	%CP	%CF	%EE	%NDF	%ADF	%Ash	TEP	%P	%Ca
T1	88.5	19.5	6.1	5.3	46	18.2	7.1	35	0.8	1.2
T2	89	19.1	6.8	2.7	37.8	10.4	9.8	55	0.6	0.8
T3	89.5	18.7	10.2	3.1	40.6	14.2	11.6	65	0.4	0.6
T4	88.5	17.3	12.2	3.1	40.2	26.2	10.6	70	0.4	0.5

DM = dry matter; CP = crude protein; CF = crude fibre; EE = ether extract; NDF = neutral detergent fibre; ADF = acid detergent fibre; TEP = total extractible Phenolics mg/g DM; P = phosphorus; Ca = calcium. Treatments: T1 = 0% MMPP (Control); T2 = (10% MMPP); T3 = (20% MMPP); T4 = (30% MMPP); MMPP = milled mature Prosopis pods

5.3.2 Analysis of variance of the broiler performance

Table 16 presents the ANOVA of the performance of the broilers. There was significant difference (P<0.05) on ADFI, Final wt, Liver wt and heart wt.

Table 16. Analysis of variance for performance of finishing broilers subjected to various replacement levels of maize with MMPP in the diet

Source of variation	df	ADFI	Final wt	ADG	Liver wt	Heart wt	G + PV wt	FCR	Dressing %
		g							
Treatment	3	204*	1760*	46	39*	13*	60	5.1	67

* Significant at (P<0.05); G + PV = gizzard + proventriculus weight.

5.3.2.1 Feed intake, final live body weight and feed conversion ratio of Broilers

Table 17 presents average daily feed intake (ADFI), average daily gains (ADG), initial and final live body weights and feed conversion ratio (FCR). The ADFI decreased with increased levels of MMPP replacing maize in the CBFD. The control group (T1) had the highest final live body weight. FCR increased with increased MMPP replacing maize the CBFD and ADG decreased with increased MMPP replacing maize the CBFD.

Table 17. ADFI, IWts, FWts, FCR and ADG of broilers offered finisher diets with MMPP replacing maize

Parameter	T1/Control	T2	T3	T4	SEM
ADFI (g/day)	218^a	218^a	192^b	187^b	23.87
Initial Wt (g)	860	918	800	700	27.96
Final Wt(g)	1983^a	1802^a	1704^a	1490^b	22.73
FCR	3.78^a	4.18^a	4.71^a	7.75^a	0.44
ADG (g/d)	58^a	53^a	43^a	30^a	2.74

Figures within a row with similar superscripts are not significantly different (P>0.05); ADFI = Average Daily Feed Intake; IWt = Initial Weight; FWt = Final live body weight; FCR = Feed Conversion Ratio; ADG = Average Daily Gains; SEM = Standard Error of the Mean; T1 = (0% MMPP); T2 = (10% MMPP); T3 = (20% MMPP); T4 = (30% MMPP); MMPP = milled mature Prosopis pods

ADFI of T1 diet T2, were similar (P>0.05), but significantly different (P<0.05) from T3 and T4. T3 and T4 had similar ADFI (P>0.05). Increasing the level of MMPP replacing maize beyond 10% decreased ADFI with T4 having the lowest ADFI. As the proportion of MMPP replacing maize in the diet increased, the faeces wetness and water consumption of the broilers also increased.

Initial weights were used as covariates in the analysis. Final live body weight ranged between 1490 -1983g (Table 17). The group offered diet T1 (Control, no MMPP addition) had the highest final live body weight of 1983g, while the group offered T4 (30% MMPP replacing maize) had the lowest final live body weight 1490 g. Final live body weight of T1, T2 and T3 were similar (P>0.05) but significantly different (P<0.05) from T4. Control group had the highest ADG of 58g. Although ADG decreased as MMPP replacement of maize in the CBFD increased, all the treatments were similar ($P>0.05$).

Feed conversion ratio was in the range of 3.78 - 7.75 (Table 17). The group offered T1 had the lowest FCR while the group offered T4 had the highest ratio 7.75. FCR increased as Prosopis replacement with maize increased in the diet. FCR of all the 4 treatments were not significantly different ($P>0.05$), however, Prosopis inclusion in diet increased FCR.

5.3.2.2 Dressed carcass weight, internal organs weights and gross pathological changes of broilers

Dressed carcass percentage and internal organ (heart, liver and proventriculus) weights are presented in Table 18.

Table 18. Dressing percentage and internal organ weights of finishing broilers fed on CBFD with incremental levels of (MMPP) replacing maize in the diets

Parameter	T1	T2	T3	T4	SEM
Dressing (%)	68^{a}	69^{a}	69^{a}	62^{a}	0.84
Liver wt (g)	60^{a}	40^{b}	30^{b}	25^{b}	1.25
Heart wt (g)	20^{a}	13^{ab}	10^{b}	10^{b}	0.63
Gizzard and proventriculus wt (g)	75^{a}	70^{a}	52^{a}	43^{a}	3.12

Figures within a row with different superscripts are significantly different at $P<0.05$; SEM = Standard Error of the Mean; Treatments: T1 = 0% MMPP (Control); T2 = 10% MMPP; T3 = 20% MMPP; T4 = 30% MMPP; MMPP = milled mature Prosopis pods.

Average dressed carcass percentage of the broilers was in the range of 62-68%. All treatments had similar ($P>0.05$) carcass dressed percentages though T4 had the lowest dressed carcass percentage.

Average liver weight was in the range of 25-60g, decreasing with the amount of MMPP replacing maize in the diet, (Table 12). Average liver weight of T1 (Control, with no MMPP) was significantly different ($P<0.05$) from the rest of the treatments. Birds fed on T2, T3 andT4 had similar ($P>0.05$) liver weights.

Average heart weight was in the range of 10-20g. Heart weight decreased as MMPP replacing maize in the diet increased, with T4 resulting in the lowest weight. Average heart weight of T1 and T2 were similar ($P>0.05$), but significantly different from T3 and T4. Also heart weights of T2, T3 and T4 were similar ($P>0.05$).

Average gizzard + pro ventricular weights were in the range of 43- 75g. Average gizzard + pro ventricular weight of all treatments were similar ($P>0.05$), though the weights reduced with increasing amount of MMPP replacing maize in the diets.

5.4 Discussion

5.4.1 Feed intake, final live body weight and feed conversion ratio of broilers

In this study, T2 had similar ($P>0.05$) effect on ADFI as the control (Table 17). This is in agreement with observations by Vanker *et al.* (1998) who reported no interference in performance of starter and finisher broilers at 10% inclusion of MMPP in broiler diets. This finding is at variance with studies done by AL-Beitawi (2010) who found that Prosopis pods could replace maize up to 20% in broiler chicks' diets without affecting feed intake. However Choudhary *et al.* (2005) suggested that Mesquite/ Prosopis pods could partially replace maize and be offered up to 20 % in the broiler diet (with multi-enzyme supplementation). Elabdin and Mukhtar (2011) reported increased feed intake when Prosopis replaced 50% of sesame meal at 7.5 % maize replacement in diet when soaked Prosopis juliflora seed meal was used, while Yusuf *et al.,* (2008), recorded high average feed intake in broilers offered decorticated fermented Prosopis seed meal, replacing full fat soybeans at 20% of the diet. In this study, increasing maize replacement by MMPP beyond 10% decreased feed intake, and from the above researchers, multi-enzyme in cooperation into broiler diets formulated with Prosopis would allow for maize replacement beyond 10%.

The final live body weights of broilers fed on T1 0% MMPP (Control), T2 (10% MMPP) and T3 (20% MMPP) were similar ($P>0.05$) though final live body weight reduced with increasing level of MMPP replacing maize. The finding is at variance with studies done by AL-Beitawi, (2010) who found that MMPP replacing maize up to 20% in broiler chicks' diets produced the highest final live body weight and best ADG. In this study, the ADFI of T3 was different ($P<0.05$) from T1 and T2 though the final live body weight of T3 was similar to T1 and T2. This possibly implies that as much as the ADFI of 20% replacement was significantly lower ($P<0.05$), the FI and nutrients taken was sufficient to sustain a final live body weight similar to T1 and T2 though numerically lower.

In this study feed conversion ratio (FCR) was not significantly different ($P>0.05$), among the treatment groups, though numerically, the FCR increased as MMPP increased in the diet. This is at variance with studies done by AL-Beitawi *et al.* (2010) who reported 20% MMPP replacing maize to have the best FCR. Jacob *et al.* (1996) found that maize diets had a better egg production and FCR compared to Sorghum in layer diets. Oladije, (2012) reported reduced weight gain and increased FCR as soaked wild cocoyam replaced maize in broiler diet, suggesting maize is of superior quality as energy source in feed for broilers than other cereals and agro industrial by-products. This could be due to low levels of ant-nutritive factors in maize compared to other cereals and also presence of highly digestible components.

5.4.2 Dressed carcass percentage, internal organs weights, and gross pathological changes of broilers

In this study up to 30% MMPP replacing maize did not affect dressing percentage (Table 18). Dressed carcass percentage decreased with increased MMPP replacing maize though not significantly different (P>0.05). This is in agreement with Yusuf *et al.* (2008), AL-Beitawi *et al.* (2010) and Girma *et al.* (2011), who reported MMPP inclusion in broiler diets up to 30% did not affect dressing percentage. Dressing percentage is a calculation of the dressed weight in relation to the live weight. As live weight reduces, so does the dressed weight unless there is serious emaciation.

Heart weights of the birds decreased as the level of MMPP replacing maize increased in the diet (Table 18). Heart weights were not significantly different among all treatments. Liver weights of the birds reduced as level of MMPP increased in the diet (Table 16). Liver weight of T1 was significantly different (P<0.05) from the rest of the treatments. When maize replaced CBFD up to 30%, the internal organs weights were similar (P>0.05). There were no gross pathological changes observed on the dressed carcass and the internal organs of the slaughtered birds. Deposition of adipose tissue on the carcasses was inversely proportional to the level of MMPP replacing maize in the diets. As MMPP replacement of maize increased, FI reduced causing less nutrients intake leading to starvation.

5.5 Conclusion

The results from this study demonstrate that mature pods of *Prosopis juliflora* can replace maize up to 20% in broiler finishing diets without adverse effects ADFI, Final weight, FCR and ADG. Replacing maize with MMPP up to 30% had no effect on dressing % and gizzard and proventriculus weights, though it affected heart and liver weights. Therefore use of dressing percentage and gizzard and proventriculus weights might not be helpful in identifying nutritional problems in broilers fed on diets containing MMPP, unless it is beyond 30% MMPP replacement. Liver and heart weights could possibly be better for identifying such problems.

CHAPTER SIX

GENERAL DISCUSSION, CONCLUSION AND RECOMMENDATIONS

6.1 General Discussion

In Kenya, the manufacture of poultry feeds solely depends on agricultural and agro industrial by-products. This leads to fluctuation in quality, quantity and prices of poultry feeds. Radull (2000) reported fluctuations to be due to unreliable availability of raw material especially during the dry season. Most of raw materials are sourced from countries, with different agronomical practices, soil fertility, crop variety etc. The nutritional qualities of a crop depend on among other factors soil fertility, variety of the crop, age of crop at harvesting etc. When raw materials are sourced from different places with different environmental conditions and farming practises, it is not possible to maintain quality of feeds as it depends on the origin of the materials. The feed manufacturers do not take these differences into account when compounding poultry feeds. Therefore feed quality is compromised. This therefore translates into fluctuations in quality thus affecting broiler growth and profits. During harvesting of agricultural products, raw materials for manufacture are abundant. This is contrary during dry season leading to reduction in quantity of feeds produced that subsequently affects prices as they are regulated by the law of supply and demand.

Prosopis juliflora tree legume has been in existence in semi-arid and arid lands of Kenya since its introduction in the early 1970s. The tree legume has been a nuisance in areas where it grows and feeding to livestock in its unprocessed form has proved injurious. King'ori *et al.* (2011) in a review reported that in Kenya indigenous knowledge of Prosopis use has been lacking and the tree has remained under-utilized and unmanaged and suggested that appropriate technologies and management strategies should be developed and employed for sustainable utilization. Such technologies should include incorporation into livestock feeds in a form that is not harmful to livestock with good bioavailability of the nutrients. Possibilities of using pods of *Prosopis juliflora* in broiler feeds should be explored to reduce the problems of feed shortage especially during the dry season as the tree legume thrives well during the dry season and is less affected by changes in weather conditions.

Findings by Yusuf *et al.* (2008) and Girma *et al.* (2011) suggested that use of Prosopis reduced feed cost and at 20% inclusion in broiler diets, there was no interference with performance. This is in agreement with this study where performance parameters were not affected at 20% inclusion and replacement with maize in experiment 2 and 3 respectively. The gross energy GE and Metabolizable ME of Prosopis was 17.489MJ/Kg and 12.803MJ/Kg respectively, which is comparable to maize with ME values of (12.970-13.807 MJ/Kg) depending on soil fertility and variety (NRC 1984). The CP value of MMPP of 11.4% is higher than maize of 8% (NRC 1984), however other cereals and agro industrial by products have higher CP%.

Pour-Reza and Edriss (1997) reported that tannin levels beyond 0.003% in broiler diets affected performance and that applying enzyme combination of amylase, protease and xylanase on sorghum based broiler diets improved performance (Wyatt *et al.,* 1997). However, other researchers have suggested higher levels of tannins as having no effect on production parameters of broilers. Hughes. (2011) found 1% condensed tannins from grape seed extract did not interfere with growth and FCR and had antibacterial properties when in cooperated in commercial broiler feeds. Qiyu and Guanghai (2012) also found that tannins could constitute up to 0.64% in diet without affecting performance. Medugu *et al.* (2010) reported 4.1% tannins from high tannin sorghum not to affect broiler performance. This is about the same level that can be tolerated by ruminants. In this study, the total extractible phenolics in Prosopis ground pods of 80mg/g DM was high compared to the treatments that had high feed intake, 45mg/g DM and 55mg/g DM for experiment 2 and 3 respectively. Ortega-Nieblas, (1996) also reported that apart from tannins, other anti-nutritive factors such as trypsin inhibitor, lectins, alkaloids, saponins are found in Prosopis pods. Tannins affect performance by making protein (enzyme) tannin complexes, bitter taste leading to low FI and inefficient enzyme activity. It is therefore possible that in this study, feed factors that reduced intake came from other sources other than tannin level of Prosopis pods. Reduction of anti nutritive factors in mature pods of Prosopis would improve availability of poultry feed and subsequently stabilize prices. Yusuf *et al.* (2008) suggested that fermenting

Prosopis pods improved the nutritional value and enzyme combination of amylase, protease and xylanase improved broiler performance when tannin based sorghum was fed (Wyatt *et al.,* 1997).

In this study, the calculated CF of 2.73% did not compare with the analysed CF of 6.1% in the control treatment/T1. CF composition of a plant is dependent majorly on harvesting time and plant species. As the plant grows, CF percentage increases. From the proximate analysis of all the 9 experimental diets, there is an emerging trend indicating that as Prosopis inclusion increased so did fibre levels and depression of feed intake. Hans-Joakim, (1997) reported high fibre to depress feed intake and animal performance. This decrease in feed intake resulted in reduced growth as MMPP inclusion increased and total loss of weight when only MMPP was fed (T6) in Experiment 2 (Chapter 4). Adamu *et al.* (2011) suggested an inclusion of up to 40% of MMPP in Rabbit diets without interference with nutrient digestibility, carcass components and blood parameters. However in this study with finishing broilers, optimal MMPP inclusion that didn’t affect performance was 20%. The caecum of poultry is less developed compared to rabbits in handling high fibre in their diets. Khattak *et al.* (2006) suggested the use of enzymes to improve performance of birds offered high fibre levels and reduce wet sticky droppings when insoluble non starch polysaccharides are offered to poultry. Choudhary *et al.* (2005) demonstrated that MMPP could be included in broiler diets up to 30% so long as multi enzyme is in cooperated in the diets.

Cruz Alcedo (1999) reported galactomannans as the non-Starch polysaccharides present in Prosopis pods. They are plant polysaccharides built mainly of galactose and mannose sugar units. Structurally they are formed by a linear β (1-4)-linked backbone of D-mannose molecules to which single units D-galactose are attached through α (1-6) linkage. These linkages lead to limitations in the ability of the animal’s enzymes to degrade the bonds. When dissolved in water viscosity increases linearly with concentration (Chaires-martinez *et al.,* 2008). Further Chaires-martinez *et al. (*2008) reported presence of excellent thickening properties useful for textile, pharmaceutical and food industries. Choge *et al.* (2007) reported above 50% of MMPP to be composed of carbohydrates. This property explains the hygroscopic properties of MMPP, and the observed increase in water intake and increased wetting of the litter by the broilers as MMPP was increased in the diets.

6.2 General Conclusion

In conclusion, this study has demonstrated that MMPP can be used to substitute Broiler finisher diets at 20% weight for weight and replace a maximum of 20% of maize in the diets. To increase the level of inclusion of MMPP in the diets, treatment is necessary to improve intake and bio-availability, reduce viscosity of the droppings and improve hygiene. Evidence obtained in this study suggest that high fibre diets influenced gizzard and proventriculus weight and size, suggesting that internal digestive organs especially gizzard hypertrophy is a factor in adaptation to feed fibre levels.

6.3 Recommendations

1. The promotion of MMPP use in livestock feeds should be done with the aim of controlling Prosopis tree invasion, increasing farmers' incomes, creating employment and conserving the environment.

2. In order to determine effects such as pathological lesions resulting from MMPP feeding, animals should be exposed to MMPP for longer duration, maybe layers or local poultry. A study should be done to determine the duration of the exposure that will expose the pathological lesions.

3. Further research to be done to establish the effects of MMPP on the intestinal mucosa of broilers.

4. There is need for further research to determine the effects of enzyme supplementation when MMPP are used at higher inclusion levels in order to establish any improvement in fibre digestion and reduction in droppings viscosity.

5. Assessment of the effect of inclusion level of Prosopis on carcass quality, adipose tissue composition and shelf life.

6. Further research on the effect of treatment of mature Prosopis pods with poly-ethylene glycol and wood ash on anti- nutritive factors.

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