COLLEGE OF AGRICULTURE AND NATURAL RESOSOURCES
FACULTY OF NATURAL RESOURCE MANAGEMENT
DEPARTMENT OF WILDLIFE AND RANGE MANAGEMENT

INVESTIGATING THE POTENTIAL OF *MORINGA* (*MORINGA OLEIFERA*) AND PIGEON PEA (*CAJANUS CAJAN*) AS SUPPLEMENTARY DRY SEASON LIVESTOCK FEED IN THE NORTHERN REGION OF GHANA

THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN FULFILMENT OF THE REQIUREMENT FOR THE AWARD OF MASTER OF PHILOSOPHY (WILDLIFE AND RANGE MANAGEMENT) DEGREE

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DECLARATION

I hereby declare that this thesis is my own work towards the MPhil and that to the best of my knowledge it contains no material published previously by another person nor material accepted for the award of any other degree of the University except where due knowledge must have been in the text.

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DEDICATION

Dedicated to my late mom, Esther Lariba Salifu and my husband, Sebastian Tiah.

ABSTRACT

Moringa (*Moringa olifera*) and pigeon pea (*Cajanus cajan)* have been both identified as a multipurpose tree and legume that have appreciable levels of crude protein that could be used as a dry season feed supplement for livestock. Growth rate, average weight gain and availability of *Moringa olifera* and *Cajanus cajan* were investigated for the potential of *Moringa olifera* and *Cajanus cajan* as supplementary dry season livestock feed in the northern region of Ghana for Djallonke sheep. Djallonke sheep were completely randomized into 3 treatments levels (T1-T3) with four replicates in pens. Sheep in treatment 1 (control) were fed with feed other than *cajanus cajan* and *moringa olifera* on dry matter basis, treatment 2 were fed with *Cajanus cajan* husk on dry matter basis while those in treatment 3 were treated with a feed containing *Moringa oleifera* leaves on dry matter basis, respectively. The findings of this study indicated clearly that there was no significant difference ($p>0.05$) among treatments for white blood cell level, haemoglobin and blood sugar concentration. However, there were significant difference ($p<0.05$) on all body weight parameters measured in the study. Animals fed with *Moringa olifera* diets had the highest average daily weight gain of 105.80g followed by those fed with *Cajanus cajan* diet (82.59g) whilst those fed with the control diet recorded the lowest average daily weight gain of 42.97g. The study further showed that 50% of farmers provide feed for the livestock. 85 % of the farmers confirmed availability of *Moringa olifera* and *Cajanu scajan* as livestock feed whilst 15% said no. It was revealed that majority of the farmers (70%) obtained the *Moringa olifera* from plantations whilst 30% obtained the *Moringa olifera* from the farm. Again, all farmers obtained the *Cajanus cajan* from the farm. The study revealed that 60% of the farmers had no knowledge of *Moringa olifera* and *Cajanus cajan* as livestock feed whilst 40% were knew about it. Again, 60% of the farmers had no knowledge that *Moringa olifera* and *Cajanu scajan* could improve growth of livestock but 40% had knowledge that *Moringa olifera* and *Cajanus cajan* can improve growth of livestock. The study revealed that *Moringa olifera* and *Cajanus cajan* are generally known to farmers as animal feed sources, readily available to farmers and largely preferred by livestock (75%). Djallonke sheep can be fed with both *Cajanus cajan* and *Moringa oleifera* diets during the dry season and further research should be conducted to assess the appropriate pre-treatment methods for these crops.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The agricultural sector provides jobs on a formal and informal basis (Clark, 1994). Within the agricultural sector, animal production is an important part of Ghana's agriculture and comprises both ruminants and non-ruminants production. Livestock contributes significantly to the growth and development of the rural economy and the nation as a whole. The livestock sector contributes approximately 51.8 percent of the agricultural value added and accounts for 40% of the world's gross agricultural production (MoFA, 2000) This situation has come about due to the fact that peoples dietary habits have shifted to increased meat consumption especially among people who earn high income (Rahjan, 2001) For Muslims, sheep has a special function and are used also for funerals and for payment of bride prices in some parts of Ghana (Koney, 2004). Sheep production is preferred by farmers who are generally poor and may not be able to afford cattle coupled with the fact that sheep is more prolific than cattle

Some common breeds of sheep reared in Ghana include the Djallonke and Sahel breeds (Birteeb*et al.,* 2012), Nungua Blackhead, West African Dwarf breed, also known as the Forest type, sahelian breed, local Forest type and the Persian Blackhead (Somali). The West African Dwarf type and West African Long-Legged type (found mostly in Northern and Upper Regions) are basically the two main types of sheep found in Ghana (Gatenby, 2002).

Most small scale livestock farmers face a lot of challenges such as feeding, housing and diseases and this affects the rate of returns of livestock production. The problems facing the livestock sector in general have led to the importation of about 50% of livestock and its products to meet Ghana's domestic requirement (Sabri*et al.*, 2001)

Animal feed becomes very scares in the savanna zone during the dry season due partly to the unavailability of the feed because of the dry spell and also the annual bushfires which destroy the already insufficient forage. This makes animal feeding very difficult during the dry season and it has created a cyclic body weight gain and weight loss during the rainy season and dry season respectively. Many animal farmers rely on feed supplementation to sustain animal growth due to the scarcity of natural forage. Over the years animal scientists have identified feed supplementation as the remedy to this cyclic weight gain and loss. The use of staple cereals however, leads to competition between humans and animals thereby increasing the cost of supplementation and making livestock production unprofitable and unsustainable. (Karbo, Avornyo, & Attigah, 2002) (Otchere *et al*., 1986; Croston and Pollot, 1994.).

1.2 Problem Statement

Poor nutrition remains the most widespread technical constraint to good animal performance in sub-Saharan Africa (Saleem and Fitzhugh, 1995). This becomes more critical during the dry season when feed availability is not only inadequate, but the quality becomes extremely poor. Effects of drought due to erratic rainfall pattern which is characteristic of northern Ghana; wanton annual bushfires and increasing pressure on land resulting in feed scarcity have led to major changes in traditional livestock feeding systems.(Kristina Muller-Kukelberg,2012 Various options have been advocated as possible solutions to this perennial problem. Consequently, feed improvement and use in developing countries has been emphasized in recent years. This includes the feeding of treated and untreated crop residues or integration of forage legumes into feeding strategies Farmers do not pay picky attention to the planting of crops to feed their livestock but rather greatly emphasize on the cultivation of food crops for human consumption.

Livestock farming being an important part of the agricultural systems of Ghana is still plagued with lack of quantitative and qualitative nutrition during the dry season. The increasing use of unconventional feedstuffs as feed for livestock especially during the dry season and in confinement calls for the evaluation of the effect of these unconventional feedstuffs on the health status of the livestock. *Moringa olesifera* and *Cajanus Cajan* has been both identified as a multipurpose tree and legume that has appreciable levels of crude protein that could be used as a dry season feed supplement for livestock.

1.3 Justification

Livestock such as sheep and goats selectively browse *Cajanus cajan* and other plants in preference to other legume shrubs in a choice feeding situation (Konlan *et al* 2012) However, the full potential of *Moringa olifera* and *Cajanus cajan* as a fodder crop has not been fully exploited. The traditional practice has been the harvesting of other browse plant species from the wild for supplementary feeding of sheep and goats.

As one of the viable entry points for a well-integrated crop-livestock system in the northern Guinea savanna, some feed supplementation studies involving the use of fertilizer-grade urea to improve feed quality and the productivity of animals by using senescent forages (cereal crop residues) have been carried out (Annor and Adongo, 1992; *Moringa oleifera* and *Cajanus cajan*, the products that could be used to supplement livestock feed in the dry season are relatively available, accessible, inexpensive thus affordable, require less technical knowhow and have been proven to be nutritious. While ample information are available on the use of forage crops as supplement, information on fodders from *Moringa oleifera* and *Cajanus cajan* as a feed supplement to poor quality crop-residues is very scanty. Hence this study to investigate the potential of *Moringa oleifera* and *Cajanus cajan* as supplementary dry season livestock feed in the Northern region of Ghana.

1.4 Main and specific objectives

The objective of this research was to investigate the potential of *Moringa oleifera* and *Cajanus cajan* as supplementary dry season livestock feeds

- Assess the availability of *Moringa oleifera* and *Cajanus Cajan* as livestock feed
- Assess knowledge of livestock farmers on *Moringa oleifera* and *Cajanus Cajan* as livestock feed supplement
- Evaluate the effect of *Moringa oleifera* and *Cajanus cajan* on the growth of livestock

CHAPTER TWO

Literature Review

2.1 Sheep Population in the World

The total world population of sheep as at 2006 was 1024 million (Table 8.1 in appendix). Together, Asia and Africa account for as much as 64 % of the world's sheep population (Zygoyiannis, 2006). The reasons for these concentrations are in two categories. The first is environmental and biological: such as ambient temperature, humidity, daylight length, nutrition, water availability, disease and heredity. The second is human: such as social and religious issues, economic factors, market facilities, credit availability, trend toward high yielding breeds and land tenure (Zygoyiannis, 2006). It is generally recognised that sheep have a potential to make a significant contribution to food security, poverty reduction and improved livelihoods of smallholder producers in Africa and globally (Winrock International, 1992).

Between 1999 and 2004 sheep growth rates in Africa were among the highest in the world with an average of 2.3 % per year. In the same period, the urban population increased by 3.89 % per year (World Bank, 2009). As expected, the total number of sheep in Africa is increasing; the continent has approximately 254 million sheep (FAOSTAT, 2009). The projection is that there would be a change in per capita meat consumption of over 40 % in developing countries by 2030 (IAASTD, 2007).

2.1.1 Sheep population in Ghana

Small ruminants are abundant in the south and predominate in the north of Ghana.

Sheep numbers have increased gradually over the years from the estimated figure of 2.4 million in 1996 (LPIU, 1997), 3.21 million in 2005 (SRID, 2006) to 3.642 million in 2009 (VSD, 2010 – see Table **8.2** in appendix).

2.1.2 Livestock production in northern region

Production of livestock in the northern region of Ghana is considered as a culture and as a form of livelihood activity. Culturally, animals are seen as part of man's life most importantly as a form of prestige and for the performance of many cultural rites including marriage in many communities. Livestock serves as livelihood activities and are sold for income for various standard of living endeavours.

The main systems of livestock production in the northern region are; intensive, semi-intensive and extensive all of which have their main merits and demerits. Very few sheep are raised under intensive systems of production in Ghana. This system requires that animals are confined and feed supplied to them in their places of confinement. Stock may also be rotationally grazed on improved, fenced pastures. The level of management should be very high if one is to prevent losses due to diseases and profit from the heavy investment. Advantages of this system include; proper feeding enhanced, good medication, uniform growth (Quaye *et al*., 1993). Disadvantages include; high investment cost, requires high technical know-how. The extensive system is by far the most common system of rearing sheep in the country. In this system, animals are left free to roam and find food for themselves. Animals receive very little medication and are poorly housed. Animals from various household roam together and mating is uncontrolled. The main advantage of the system is that it is a low-cost investment with some benefits. The animal is also free to select the best parts of plants when it grazes. Available areas for grazing include grassy and open areas around the village and fallow fields further away from settlements. Disadvantages associated with the system are high incidence of deaths of lambs and losses associated with theft and accidents. Destruction of large unfenced cultivated areas by sheep and other animals is common with this system. Difficulty in carrying out effective management practices such as vaccinations, parasite control and control breeding due to their free roaming nature (Quaye *et al*., 1993). The system appeared to be the dominant type in the northern region basically as a result of drought due to erratic rainfall pattern which is characteristic of northern Ghana; wanton annual bushfires and increasing pressure on land resulting in feed scarcity. Semi-intensive systems combine various aspects of intensive and extensive systems of production. The common method is to allow animals to graze for part of the day/season and then supplement their daily feeding with cut browse/grasses and agro-industrial by- products such as brewer's spent grains and corn chaff (Quaye *et al*., 1993).

2.1.3 Prospects for Sheep Production in northern Ghana

Local meat production in Ghana has not been able to meet the total meat demand. The goals for the livestock industry are to increase the supply of meat, animal and dairy products from the current aggregate level of 30 % to 80 %. The increase in the supply of animal and animal products would subsequently contribute to the reduction of the incidence of poverty among food farmers (who are also livestock keepers) from 59 % to 30 % by the year 2015 (UNCTAD/WTO, 2006). It is projected that there is going to be a higher consumption of livestock products globally compared to other agricultural products like cereals (IAASTD, 2007). This is because there is an expanding urban market as urbanization is generally associated with higher average household incomes and changing lifestyles such as more food consumed outside homes (Delgado, Rosegrant, Steinfeld, Ehui, & Courbois, 1999); this is fuelling demand for food, including livestock products. Sheep off-take supplies only 30 % of the animal protein requirements of Ghanaians (UNCTAD/WTO, 2006). While agriculture as a whole contributes 54 % of Ghana's GDP, the livestock sector contributes in direct products only about 7 % of GDP (SRID, 2001) excluding manure and draught power provided to the crop sector. It is obvious that the animal industry has a lot of room for improvement. Livestock are a key resource in Ghana's agriculture contributing significantly to the livelihoods of smallholder farmers and to consumers in general, through the provision of animal products, income, nutrients and traction. Sheep production is also a key capital asset for poor families, making an indirect contribution to rural poverty reduction. In addition, it offers rapid growth opportunities, as the necessary internal market exists.

2.1.4 The Importance of Sheep Production

Sheep are processors of resources that are unsuitable for human food, such as fibre from forages and crop residues, into products (milk, meat, skin and leather) for human consumption and clothing.s Sheep also produce manure that can be used as fertiliser for crop production or as fuel for cooking or heating in some systems. It is easier to increase the population of small ruminants such as sheep than cattle as the reproductive turnover of sheep is higher. A ewe can lamb when conditions are favourable every eight months and the generation interval is less than two years Also the capital investment for sheep farming is relatively low and average land holdings are usually small making them more suitable to smallholder family operations. Sheep, being small, are easy to control. Keeping sheep and eating mutton are activities, which are virtually free from cultural and religious barriers (Animut, Merkel, Abebe, Sahlu, & Goestsch, 2002; Attoh-Kotoku, 2003).

Sheep meat (mutton and lamb) are relished all over the world. Sheep are economical of labour because they stay together while grazing; thus one shepherd can herd a sizeable flock (of about 50) in an open grazing system. Sheep production has the potential to make a significant contribution to food security and poverty reduction and improve the livelihood of smallholder producers (Winrock International, 1992) Sheep in Africa make substantial contribution to the well-being of the people by the supply of meat, milk, skins, wool/hair, draught power, manure and cash (Zygoyiannis, 2006) Sheep are multipurpose animals and their primary function is meat production, although in some countries sheep milk has become of greater importance. The economic importance of sheep production in both rural urban and peri - urban areas in Africa is well documented. Documented statistics in literature demonstrate the important role sheep production plays in the life of various classes of the human population. The sheep sector provides employment and income to the unemployed and low income urban and rural families. It also serves as supplementary income to the employed as well as the poorly paid. Another role that the sector plays is that it contributes to food security for urban and rural households, which cannot purchase all of their food requirements. Ruminants are able to convert inedible feed (grass) to highly nutritious human food. They can be reared in very hash and difficult terrains where crop production would be impossible. The cost of small ruminants is such that the rural poor can afford to start a livestock farm in his or her backyard that is low initial capital is required and the maintenance cost is also low. Small ruminant farming can thus be said to contribute substantially to the animal protein needs, as well as economic benefits, which accrue when sold, with a resultant improvement in the living standards of small holder families Sheep are able to use marginal land and crop residues to produce milk and meat in readily usable quantities and can be easily cared for by most members of the family. Sheep are prolific and are able to increase their flock sizes within a short period after catastrophies (Winrock International, 1992). Consumers are also motivated by cultural and religious considerations. Sheep are preferred by Moslems for ceremonial purposes and are used to celebrate Tabaskis and other Islamic holidays. There is a sharp increase in demand during these celebrations for live solid white rams, which are a premium (Attoh-Kotoku, 2011).

To a small farmer the security value of owning small ruminants may be as important as their tangible production. Small ruminants are a low-risk investment, which keeps its value. In a drought, sheep and goats can be eaten whereas when a farmer has cash there is no guarantee that he could buy food; and after the drought, small ruminants have the capacity to quickly regenerate again. Pastures and other forages provide most of the feed for livestock, especially for ruminants (four stomached animals such as cattle, sheep, goats etc.) throughout the world (Attoh-Kotoku, 2011).

2.2 Constraints in livestock production in the northern region of Ghana

The northern region of Ghana remains the dominant area for the production of the bulk of the livestock species in the country. Major constraints to livestock production include lack of improved breeds, lack of cheap quality feed, a weak livestock extension system, lack of appropriate managerial skills, lack of appropriate technology and weak livestock veterinary services(Karbo et al 2002) The effects of drought due to erratic rainfall pattern which is characteristic of northern Ghana; wanton annual bushfires and increasing pressure on land resulting in feed scarcity have led to major changes in traditional livestock feeding systems. Of these, lack of good quality feed at affordable prices is the major problem. With low productivity, the livestock sector contributes less than its potential to national economic and agricultural growth.

2.2.1 Rainfall

Rainfall is erratic, low and unpredictable with seasonal dry periods and occasional long droughts. The Sahel and Eastern Africa are examples of recent lengthy droughts which have caused the loss of large numbers of animals.

2.2.2 Dry land Farming

With developments in farm technology during the last two decades dry farming has spread in the arid and semi-arid regions with its highest toll being in the low rainfall areas where such activities are extremely dangerous to soil fertility and cover. Countries with very arid environments, such as Saudi Arabia and the United Arab Emirates, are using several water harvesting and management techniques to grow cereals with the aim of self-sufficiency. On the other hand, traditional cereal cultivation in the wadis and depressions of the 150–200 mm rain belt of Libya has proven to be economically sound (FAO, 1994). In these depressions usually the “rain- equivalent” exceeds annual rates and probably is above the 500 mm limit mentioned above.

2.2.3 Overgrazing

The arid and semi-arid rangelands occupy one third of the potential meadows and pastures of the world. More than three quarters of the world's range-lands are in poor to fair condition producing less than half their potential, and in many cases (LPIU- 1997). Dry season farming, water provision, transport of animals to the far out- reaches by trucks etc. have imposed tremendous pressures on these rangelands.

Expansion in veterinary care resulted in sharp increases in livestock numbers.

Development projects, relief funds and health care have caused sharp increases in human population of some regions. For example, drought stricken districts of Turkana in Kenya suffer from a high population density (3 persons/km ^{2}) with no resources for survival other than famine relief provisions. Consequences of over-stocking are many, most important being conversion of rangelands to waste lands (as happened in the Sahel) and the spread of undesirable plants. Soil compaction is another consequence of heavy livestock pressure. A majority of the shallow gravel plains and clay depressions in northern Saudi Arabia have developed crusted hard pans as a result of trampling by grazing livestock.(Adegun et al 2013) This has increased surface run-off and has depleted large areas of vegetation. Also, incentives and subsidies paid to livestock owners in the oil rich countries of the Arabian Peninsula have caused higher stocking rates than the capacity of the rangelands with ultimate deterioration and degradation.

2.2.4 Administrative

Pastoral systems are based on communal grazing of rangelands. The livestock owner's strategy is to ensure maximum conversion of primary production to his animals. When the traditional systems prevailed management procedures ensured adequate seed reserves, less trampling and appropriate stocking densities. Recent technological advances have not recognised the pastoral systems and have always worked against their interests. Consequently, land use practices were altered by an increasing trend toward cultivation, urbanization and in some countries industrialization. Animal herding ceased to be a respected profession and way of life in countries like Saudi Arabia and was replaced by immigrant labour with little or no experience in animal husbandry. In countries such as Sudan the long traditions of local administration systems were abolished without an effective alternative; hence subjecting the pastoral systems to extreme pressures and inflicting drastic levels of deterioration to the rangelands (Adegun et al 2013). The mutually beneficial relations between village farmers and pastoralists have deteriorated with trespassing of growing crops replacing the use of crop residues during the dry season causing personal conflicts and imposing harm to both arable and grazing lands.

2.2.5 Socio-economic

Livestock for nomads and trans-humans is a symbol of wealth and social prestige. Traditionally large numbers of stock are raised, and several observers have identified this social behaviour as the major cause of rangeland deterioration. However, others (FAO 1994) observed that pastoralists keep large numbers of livestock as a security against uncertain environments and natural disasters. Nomads sell their livestock only when the price is right and only when they need cash. During recent decades several developing countries which were subjected to inflation and foreign debt pressures were forced to devalue their local currencies. Commodities such as land and livestock maintained high and stable prices, encouraging more investment in livestock production. This encouraged livestock owners to import concentrates to feed their stock during dry seasons. This prolongs the life of standing animals and leads to overgrazing and range deterioration.

2.4 Breeds of Sheep in Ghana

The major sheep breed, the indigenous West African Dwarf (WAD) or Djallonké breed is distributed nation-wide in Ghana. The breed is acknowledged for its hardiness, trypanotolerance, prolificacy and suitability for year round breeding. Although it is a small animal, with an adult weight of 25 – 30 kg in males and 20 – 25 kg in females with a height of 50 cm, it does not exhibit traits associated with dwarfism.. The most common colour of the Djallonké sheep is white, although many animals have black or brown patches. Rams have horns, a mane and a throat ruff.

Ewes are usually polled. The Djallonké has a thin and medium-length tail. The larger and long-legged Sahelian sheep and crosses between the Djallonké and the Sahelian sheep, are found mostly in the north of the country and in peri-urban areas.. Attempts to improve the indigenous breeds by crossing them with exotic breeds have been unsuccessful due to the inability to sustain initial efforts and lack of coordination. The Nungua Blackhead sheep developed in Ghana and the Permer sheep (a cross between the Persian and the Merino in Nigeria) are examples (Animut *et al* 2002). Indigenous breeds are able to survive and produce under very hash and unstable (unpredictable) environmental conditions despite their low productivity. Crossbreeding should be preceded by rigorous selection among the adapted breeds for desirable characteristics and good productivity.

2.5 Nutrient Requirement of Sheep

Several different methods have been used to estimate nutrient requirement of livestock. Examples include comparative slaughter of animals at different weights and ages, calorimetric method and others. These methods have their disadvantages such as high cost of equipment, labour intensive and unnatural conditions of animals under the calorimetric method. Also, some assumptions must be made before the estimates (Konlan *et al* 2010). Another method is the use of body weight gain (BWG) as a measure of retention and to relate BWG to energy or protein intake using regression equations. The lapses of these relations are gut fill and variations in the composition of the gain.

2.6 Management Systems for Small Ruminants

The systems identified for managing sheep and other small ruminants in Ghana include the extensive, intensive, semi-intensive, commercial smallholder and commercial and some of these systems run into each other (Attoh-Kotoku, 2011).

2.6.1 Extensive System

Most small ruminants in Ghana are kept under the traditional extensive system. This is the main production system based generally on extensive free grazing or free range, with access to household and kitchen wastes when available among smallholder farmers. This system is easy to manage but it is not ideal as mortality rates especially among the young, losses from outright stealing, predators and accidents are very high. There may be under estimation of pre-weaning mortality under the extensive system. There are losses which are not noticed when births occur during grazing in the bush, in addition to abortions and still births (Tona *et al* 2014). Productivity is very low since there is no control over the pasture and it takes a long time to detect ill health in sheep. Breeding cannot be fully controlled as some of the animals on heat go undetected and would not be serviced. Animals are generally uncared for since the main activity of the smallholder farmer is growing of food crops. During the main cropping season, the owners are obliged to confine and provide sheep with food and water in order to protect their crops.

2.6.2 Intensive System

In the intensive system, there is elaborate housing; and there are two main types. One type involves the intensive use of cultivated pastures and crop residues. In this system, there is an effort to cultivate forages. The cultivated land is divided into paddocks and the animals are grazed from paddock to paddock. The paddocks usually have watering points and shelter, which are most often shade trees. The Ministry of Food and Agriculture Sheep Breeding Farm at Bonyon in the Ejura-Sekyeredumase District of the Ashanti Region practises this system (Attoh-Kotoku, 2003). In the other type of the intensive system, the animals are zero –grazed. In this system, which is also called stall-feeding or „cut and carry", the forage is cut and fed to the sheep in their stalls. In Ghana, this system is practiced in the cities by the Zongo communities for fattening rams for the Moslem festival, Eid-ul-Adha (Attoh-Kotoku, 2003). This system requires elaborate housing, with or without slated floors. The system allows for the use of agro-industrial by-products and hay. It is however, capital and labour intensive. There is also the tendency of stall-fed sheep to be under fed. Animals are also susceptible to injuries when slated floors are used. There is however, a higher return on the investment as productivity is very high, when well managed. Manure also accumulates, which can be used for fertilising crops (Attoh-Kotoku, 2003).

2.6.3 Commercial smallholder (Backyard small ruminant rearing)

In the commercial smallholder system of management, which is practised mostly by urban and some rural households, animals are confined at the backyard and fed with cut herbage (cutting is done mostly by the younger members of the family). Prepared feed is sometimes purchased for the animals, as well as kitchen waste. They are not allowed to scavenge as they can be hit by an automobile, or they can destroy a neighbour‟s backyard crop garden. In this system, family labour is solicited, and does not put heavy financial burden on the household Ill-health is identified early and prompt treatment given. Inbreeding is controlled by castrating the young rams and bucks. Simple pens are usually provided for sheep within or attached to the owner’s house. The pens are constructed from locally available materials such as timber off cuts, bamboo, tree branches and mud, and roofed with palm branches, split bamboo or metal sheets (Opp. This backyard system supplies fattened rams for the expanding urban market, and especially during festivals.

2.6.4 Commercial large scale farms

The large farms under this system, which are privately owned, utilise little or no family input except at management level. Even where family labour is utilised it is well remunerated (Smith and Olaloku, 1998). The required inputs in the form of improved genotypes, adequate nutrition and effective health management are supplied; and with good pricing policy, this system becomes potentially economical. This system is also practised by para-statal institutions in Ghana. They are found in the hinterlands in many parts of the country where large tracts of land are available for growing fodder, which is the main feed source and also natural pastures, which are often improved with forage legumes e.g. MOFA research and breeding farms are at various parts of the country. Examples of such farms are at Nkwanta in the Volta

Region, Ejura in the Ashanti Region, Kintampo in the Brong Ahafo Region and Pong-Tamale in the Northern Region. The commercial system therefore, represents a comparatively safe, automatically incremental and readily realizable investment.

2.6.5 Semi-intensive

The semi–intensive system, which is also practised, is a compromise between the extensive and the intensive systems. The system is characterised by limited stall feeding and grazing. The sheep are housed at night and released in the morning and left for the most part of the day to scavenge for most of their required feed and supplemented in the evening with kitchen wastes, which consists mostly of peels of cassava and plantain, and sometimes cassava leaves from the crop farms (Attoh-Kotoku, 2011).

2.6.6 Tethering (Village system)

This is another type of sheep production where the farmer takes his sheep to the farm and tethers them in an area of good quality fodder away from the crops. Their positions are changed two or three times daily so that they can eat enough forage. In the compound farming areas of the Northern, Upper East and West Regions this system is practised during the cropping seasons between July and October. Also found in neighbourhoods, across Ghana with animals tied to trees, large stones, old vehicle tyres etc. (Attoh-Kotoku, 2011).

2.6.7 Integrated crop-livestock system

There is also an integrated system of crop and livestock production. Generally the system is associated with the humid and sub-humid tropics where crop production is intensive. Here, sheep are reared under tree crop plantations, mainly oil palm, citrus and coconut. Introduced leguminous forage species such as *Pueraria phaseoloides* constitutes the main diet for the sheep. However, a wide range of volunteer forbs and grasses such as *Aspilia africana, Asystasis gangetica, Panicum maximum* and *P. luxum,* contribute significantly to the forage biomass. When sheep are integrated with tree crops, there is improved fertility of the land due to the return of manure and urine to the land and that leads to increased crop yield. There is control of herbage growth due to the different levels of grazing. The system is practised at the Okumaning oil palm plantation in the Eastern Region of Ghana (Attoh-Kotoku, 2003). Among all the production systems, the intensive system has become more popular with smallholder ruminant farmers in both the urban and rural areas. This may be due in part to pressures on land use for residential purposes as population increases. Also by-laws prohibiting the roaming of ruminants in towns and cities make it obligatory for most backyard farmers to confine their animals and feed them. During the cropping season, particularly where compound farming is practised, in the savannah zones, small ruminants are confined in pens and fed to prevent them from destroying crops (Attoh- Kotoku, 2003). Backyards gardening in the cities and crop farms being walking distances from townships have made it inevitable to keep and feed livestock in confinement. The most promising small ruminant production system in both urban and peri-urban areas is zero grazing. This allows for maximum utilisation of grass, crop residues and agro-industrial by-products for maximum productivity.

2.7 Animal nutrition and its purpose

Livestock play an important role in most small-scale farming systems throughout the world. They provide traction to cultivate fields, manure to maintain crop productivity, and nutritious food products for human consumption and income-generation. Despite the importance of livestock, inadequate livestock nutrition is a common problem in the developing world, and a major factor affecting the development of viable livestock industries in poor countries.

The international fund for Agricultural development (IFAD) recognizes both the significant role that improved animal feed and feeding practices can play in the long-term alleviation of rural poverty and their specific benefits to the rural poor such as increased livestock productivity, household food security and income.(FAO 1994)

Because of the growing demand for animal feed, new technologies and techniques need to be continuously developed and transferred in order to avoid environmental deterioration or increases in the prices of food products. Research and technology generation seeking ways to overcome food insecurity and poverty are therefore essential for agricultural and rural development.

Numerous IFAD livestock projects have identified the poor quality and insufficient quantity of pastures, forages and crop residues as major constraints to increasing productivity. A significant number have also reported the inadequate use of sown forages and forage legumes, due to lack of farmer awareness and the low availability of forage seed.

Feeding systems practised by the rural poor are mainly based on the use of natural pastures during the rainy season and agricultural by-products and low-cost feed during the dry season. Agricultural by-products such as crop residues although widely used as sources of feed by smallholders, do not provide the nutrients needed to ensure productive gains.

Prior to the Cuchumatanes Highlands Rural Development Project, Guatemala**,** the only feed supplement received by sheep was salt, distributed every 10 - 15 days. Natural pastures, in addition to having a low carrying capacity, are often inappropriately used and overgrazed. The mismanagement of natural pastures has resulted in soil degradation, an acceleration of erosion and desertification processes, and hence low livestock production and income insecurity (FAOSTAT 2009).

In most small-scale farming systems, livestock mainly graze on native pastures and cultivated forages, including cereal and legume residues and, increasingly, fodder trees and shrubs. However, the nutritive value of forages varies seasonally, with significant qualitative and quantitative decreases during the dry season. Smallholders therefore need to grow their own fodder in order to increase animal productivity and reduce the incidence of nutritional deficiencies.

A more practical approach to the problem of feed scarcity is for farmers to establish fodder banks. Fodder banks are plantings of high-quality fodder species. They can be used all year, but are designed to bridge forage scarcity in dry seasons. Fodder banks do not meet all feed needs, but supplement available dry-season forage. Forage / protein banks of Leucaena were successfully established in the Generation and Transfer of Agricultural Technology and Seed Production Project, Guatemala which, support project for small producers in the Semi-Arid zones of Falcon and Lara States (PROSALAFA), Venezuela. (FAOSTAT 2009).

The integration of livestock within cropping systems is becoming increasingly widespread, especially in densely populated areas where land is scarce. This has given rise to integrated cropping systems combining food crop, cash crop and fodder crop production aimed at meeting both livestock and human needs. Such systems have proved to be an effective way to encourage rural farmers to grow animal feed. They are especially popular because of their added benefits, such as manure, animal feed, food and income security, and environmental and soil conservation. In the Smallholder Cattle Development Project, Indonesia, mixed farming systems were designed and implemented with a view to improving the sustainability of the dominant cropping component while securing forage for livestock (LPIU 1997).

IFAD's experience in fodder planting has not always been successful, a fact generally not given due consideration. In the Indonesia project, failure to assess the agro-ecological conditions negatively affected the implementation of the forage improvement programme. In the Northern Pasture and Livestock Development Project, China, the increased availability of fodder resulted in an unexpectedly high increase in livestock numbers. This led to the degradation of existing pastures thus threatening the sustainability of pasture carrying capacity

2.7.1 Loss in weight of ruminants during the dry season

It has been recognized that ruminants gain weight in the rainy season as there are abundant green natural pasture which is nutritionally rich. They, however, lose weight in the dry season due to low quality fodder which is compounded by its unavailability (Annor, Djan-Fordjour, & Gyamfi, 2007). This underscores the need for feed supplementation of the ruminant in the dry season to maintain or improve weight gain. Indeed, supplementation often relies on the energy rich grains. This is, however, often scarce and expensive and not economical to use (Karbo et al., 2002). The other way out is to investigate agro-industrial by-products and/or crop residues that are not used by humans and non-ruminants for supplementing ruminants.

2.7.2 Efforts to Enhance Feed improvement.

The growing human population and livestock numbers, decreasing pasture availability and the increasing use of grazing land for crop production have made the use of improved feed in animal production systems all the more urgent. Adequate quantities of high-quality feed are necessary for profitable livestock production. Feeding systems based on improved feeding practices will help maintain the body conditions of animals, increase their resistance to disease and nutrition-related problems, and hence increase animal productivity and rural income opportunities.

The use of improved animal feed is becoming more prevalent, with feeding systems based on improved crop residues and agro-industrial by-products such as molasses, processed cassava and potatoes, oil cakes and milling by-products (IAASTD 2007). Because of feed insufficiencies, animals reared by smallholders often exhibit high mortality, high susceptibility to diseases, low calving periods, late maturity, infertility and reduced reproductive parameters – all of which have obvious negative impacts on household food security and income. Poor feeding practices are the primary reasons for low animal production in developing countries.

In areas of land scarcity, smallholder and landless farmers are faced with the dilemma of choosing between the production of feed for animals and the cultivation of food and cash crops for household consumption and income-generation. The appraisal of the Smallholder Cattle Development Project, Indonesia, established that due to limited land, smallholders rarely planted forage crops and relied on crop residues and grass collected from roadsides to feed their cattle. The increase in population and demand for food has resulted in the conversion of grazing land into cultivated fields and its use for other economic activities. Insecure grazing and user rights and uncertain land ownership further aggravate the problem of insufficient land and give smallholders little incentive to invest in feed cultivation. (IAASTD 2007).

Government livestock development programmes in developing countries often give low priority to the improvement of feed mainly due to budgetary constraints. Furthermore, most smallholders lack access to improved feed such as concentrates and supplemental feed because of their high costs.

Feed improvement and use in developing countries should therefore be based on:

- farmer practices, production systems and participation;
- on-farm trials;
- locally available and potential feed resources and livestock production systems;
- Improved techniques appropriate to the farming system in use and economically and socially acceptable

The international fund for Agricultural Development (IFAD) has supported feed improvement and use in numerous ways, obtaining diverse results. Given the limited land available for feed production, it has promoted the efficient use of agricultural crop residues by farmers. Food crop residues such as straw, stalks and leaves can be used for animal feeding. However, these by themselves do not provide sufficient nutrients to increase animal productivity. In response to this, IFAD has sought to improve the nutritional value of crop residues. In the Punjab Smallholder Dairy Development Project, Pakistan, for instance, demonstrations and trials were carried out on rice straw and wheat straw using urea treatment, molasses blocks and mineral supplements. This was effective in improving animal nutrition systems based on low- quality fodder.

A more thorough approach to the problem of feed inadequacy and scarcity has been to provide beneficiaries with training in simple/basic feed improvement techniques based on locally available inputs and traditional feeding practices. In the Punjab project, Pakistan, smallholder farmers have benefited from training in fodder production, feed formulation, hay and silage making, and animal nutrition. The Family Sector Livestock Development Programme, Mozambique, funded training and awareness-raising workshops for staff of extension services, during which demonstrations of fodder bank preparation and locally produced mineral blocks were carried out. The Cuchumatanes Highlands Rural Development Project, Guatemala, successfully developed a sheep production model based on improved nutrition practices. Rural farmers were involved in training and demonstration activities related to improved nutrition practices (FAO, 1994).

2.7.3 Mixed Farming Systems in the Tropics and Sub-Tropics

In the humid, sub-humid and semi-arid zones of the tropics (irrigated and medium to high rainfall areas) the small ruminants play an integral part in the production systems. Livestock production in these systems comes second in importance to food production. For example, in Western Java villages of Indonesia (3000–4000 mm annual rain) agriculture is intensive and the small ruminants are raised in complete confinement. On the other hand, in the wet-dry tropical sites of Western Kenya the rainfall (1100–2100 mm) pattern is bimodal with two distinct dry periods (June– August and November–February). In these areas, small ruminants are confined over- night (to avoid predators and theft) and herded or tethered during the day. Cut-and- carry of local forage resources and crop residues also contribute significantly to animal feed.

2.8 Factors affecting choice of livestock feeding

The major objective of livestock production should be the efficient conversion of feed and other resources into quality produce in the form of meat, milk, eggs, draught power and other produce. No animal can continue to live without food and hence the proper feeding or nutrition of livestock is very necessary. This is more so when we recognise that feed could account for up to 90 per cent of the cost of producing animals. Proper feeding strategies should therefore, be used to promote both the short term and long term benefits of our livestock operations

If all the things required to produce meaty animals were available to the farmer with the exception of correct feed or nutrition, the animal production project will not succeed. Poor feeding will not allow animals to attain their possible best growth.

Inadequate feeding will also put the animal under stress or discomfort which will eventually cause the animal to fall prey to disease. Proper feeding of animals is so important that we should consider it to be the most limiting factor in animal production. The feeding methods or strategies to be adopted on a farm will depend on the kind of animals being kept, the availability of feed ingredients and their prices, the technical knowhow in terms of feed formulation, the level of production and other factors that influence the marketing and production of animal products (Adegun *et al* 2013).

2.8.1 Livestock Feed supplementation

Dietary supplements serve a wide range of purposes. Some of these are medically appropriate, while others may do nothing or harm the individual. Reasons for taking dietary supplements include: replacing a necessary substance not found in large enough quantities in the diet, preventing or decreasing the risk of developing a disease or condition, boosting the immune system and improving general health, boosting energy levels, improving mental or physical performance, stimulating weight loss and reducing symptoms of a disease or health condition (Konlan *et al* 2012). There has been an increase in the use of dietary supplements and this has necessitated that individuals consult with their physicians so as to get the appropriate supplement without any detrimental effects.

The use of improved animal feed is becoming more prevalent, with feeding systems based on improved crop residues and agro-industrial by-products such as molasses, processed cassava and potatoes, oil cakes and milling by-products.

The factors that hinder smallholder access to improved feed and the effective use of the vast unexplored feed resources include:

- lack of sufficient land; and where it does exist, it is often unproductive and of low quality;
- limited capital resources, forcing smallholders to seek less costly alternatives that are low in nutritional content; and
- Insufficient knowledge of available feed resources, potential feed and its use.

The combined effects of drought and increasing pressure on land have led to major changes in traditional livestock feeding systems. Consequently, feed improvement and use in developing countries has been emphasized in recent years for the following reasons:

- As the human population grows, the demand for animal products increases, thus requiring better animal nutrition based on improved feeding systems.
  Increases in livestock numbers have boosted the demand for animal feed.
- To feed the increasing human population, more land will need to be devoted to crops, thereby reducing the land available for pasture and fodder. The limited land available for feed and fodder production and the decreasing quality of available pasture have given rise to the use of improved crop residues and by-products as animal feed.
- Increasing human demand for food makes feed improvement essential in order to avoid competition between animal feed and human feed requirements.

Supplementation might permit more efficient utilization of crop residues, which are inadequate in energy, protein, minerals and vitamins to support optimum animal productivity The supplements act to correct deficiencies of soluble nitrogen and minerals such as phosphorus and sulphur, and also as sources of protein or energy, which escape rumen fermentation. Forage legumes and tree leaves are rich in nitrogen and this offers the opportunity for their utilization as supplements (FAO 19194)

Supplementation with energy and protein sources is a prerequisite to increasing the efficiency of utilisation. Energy sources such as molasses, cassava chips and by – products from starch processing are appropriate for this purpose. Leguminous forages can supply protein to the level that can support optimum dry matter intake. The importance of maintaining a balance between carbohydrate sources such as molasses with rice straw and dietary nitrogen has been emphasized if the maximum utilisation of the rice straw, is to be obtained.

2.8.2 Impact of feed supplementation on lsivestock production

The use of improved animal feed is becoming more prevalent, with feeding systems based on improved crop residues and agro-industrial by-products such as molasses, processed cassava and potatoes, oil cakes and milling by-products.

Because of feed insufficiencies, animals reared by smallholders often exhibit high mortality, high susceptibility to diseases, low calving periods, late maturity, infertility and reduced reproductive parameters – all of which have obvious negative impacts on household food security and income. Poor feeding practices are the primary reasons for low animal production in developing countries.

Adequate quantities of high-quality feed are necessary for profitable livestock production. Feeding systems based on improved feeding practices will help maintain the body conditions of animals, increase their resistance to disease and nutrition- related problems, and hence increase animal productivity and rural income

opportunities.
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2.8.3 Fodder Legumes

Fodder from leguminous plants and MPTs contain higher amounts of proteins, vitamins and minerals as well as having higher digestibility than grasses when fed to ruminant livestock (Odeny 2007). Unlike grass, leguminous plants and tree fodders maintain their protein content and digestibility throughout the year.

Forage legumes are a dependable source of protein feed for animals. The seeds and leaves are rich in nitrogen. Forage legumes are adequately supplied with protein for livestock feeding, even when harvested at an advanced stage of maturity (Delgado *et al* 1999). The high nitrogen content of leguminous species contributes to improving the nutritional quality of the diet of ruminants whether grazed or cut and fed Animal productivity is normally greater from grass-legume mixtures than pure grass stands (Maroyi 2006)). Tree legumes provide a wide range of products: ie fodder from leaves, twigs and pods, as well as shade, live fences, timber and firewood. Fallen pods from the raintree are highly palatable to livestock Leaves of fodder trees, however, have constituents like tannins, saponins and non protein amino acids, which affect fodder utilisation and may be toxic to rumen microbes . Leaves from fodder trees notwithstanding the above are used as they are high in crude protein, minerals and vitamins (Maroyi 2006) and are available during the dry season. Sun drying reduces the levels of some of these plant secondary metabolites (Attoh-Kotoku, 2011).

2.9 The Moringa oleifera plant

Moringa olifera (*Moringa oleifera* Lam), according to (H.P.S. Makkar & Becker, 1997), belongs to the *Moringaeaec* family, is considered to have its origin in the north-west region of India, south of the Himalayan mountains. It is now widely cultivated and has become naturalized in many locations in the tropics (*Moringa oleifera* is indigenous to Northern India and Pakistan (BOSCH, 2004) and was introduced throughout the tropics and sub-tropics becoming naturalized in many African countries. *Moringa oleifera* tree can be used for food, medication and industrial purposes People use its leaves, flowers and fresh pods as vegetables, while others use it as livestock feed This rapidly-growing tree also known as horseradish tree or drumstick tree was utilized by the ancient Romans, Greeks and Egyptians. All parts of the *Moringa oleifera* tree are edible and have long been consumed by humans. Fuglie (2001) reported the many uses of *Moringa oleifera* as follows: alley cropping (biomass production), animal forage (leaves and treated seed- cake), biogas (from leaves), domestic cleaning agent (crushed leaves), blue dye (wood), fertilizer (seed-cake), foliar nutrient (juice expressed from the leaves), green manure (from leaves), gum (from tree trunks), honey and sugar cane juice- clarifier (powdered seeds), honey (flower nectar), medicine (all plant parts), ornamental plantings, biopesticide (soil incorporation of leaves to prevent seedling damping off), pulp (wood), rope (bark), tannins for tanning hides (bark and gum), and water purification(Powdered seeds). The cytokinine-type hormones extracts of *Moringa oleifera* leaves in 80% ethanol as a foliar spray can be used according to Foidl, Makkar, and Becker (2001) to accelerate the growth of young plants such as soyabean, blackbean, maize, onion, sorghum, tomato, coffee, and sugar cane.

Moringa oleifera leaves have also been shown to increase breast milk production. In many Asian and African countries (Fuglie, 2001) women consume *Moringa oleifera* leaves to enhance breast milk production. *Moringa oleifera* leaves have very strong antioxidant activity.

2.9.1 Nutritional value of *Moringa oleifera*

A prolonged and good-quality food supply is essential for the development of any stable community. Moreover, this statement seems reasonable in light of the fact that 1 tablespoon of *Moringa oleifera* leaf powder contains 9.9%–13.6% of the daily CP requirement of children and breast-feeding mothers. It has also been reported that the amino acid profile of *Moringa oleifera* leaves meets the standards of the World Health Organization *Moringa oleifera* leaves have higher amounts of all amino acids than are required for children, according to FAO reference protein levels (H.P.S. Makkar & Becker, 1997). Methionine and cysteine contents in raw *Moringa oleifera* leaves and extracted *Moringa oleifera* leaves are 14.14 and 8.36 mg g^{-1} of DMI, respectively, while nonfat dry milk and dry whole milk contain 12.41 and 9.03 mg g^{-1} (methionine + cysteine), respectively, which are less than levels in *Moringa oleifera* raw and extracted leaves.

Some plant leaves have been used as feedstuffs for rabbits and other animals as a partial substitute for the conventional grains and forages. *Leucaena leucocephala* has been successfully used in rabbit diets when incorporated in low levels In an experiment to determine the nutritional potential of two leafy vegetables (*Moringa oleifera* and Ipomoea batatas), Oduro *et al*. (2008) reported that *Moringa oleifera* leaves contained crude protein 27.51%, crude fibre 19.25%, crude fat 2.23%, ash 7.13%, moisture 76.53%, carbohydrates 43.88%, and caloric value 1296.00 kJ/g (305.62 cal/g).Calcium and Iron content in mg/100 g (DM) were 20.09 and 28.29, respectively. They concluded that *Moringa oleifera* leaves could contribute to the nutrient requirements of animals and should be strongly recommended in Ghana. *Moringa oleifera* leaves could serve as a valuable source of nutrients for all age groups. For example, in Haiti and Senegal, health workers have been treating malnutrition in small children, pregnant and nursing women with *Moringa oleifera* leaf. The leaves are known to be great source of vitamins and minerals being served raw, cooked or dried. Fugile (2001) reported that 8 g serving of dried leaf powder will satisfy a child within ages 1 - 3 years with 14% of the protein, 40% of the calcium, 23% of the iron, and nearly all vitamin A that the child needs in a day. One 100 g portion of leaves could provide a woman with over a third of her daily need of calcium and give her important quantities of iron, protein, copper, sulphur, and B- vitamins. It is estimated that only 20 - 40% of vitamin A content will be retained if leaves are dried under direct sunlight, but that 50 - 70% will be retained if leaves are dried in the shade.

The nutritional characteristics of the *Moringa oleifera* tree are excellent so it can easily be used as a fresh forage material for animals. The leaves are rich in protein, carotene, iron and ascorbic acid and the pod is rich in the amino acid lysine. In an experiment where extracted and unextracted leaves of *Moringa oleifera* were used as a component of animal feed, Makker and Becker (1996) analyzed these samples for nutrients and antinutrients. The extracted and unextracted *Moringa oleifera* leaves gave crude protein values of 43.5 and 25.1% respectively, suggesting that both the extracted and unextracted leaves are good sources of protein for livestock. As expected, the crude protein and fibre contents of the extracted leaves were higher than those of the unextracted leaves due to the loss of some cell solubles and lipids during the treatment with 80% ethanol. The crude protein, crude lipids and ash values of 26.4%, 6.5% and 12%, respectively were reported for the unextracted leaves by Gupta *et al*. (1989). Also, higher levels of NDF (28.8%) and ADF (13.9%) were reported,.

However, the CP value obtained in this study differs from values reported by other authors. For instance, Makkar and Becker (1996) obtained CP values of 25.1 and 26.4% for *Moringa oleifera* respectively. Variability in the nutrient content of browses has been attributed to within species differences, plant parts, season, harvesting regime, location, soil type and age (Norton, 1994). The variations in the reported values may be due to differences in agro-climatic conditions or to different ages of trees, and possibly not due to different stages of maturity, since tender green leaves have been used in both studies.

Recently, there has been interest in the utilization of *Moringa oleifera* (*Moringa oleifera*) commonly called horseradish tree or drumstick tree, as a protein source for livestock (Makker and Becker, 1997). *Moringa oleifera* leaves have quality attributes that make it a potential replacement for soyabean meal or fish meal in non-ruminant diets. *Moringa oleifera* can easily be established in the field, has good coppicing ability, as well as good potential for forage production. Furthermore, there is the possibility of obtaining large amounts of high quality forage from *Moringa oleifera* without expensive inputs due to favourable soil and climatic conditions for its growth. The advantages of using *Moringa oleifera* for a protein resource are numerous, and include the fact that it is a perennial plant that can be harvested several times in one growing season and also has the potential to reduce feed cost. *Moringa oleifera* is in the group of high-yielding nutritious browse plants with every part having food value. Despite the high crude protein content of *Moringa oleifera* leaf meal, there is little information available on the use of this unconventional feed resource, especially as an alternative protein supplement for rabbit production.

In addition, it has been reported that total carotenoids' mean concentration is 40,139 μg 100 g^{-1} of fresh weight in *Moringa oleifera* leaves, out of which 47.8% (19,210 g kg^{-1}) corresponded to β-carotene *Moringa oleifera* leaves contain 379.83 mg kg^{-1} iron, 18,747.14 mg kg^{-1} calcium, 1121 mg kg^{-1} phosphorous, 22.05 mg kg^{-1} zinc, and 20.5 mg kg^{-1} crude fiber on dry matter basis (Foidl et al., 2001; Fuglie, 2001; H.P.S. Makkar & Becker, 1997). Moreover, *Moringa oleifera* leaves are also a good source of oxalic acid contents (11.2 mg g^{-1}) , which are not harmful to the immune system (H.P.S. Makkar & Becker, 1997).

Iron and zinc elements are said to act as a brain activator. It has been repeatedly found in the literature that *Moringa oleifera* leaves contain 25 times more iron than spinach Spinach leaves have good iron quantity but its absorption is very limited, while in *Moringa oleifera* leaves the absorption level is better than in other leafy vegetables. Iron in the presence of zinc activates the brain more sharply. Moreover, the high concentrations of these elements or compounds are relevant because it has been reported that about 2 billion people worldwide, especially in developing countries, have deficiencies of some of these nutrients, mainly of vitamin A and Fe Moreover, *Moringa oleifera* fresh pods also considered as a rich source of Ca (1248 mg kg^{-1}) , P (1757 mg kg^{-1}), K (15416 mg kg^{-1}), and Na (1709 mg kg^{-1}). Researchers and nutritionists have reported these *Moringa oleifera* parts as beneficial nutritional supplements for livestock improving their nourishment and metabolic activities (Foidl et al., 2001)

2.10 The Pigeon pea plant

Pigeon pea (*Cajanus cajan*), is a short-lived perennial member of family Fabaceae and it is invariably cultivated as an annual crop. The centre of origin is most likely Asia, from where it traveled to East Africa. *Cajanus cajan* is an often cross-pollinated (20 - 70%) crop with 2n = 2x = 22 diploid chromosome number. It is the fourth important pulse crop in the world and predominantly cultivated in the developing countries (FAO, 1994)

Cajanus cajan is an important source of plant proteins for human beings and livestock in the tropics and semi-arid tropics of the world. Its seeds are considered non-conventional poultry feed and are available potential protein source and resource that can avail an option or protein substitute in poultry feeding in many parts of the country.

Cajanus cajan is a rich protein source in which, crude protein (CP) varies from 12 to 32%. It is also rich in carbohydrates, minerals and sulphur-containing amino acids, methionine and cysteine.

Feed value of *Cajanus cajan* for fodder is excellent with 10-15 % CP on the green material DM. But *Cajanus cajan* is not always readily accepted by stock that has not acquired a taste for it Leaves remain on the plant throughout the dry season. Yields of fodder vary widely with the ecological conditions and the care given to the crop. Tall perennial varieties are amenable to trimming as fodder, but also as green manure (2.6 % nitrogen). The effect of *Cajanus cajan* on soil fertility has been studied in detail. Due to its deep rooting system *Cajanus cajan* offers little competition to associated crops and is therefore much used in intercropping systems with cereals such as millet, sorghum and even maize, it also provides a good means to improve fertility in fallows. Fodder yields may reach 25 t DM / ha / yr in close to optimal conditions without fertilization, and 38 t with a 100 kg nitrogen and phosphorus applications. Grain yields may vary from 1 to 10 t /ha/yr of shelled grain. Naturally, under the conditions of the South Sahel the expected results are much lower: 2 - 4 t DM of fodder and stalks plus 600 - 1,200 kg of clean beans / ha / yr. As a human food, *Cajanus cajan* produces, under the Sahel conditions, some 650 kg of beans /ha/yr, having some 25 % crude protein, with a well-balanced composition in amino-acids, save for methionine and cystine which are too low for an ideal human food. The pods may be consumed green, used as green peas, or as ripe beans, like cowpea. Nitrogen fixing ability for a density of 7,000 - 10,000 plants ha is of the order of 100 - 120 kg N_2 / ha / yr (ca 15 mg / pl / yr). The crop has long been used as a windbreak and shade for young coffee trees, forest seedling nurseries and vegetable beds, and is an important honey-producing plant. The canning of green *Cajanus cajan*s is a major industry in Puerto Rico and Trinidad. (Waterman *et al* 1994)

The nutritional profile of *Cajanus cajan* is interesting for poultry, with values close to field pea widely used in animal feeding. Anti-nutritional factors are present but in a lesser quantity than for other legume seeds, leading to higher nutritive value In particular the toxicity assessed by the effect of *Cajanus cajan* on organ weights or blood parameters is generally low. However a high variability in nutritional value is reported in literature, with sometimes low digestibility.

- Variation in composition and ANFs. For examples white-seeded varieties are sometimes claimed to have a higher nutritional value than dark ones (Odeny, 2007) even if in some cases experiments fail to confirm this
- Formulation of diets. In some cases the level of amino acids (particularly methionine) is deficient in experimental diets, which can lead to mis-interpretation of results.
- Technological treatments. Thermal treatments seem to have a positive effect on protein digestibility and energy value.

Cajanus cajan is very heat-tolerant prefers hot moist conditions and under Hawaiian conditions grows between 18 and 30°C.It can also grow at temperatures above 35°C under adequate soil conditions of moisture and fertility. It does not tolerate frost, but will grow in temperatures to just above frost level. *Cajanus Cajon* will seed as a perennial at 1840 m down to a minimum night temperature of 10°C Tall plants may escape light frosts because of the height of the foliage. *Cajanus cajan* is one of the most drought tolerant legume crops, with a wide range of rainfall tolerance, but prefers more than 625 mm and in elevated areas exceeding 2000 mm cold nights and cloudy weather interfere with fertilization of flowers. It flowers well where rainfall is 1500 to 2000 mm. On deep, well-structured soil will grow where rainfall is 250 to 375 mm Tolerates a wide range of soils, from sands to heavy black clays. Tolerates a wide range of pH, but the most favourable range is pH 5.0 to 7.0. It is sensitive to salt spray, high salinity and to water logging. It can grow in sand provided it does not contain more than 0.0005 g of sodium chloride per gram of soil.

The grain is used for human and stock feed. Straw, husks and screenings are useful roughages. Nearly 2 350 000 hectares are grown in India yearly. In one single harvest in Hawaii, the fully podded tops gave 11.2 tonnes of green forage, 4.97 tonnes of dry matter and 400 kg Protein per hectare Cattle fed wholly on pigeon-pea pasture have gained in weight from 0.7 to 1.25 kg per head per day at a carrying capacity of 1 to 3.75 beasts/ha, and live weight gains of 200 to 500 kg per hectare per annum have been recorded..

Cajanus cajan is harvested for hay and for milling for meal in Hawaii when a large percentage of pods are mature probably two-thirds to three quarters of the pods in sight because a large part of the nutritive value of the plant is contained in the seed. Harvest not more than the upper third of the plant to avoid the woody base unless the plant is spindly. Cure on the cut surface of the plant which has just been harvested for six to eight days and then mill into meal. Pigeon-pea hay is an effective substitute for more expensive industrial concentrates.

2.11 Phytochemical factors of *Moringa oleifera* and *Cajanus cajan*

Phytonutrients unlike the macro and micro nutrients are needed for growth and metabolic activities are considered non-essential. The absence of phytochemicals in the diet has no detrimental effects on the nutritional status. However, research has shown that they play important roles related to better health when they are in the diet They may impart flavour to the food and are all plant based; they may be derived from plant foods such as fruit and vegetables. In nutrition phytochemicals are put into three main classes namely phytochemicals, medicinal plants, herbs and spices (Moyo *et a*l 2011)

Some of the phytochemicals found in the *Moringa oleifera* leaves with health benefit include the carotenoids, flavonoids, terpenes and phytosterols (Esubonteng, 2011) whiles those found in *Cajanus cajan* includes flavonoids, and terpenes.

Carotenoids

Carotenoids are fat-soluble plant pigments found in certain fruits and vegetables such as carrots and are responsible for the red, orange and yellow colours, some of which are important to human health. The most common carotenoids in the diet are alpha-carotene, beta-carotene, beta cryptoxanthin, lutein, zeaxanthin, and lycopene. It was shown in comparative studies of the nutritional quality of four species of the genus that *Moringa oleifera* has the highest beta-carotene content (Waterman *et al* 1994). Though the role carotenoids play in the human body are not well understood, they also act as antioxidants scavenging free radicals. In this way the damage that would be caused by free radicals to cell membranes through oxidation is prevented. The most abundant carotenoid is the beta-carotene of carrots and sweet potato, together with alpha-carotene and beta-cryptoxanthin are converted to retinol (vitamin A) in the body. Vitamin A effects are important for maintaining good vision, a healthy immune system, and strong bones. Vitamin A also helps turn on and off certain genes (gene expression) during cell division and differentiation. Lutein, zeaxanthin and lycopenes are not converted to vitamin A.

Flavonoids

Flavonoids are phenolic derivatives and they include flavones, flavonols, isoflavones, catechins, quercetins and anthocyanidins. Phytochemical screening of *Moringa oleifera* leaves indicated the presence of flavonoids in its ethanolic extract (Makkar and Becker 1996) and a quantitative analysis with hydro alcoholic extract estimated at 27µg/mL of flavonoid content Most often than not, many flavonoids have diverse biochemical roles and act as antioxidants. Nutritionally, they help in preventing cardiovascular and cancerous conditions. Some of these flavonoids may act to decrease the level of total and LDL-cholesterol in the blood, while others may decrease free-radical activities, thereby protecting LDL from oxidation as well as helping to protect the walls of the arteries. This is why substances abundant in flavonoids (green tea, onions, chocolate and red wine) are recommended to be

beneficial in health.

Flavonoid has been referred to as nature's biological response modifiers because of strong experimental evidence of their inherent ability to modify the body's reaction to allergy, virus and carcinogens. They show anti-allergic, anti-inflammatory, anti-microbial and anti-cancer activities. Some flavonoids have also been reported to behave like some coumarins in the inhibition of giant cell formation in HIV-infected cell cultures

Terpenes

Terpenes are cyclic compounds with 10, 15, 20 or correspondingly more carbon atoms. They also act as antioxidants and are important in cancer prevention though they may inhibit some enzyme activities (Moyo *et al* 2011) Terpenes are constituents of the essential oil fractions which occur in the leaves of *Moringa oleifera* and have been implicated in the antifungal activity against dermatoph and also are found to be efficacious antibacterial and antifungal These antioxidant and antimicrobial properties are benefits that may be gained from the use of the leaf powder.

Terpenes are very important group of organic compounds that have been reported as potent drugs used in the treatment of a wide range of ailments. They can be simple essential oils to the more complex triterpenes and teraterpenes. The most rapidly acting anti-malarial, artemisinin and its derivatives are terpenes (Makker and Becker 1997) The presence of terpenes will encourage further research for possible new drugs leads .

Phytosterols

Phytosterols are known to lower LDL thus reducing the risk of developing heart diseases. Phytosterols appear to block the absorption of cholesterol in the digestive tract, which in turn lowers the level of total and LDL cholesterol in the blood The *Moringa oleifera* leaf contains the phytosterol called beta-sitosterol a plant sterol with close chemical resemblance to cholesterol which enables it to block the absorption of cholesterol by competitive inhibition (Prashith *et al* 2010). The beta-sitosterol of the *Moringa oleifera* leaf was concluded to be responsible for its hypolipidaemic and as well as antioxidant properties.

2.12 Anti-nutritional factors of *Moringa oleifera* and *Cajanus cajan*

Anti-nutritional factors are compounds mainly organic, which when present in a diet, may affect the health of the animal or interfere with normal feed utilization (Nuhu, 2010).

Anti-nutritional factors may occur as natural constituents of plant and animal feeds, as artificial factors added during processing or as contaminants of the ecosystem . Ingestion of feed containing such substances induces, in some cases, chronic intoxication and in others interferes with the digestion and utilization of dietary protein and carbohydrate and also interferes with the availability of some minerals, thus feed efficiency and growth rate and, consequently, the production of the edible products (Nuhu, 2010).

Although anti-nutritional factors are present in many conventional feeds, they are more common in most of the non-conventional feeds. (Nuhu 20110) classified the various antinutritional factors (ANFs) in feedstuffs according to their chemical nature and their activity in animals as:

1. Chemical nature, in this category are acids, enzymes, nitrogenous compounds, saponins, tannins, glucosinolates and phenolic compounds
2. Factors interfering with the digestion and utilization of dietary proteins and carbohydrates, for example, tannins, trypsin or protease inhibitors, saponins, and haemagglutinins
3. Factors interfering with the availability of minerals are for example, phytates or phytic acid, oxalates or oxalic acid, glucosinolates and gossypol

Cyanogenic glycoside, tannins, saponins, phytates and alkaloids are some of the secondary metabolites or anti-nutritional factors that occur in the *Moringa oleifera* plant (Esubonteng, 2011) whiles those found in *Cajanus cajan* includes alkaloids, saponnins, tannins among others their advantage and disadvantages are discussed.

Cyanogenic glycosides

Cyanogenic glycosides are rapidly degraded in the plant cell to corresponding aldehyde or ketone, cyanide and sugar and it is the cyanide (HCN) portion that is toxic to the human system. This is an anion that blocks the electron transport chain by reacting with the ferric form of cytochrome aa3 and thus acts as an inhibitor of respiration. The symptoms of toxicity include headache, salivation nausea, anxiety, confusion, vertigo, convulsions, paralysis, unconsciousness coma, cardiac arrhythmias, hypotension, and respiratory failure A report in Nigeria of people poisoned from consuming cassava product stated that they presented with vomiting, abdominal pain, became comatose with acute renal failure and death due to cardio- pulmonary arrest (Vetter, 2000). However, the *Moringa oleifera* leaves are absolutely free from cyanogenic glycoside (H.P.S. Makkar & Becker, 1997) thus assuring the absence of HCN poisoning on consuming the leaf product as food. Negligible amounts were detected in the twig and stem of the plant.

Tannins

Tannins, a collective term refer to a variety of plant polyphenols used in the tanning industry. The phenolic group of tannins binds strongly to proteins through hydrogen bonding and this bond cannot be cleaved by digestive enzymes. This prevents the bioavailability of nutritional protein in such diets to the body. They also have a very sharp and unpleasant taste thereby reducing the acceptability of the diet. Tannins occur in innocuous amount of 1.4% in the *Moringa oleifera* leaf with no condensed tannins. Some methods of detection did not show its presence in the leaf if any at all (Foidl et al., 2001).

Tannins which are complex polymeric phenols having molecular weight greater than 500 are natural constituents of many plants, and grouped into two forms-hydrolysable and condensed tannins Hydrolysable tannins are potentially toxic and cause poisoning if large amounts of tannin-containing plant material such as leaves of oak (Quercus *spp*.) and yellow wood (*Terminalia oblongata)* are consumed (Makkar *et al*. 1997) reported that tannins can inhibit the activities of rumen microbes.

The tannins form complexes with protein, cellulose, hemicelluloses, lignin and starch and interfere with their optimum utilization in the digestive tract and systems. Protein sources of plant origin containing high amounts of tannins and in particular hydrolysable tannins should be used with caution (Becker and Makkar, 19997). reported that soaking and washing removes substantial amount of tannins and this is usually accompanied by some loss of dry matter. Tannins have been found to affect digestibility and therefore rate of utilization of dietary nutrients in both ruminants and non-ruminants

Tannins sacs are known to be common in Caesalpinoideae and known to exhibit antiviral, antibacterial and anti-tumor activities. It was also reported that certain tannins are able to inhibit HIV replication selectively and is also used as diuretic.

Plant tannins are also source of commercial tannic acids and tanning agents.

Saponins

Saponins are a class of glucosylated steroids named after their soap-like property. They act as detergents because of the hydrophilic polysaccharide and hydrophobic steroid side chains thereby dissolving the cell membrane of fungi and causing haemolysis of red blood cells in animals. They are used in the pharmaceutical industry as component in synthesizing contraceptives and also as medicine against heart disease in low doses. Saponin content of 80 g/Kg was found in the leaves of *Moringa oleifera* and this did not produce any haemolytic effects (H.P.S. Makkar & Becker, 1997).

Saponins are bitter in taste and hence reduce palatability; they are also haemolytic and alter the permeability of cell membranes and produce toxic effects on organized tissues when ingested. Lucerne, white and red clovers, mahua seed cake and soyabean are rich sources of saponins. Soaking and washing in water is quite effective in removing a greater proportion of saponins.

Saponins from plants have long been employed for their detergent properties. It is used as mild detergents and in intracellular histochemistry staining to allow antibody access to intracellular proteins. In medicine, it is used in hypercholesterolaemia, hyperglycaemia, antioxidant, anti-cancer, anti-inflammatory and weight loss etc.

Phytates

Phytate is the major phosphorus compound in plants and is important for phosphate storage in cereal grains, especially as its calcium-magnesium salt, phytin. It occurs in many plant seeds, grains, fruits and vegetables. The minerals in these products are therefore not bio-available when consumed thus can lead to mineral deficiencies of calcium, magnesium, manganese, copper, iron and zinc. A phytate content of 3.1% was reported to be present in the *Moringa oleifera* leaves (Foidl et al., 2001; H.P.S. Makkar & Becker, 1997). The leaves are rich in minerals and the bioavailability may be reduced due to phytate interaction.

Phytates (salts of phytic acid) are found in almost all feeds of plant origin. The phytates are present in association with protein and generally high in protein feeds e.g. groundnut cake, soyabean cake and sesame cake. Phytic acid possesses high chelating ability and in plants, it is found as phytates of many minerals which are mostly not available to monogastrics as they lack the enzyme phytase. The use of the enzyme phytase can make minerals such as phosphorus available to monogastrics

Alkaloids

Alkaloids are synthesized from amino acids and contain heterocyclic rings with one or several N atoms. They can be used as stimulants, narcotics, poison and medicine in the extracted form. They are classified based on the ring structure present with cocaine (tropane), morphine, caffeine, atropine and nicotine. Because of the effects they have in the body, the amount in a plant product is of biological interest. Some of these alkaloids are used in the synthesis of pain killers while other people use it because of the euphoric effect they give. Without tolerance, the alkaloids on initial ingestion or use result in nausea, dizziness, and muscular weakness (Moyo *et al* 2011) The bark of *Moringa oleifera* is also a repository of tannins used in the tanning industry. The root-bark was commonly used as a condiment or garnish but this practice is not recommended due to certain toxic components. The alkaloids moringine and moringinine have been identified in the root-bark of the plant. It also contains a bacteriocide called spirochine (Maroyi, 2006).

Though some secondary metabolites are toxic especially for human consumption, there are some that have beneficial roles in the body; the carotenoids, flavonoids and phytosterols. Parts of the *Moringa oleifera* plant have been used widely on many experimental grounds with appreciable results. Some of these experiments sought to exploit the fundamental function of the secondary metabolites produced by the plant.

For example, the seed powder of the plant has been used as coagulating agent in water purification where it binds particles and bacteria. This water is not harmful for drinking It has been used to spray crops (Foidl et al., 2001) and as an anti-bacterial agent against human pathogens (Prashith Kekuda et al., 2010)

The *Moringa oleifera* leaves have some amounts of tannins, saponins, phytate but no proteinase inhibitor, amylase inhibitor, lectins and cyanogenic glucoside (Foidl *et al*., 2001). Nonetheless the pod, seed, flower, stem and roots contain various amounts of biologically important compounds. Moringinine acts as cardiac stimulant, produces rise of blood-pressure, acts on sympathetic nerve-endings as well as smooth muscles all over the body, and depresses the sympathetic motor fibres of vessels in large doses only .

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental Location

The experiment was carried out at the Animal Research Institute (ARI) of the Council for Scientific and Industrial Research (CSIR) at Nyankpala, in the Tolong-Kumbungu District of the Northern Region. Nyankpala is located at longitude 00 581 4211 W and latitude 90 251 4111 N and at a height of 183 m above sea level and in the dry savanna ecological zone of Ghana (SARI, 2007). It has a unimodal rainfall pattern that begins in late April and ends in October. The mean annual rainfall is 1043 mm. Temperatures normally fluctuate between 15^{o} C (minimum) and 42 ^{o}C (maximum) with a mean annual temperature of 28.3 ^{o}C. The mean annual day time relative humidity is 54% (SARI 2007). The Nyankpala area experiences dry cold harmattan winds from November to February and a period of warm dry conditions from March to mid-April. The dry season therefore stretches from November to late April.

A survey was also conducted among 100 livestock farmers in the Yendi municipality to access the extent to which *Moringa oleifera* and *Cajanus cajan* are used as livestock feed. The interview included both men and women involved in livestock farming. This was considered because the Yendi Municipality has over thousand livestock farmers who formed the sample frame. The first 100 farmers which represented 10 % of the farmer population were simple randomly selected based on the following criteria: each of them had at least 4 sheep, each of them occasional feed their livestock in the dry season, and each of them has at least seen and heard about *Cajanus Cajan* and *Moringa Olifera* but only differed from not consciously using *Cajanus Cajan* and *Moringa Olifera* as a supplementary feed for dry season livestock production.s

3.2 Experimental Animals

Twelve young Djallonke rams with a mean age of 12 ± 2 months were used. The average live body weight was 12.8 ± 2.4 kg at the start of the work and quarantined for 30 days using the routine treatments for animals. The animals were randomly distributed to three treatment diets at the beginning of the experiment. The adjustment period was three weeks (Konlan *et al* 2012) after which measurements were taken for one week.

Housing

Animals were housed in a pen and fed individually. The floor of the pen was made of concrete and the divisions were done with wood. The area of each pen was 4.5 × 2 m with a height of 3.0 m. The wall was made of concrete blocks and roofed with aluminium sheets. There were ventilation holes for free movement of air in and out of each pen. The experimental duration was 8 months; starting from March 15 2013 to October 28 2013

3.3 Experimental layout and Treatments

The experiment was laid out in a complete randomised design (CRD) with three treatments (Table 1).

Table 1: Experimental treatments

Treatment	Number of replications
T1-Control (diet without T2 & 3) on dry matter basis	4
T2- *Cajanus cajan* on dry matter basis	4
T-3 *Moringa oleifera* on dry matter basis	4

Dried *Cajanus cajan* husk was dried, pounded and fed to animals at 3% of their body weight to constitute the second treatment T2, (*Cajanus cajan*). Shade dried *Moringa oleifera* leaves were also stored and fed to animals at 3% of their body weight to constitute the third treatment T3 (*Moringa oleifera*). The amount of the basal diet offered was more than the standard requirement of 0.46 kg/day for sheep weighing 20 kg and growing at 0 to 50 g/day This was given to allow left over for intake measurement.

3.4 Data collection

Data were collected in the second week of every feeding period. Feed offered and refusals were weighed daily to determine measurement of feed intake. Live weight was measured every two weeks in the morning before feeding to determine weight gain. The animals were bled between 06:30 and 07:30 h GMT using a needle and a syringe before the start of the experiment and at the end of the experiment from the jugular vein and the blood samples were analyzed to determine the effect of the dietary treatments on some blood constituents. (WBC, HB and blood sugar levels)

3.4 Statistical analysis

The data collected were subjected to one- way analysis of variance (ANOVA) using Genstart Computer Software Programme and means compared using least significant difference. Results were displayed in tables and charts for easy understanding.

CHAPTER FOUR

RESULTS

4.1 Availability of *Moringa oleifera* and *Cajanus cajan* as livestock feed

Hundred farmers were interviewed on their knowledge on the availability and use of *Cajanus cajan* and *Moringa olifera* as livestock feed (Table 3). Most of the farmers owned their livestock and the livestock were housed and fed with various diets

Table 2: Survey on the use of *Moringa olifera* and *Cajanus cajan* as livestock feed and farmer knowledge on its use.

FACTORS	VARIABLES	PERCENTAGES (%)
Ownership of livestock	Yes	80
	No	20
Housing of animals	Yes	60
	No	40
Feeding of animals	Yes	60
	No	40
Moringa and *Cajanus* availability	Yes	85
	No	15
Parts of plants	Leaves	80
	Vine	20
Nature of *Moringa oleifera*	Fresh	75

used:		
	Dried	25
Nature of *Cajanus cajan* used	Fresh	25
	Dried	75
Season feeding is done	Raining	70
	Dry	30
Sources of feed *Moringa oleifera*	From Farms	30
	From Plantations	70
Sources of feed *Cajanus cajan*	From Farms	100
	From Plantations	0

The two main plant parts used in feeding livestock were leaves and vines (which represented 80 and 20 % respectively). (85 % of the farmers generally indicated the availability of *Moringa oleifera* and *Cajanus cajan* especially in the rainy season and farmers could readily harvest it in the communities. *Moringa oleifera* was mostly harvested from plantations (representing 70 % of farmers) whilst *Cajanus cajan* was from farms (representing 100 % of farmers). Mostly *Moringa oleifera* was fresh fed (representing 75 % of the farmers) whilst *Cajanus cajan* was dried fed to animals (representing 25 % of farmers).

4.2 Knowledge base of farmers

Hundred farmers were interviewed in the farmer knowledge survey (Table 4.2.) on *Moringa oleifera* and *Cajanus cajan* as livestock feed, most of them had knowledge that *Moringa oleifera* and *Cajanus cajan* are liked by animals (representing 75 % of farmers) and (40 % of them indicated) it improves on their growth.

Table 3 Knowledge of famers regarding the use of *Moringa oleifera* and *Cajanus. Cajan* as a livestock feed

FACTORS	VARIABLES	PERCENTAGES (%)
Farmers knowledge on *Moringa*	Yes	40

oleifera and *Cajanus cajan* as livestock feed		
	No	60
Improved growth of livestock by *Moringa oleifera* and *Cajanus cajan*	Yes	40
	No	60
Likeness of *Moringa oleifera* and *Cajannus cajan* by livestock	Yes	75
	No	25

Farmers were interviewed to ascertain the knowledge they have regarding *Moringa oleifera* and *Cajanus cajan* as animal feed. Of all the farmers interviewed, 40% responded affirmative while 60 % said they did not have knowledge that *Moringa oleifera* and *Cajanus cajan* (could) be used as a livestock feed.

4.3 Evaluation of the effect of *Moringa oleifera* and *Cajanus cajan*

An evaluation of the effect of *Moringa oleifera* and *Cajanus cajan* using parameters such as haemoglobin levels, blood sugar levels and white blood count on the West African Dwarf sheep (did not indicate any significant difference, table 4.3

Table 4 Blood profile of Djallonke sheep fed *Moringa oleifera* and *Cajanus cajan* diets

Parameter	T1	T2	T3	Sign.
Blood sugar, mmol	2.87	3.30	3.13	NS
Haemoglobin, g/dl	9.20	11.80	11.43	NS
WBC X10^9 /l	17.13	16.70	15.80	NS

NS- Not significant

A proximate analysis on the feed being used as the supplement to ascertain the crude protein, crude fibre, ether extract, ash, moisture, NFE and DM content of the feed as shown in Table 4.4

Table 5 Proximate analysis (%) of *Moringa oleifera* and *Cajanus cajan* leaves

Feedstuff	Crude protein	Crude fibre	Ether extract	Ash	Moisture	NFE	DM
Moringa. oleifera	30.8	3.45	8.00	6.65	25.50	25.60	74.50
Cajanus cajan	9.8	26.80	3.00	6.65	15.50	38.25	84.50

4.4 Haematological indices of West African Dwarf (WAD) sheep fed

The mean values of the blood sugar were 2.87, 3.30 and 3.13 mmol for the T1, T2 and T3 treatments respectively. There were no significant (P > 0.05) differences among treatment means (see Table 4.4). Also, the values for the haemoglobin were 9.2, 11.8 and 11.40 g/dl for T1, T2 and T3 dietary treatments respectively while values for the white blood cells were 17.13, 16.70 and 15.80 X10 ^{9}/l for T1, T2 and T3 diets respectively. The values were similar (P > 0.05) among the dietary treatments.

4.5 Mineral Composition of *Moringa oleifera* and *Cajanus cajan* leaves

With the exception of zinc, calcium and sodium, *Moringa oleifera* contains substantial higher amounts of the other nutrients than *Cajanus cajan*. *Moringa oleifera* leaves had 58.33%, 33.33%, 14.29%, 19.14% and 17.02% more for copper, iron, manganese, potassium and phosphorus respectively than that of *Cajanus Cajon,* (Table 4.5).

Table 6: The mineral composition of *Moringa oleifera* and *Cajanus cajan* leaves

Macro-	Micro-minirals/mg/kg minerals/mg/100g								
Feedstuff	Cu	Fe	Mn	Zn	Ca	Mg	K	Na	0.2 0.
Cajanus cajan	0.5	2.4	1.2	3	0.41	0.29	2.45	3 3	
Moringa oleifera	1.2	3.6	1.4	1.8	0.27	0.29	3.03	0.1 2	0.4

P

9

7

Samples of moringa and cajanus were tested to determine the level of anti-nutritive factors found in them and the results are shown below in Table 7.

Table 7: Anti-nutritional factors in *Moringa oleifera* and *Cajanus cajan* leave

Code	**Sample weight**	**Weight of dry extract**	**Weight of precipitate**	**% condensed tanins**
MOR 1	4.00	3.40	0.12	3.53
MOR 2	4.08	3.42	0.14	4.09
CJ 1	4.01	3.86	0.25	6.48
CJ 2	4.08	3.90	0.27	6.92

4.6 Growth performance of djallonke sheep on supplementation of *Moringa oleifera* and *Cajanus cajan* leaves

The growth performance of the sheep on the supplementation of *cajanus cajan* and *Moringa oleifera* (revealed significant differences between and among the treatments), table 4.7. It was observed that the mean feed given to animals (per treatment) varied with body weight and therefore, indicated significant difference, Table 4.8 although there was no significant difference within the amount (kg) of feed given to the animals.

Table 8: The growth performance of Djallonke on the treatment diets

Parameter	**T1**	**T2**	**T3**	**Sign.**
Mean final live weight, kg	21.62^{c}	31.00^{b}	35.88^{a}	*
Mean weight gain, kg	9.62^{c}	18.50^{b}	23.70^{a}	*
Average daily weight gain, g	43.00^{c}	82.60^{b}	105.80^{a}	*

**a, b, c : ** Values in the same row with different letters are significantly different (P < 0.05), sign.: level of significance, *: significant. a b c = Means in the same row with the same superscript are not significantly different ($P > 0.05$). T (1) = control, T (2) = *Cajanus cajan and* T (3) = *Moringa oleifera.*

4.6.1 Average Daily Weight Gain

(Average daily weight gained indicated variations with the highest daily weight gained of 105.80g recorded by T3, followed by T2 with 82.59g and T1 recording the least weight gained of 42.97g thereby indicating significant differences between the treatments, figure 4.1).

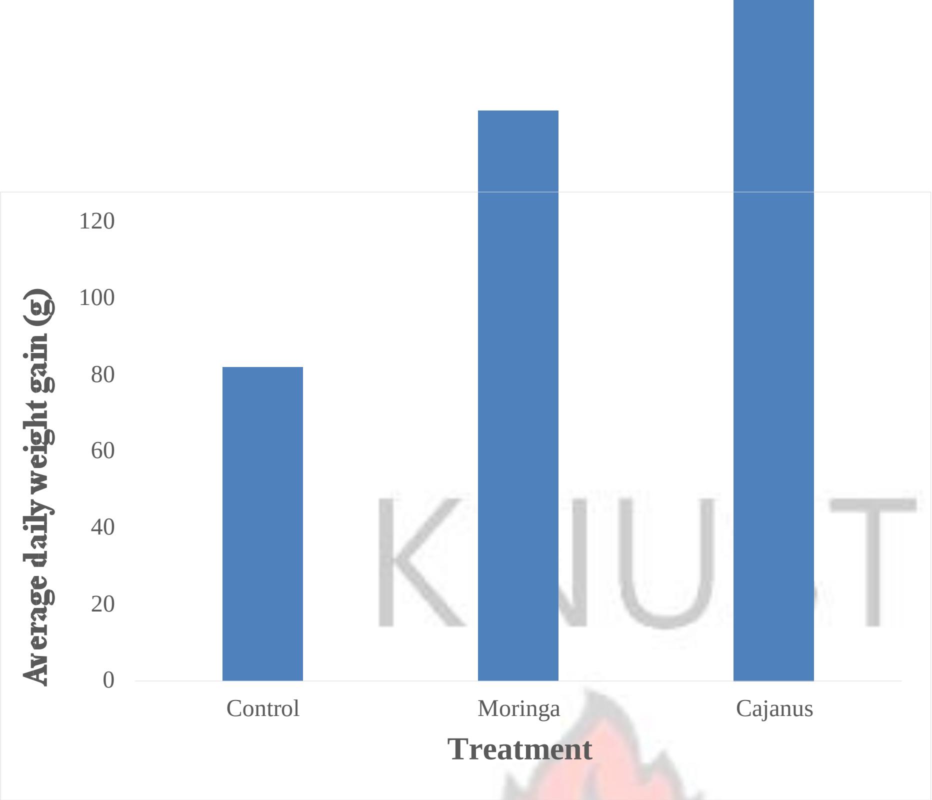

Figure1: Average Daily weight gain

4.6.2 Total weight Gain

The results showed total weight gained of 23.70, 18.50 and 9.62 respectively for *Moringa oleifera, Cajanua caja*n and the control. This revealed significant difference between the treatments, figure 4.2).

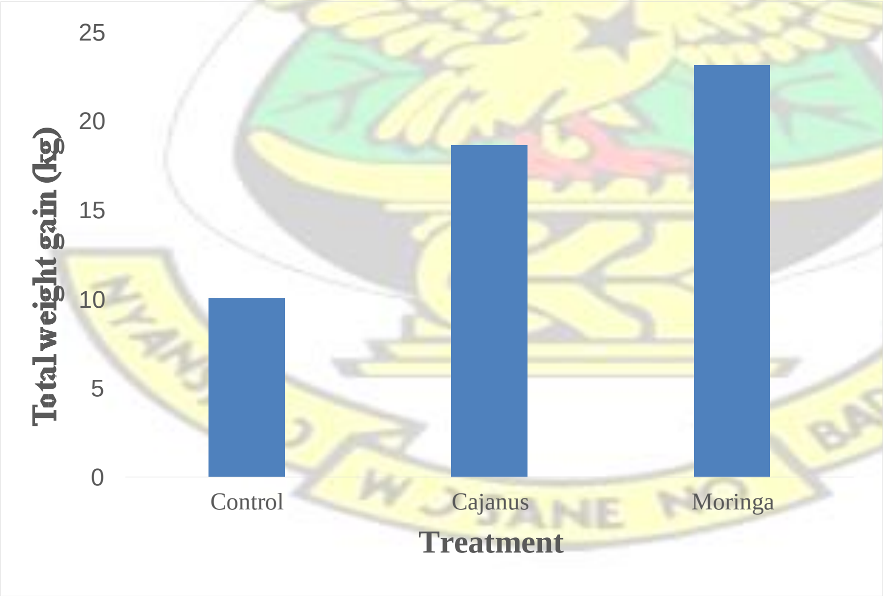

Figure 2: Total weight gain

4.6.3 Final Weight of Sheep

Statistically, significant difference ($p < 0.05$) existed among the treatments for final weight gained Sheep fed with *Moringa oleifera* feed (T3) recorded the highest final weight with a mean of 35.88 kg followed by *Cajanus cajan* feed (T2) having a mean of 31.00 kg and lastly by the control diet (T1) with the least mean of 21.62 kg, figure 4.3).

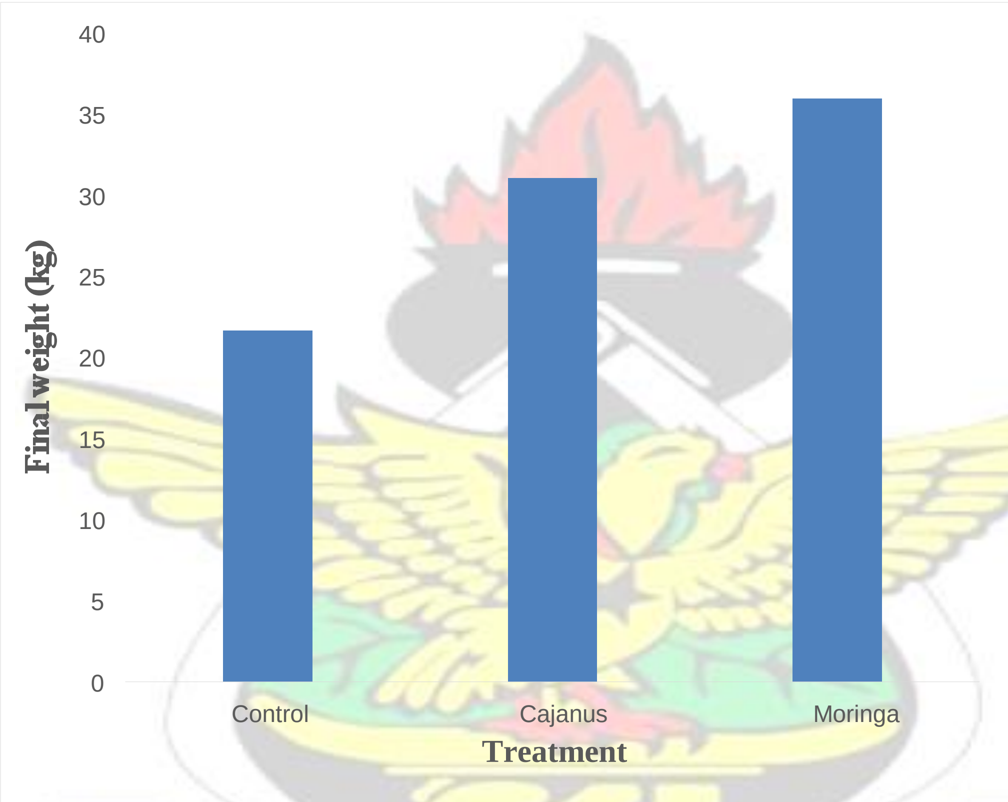

Figure 3: Final weight

CHAPTER FIVE

DISCUSSION

5.1 Availability of *Moringa oleifera* and *Cajanus cajan* as livestock feed

Eighty five percent of the respondents held the view that *Moringa oleifera* and *Cajanus cajan* were available and could be used as livestock feed whilst the response from 15% was no. The availability of *Moringa oleifera* and *Cajanus cajan* according to Fuglie (2001) are as a result of their being indigenous to Africa. *Moringa oleifera* is grown on the farm as alleys and in the backyard of most farmers and can therefore be easily accessed by farmers as feed for their animals. *Moringa oleifera* is also widely grown in plantations and leaves are available throughout the year for animals to feed on. (80 % of respondents indicated that the leaves were the major part of the plants used in feeding livestock whilst 20 % of them relied on the vines).

Majority of the farmers using the leaves as a feed stock increases milk production in livestock and provides very strong antioxidant activity (Makkar and Becker 1996)

5.1.1 Care for animals such as housing and feeding

The study revealed that, 80% of the livestock in the study area were owned by the farmers whiles 20% were care takers of the livestock. On the housing of the livestock, majority of the farmers interviewed during the study representing 60% provides housing facilities for the livestock whiles 40% do not. This conforms to a study by konlan and Avornyo, (2013), where they concluded that most farmers of livestock in the northern region housed their livestock. According to them, these farmers housed the livestock in the night and offer them some feed and allow them to go for free range whole day. Again Konlan and Avornyo, (2013) indicated that farmers who do not provide housing facilities for the livestock are not bothered where the livestock sleep at night but complain of livestock losses. The study indicated that 60 % of the respondents provided housing and fed their animals whilst 40 % do not.

5.1.2 Plant part used to feed livestock

The plant part of *Moringa olifera* used to feed livestock from the survey was the fresh part with 75% of the farmer's attesting to whiles 25% of the farmers used the dried part to feed the livestock. This was different for the *Cajanus cajan* as majority of the farmers used the dried part of the plant to feed the livestock representing 75% whiles 25% used the fresh part. 70% of the farmers fed their livestock with *Moringa olifera* and *Cajanus cajan* during the raining season whiles 30% fed livestock during dry season.

5.1.3 Source of feed

From the study, it was revealed that majority of the farmers obtained the *Moringa oleifera* from plantations with a percentage of 70% whilst 30 obtained the *Moringa oleifera* from the farm. Again 100% of the farmers obtained the *Cajanus cajan* from the farm.

5.1.4 Knowledge of livestock farmers on *Moringa oleifera* and *Cajanus cajan* as livestock feed supplement

Farmers were interviewed to ascertain their knowledge on *Moringa oleifera* and ss*Cajanus cajan* as livestock feed and the study revealed that 60% of the farmers had no knowledge on *Moringa oleifera* and *Cajanus cajan* as livestock feed whilst 40% of them knew. Again 60% of the farmers had no knowledge that *Moringa oleifera* and *Cajanus cajan* can improve growth of livestock but 40% had knowledge that *Moringa oleifera* and *Cajanus cajan* can improve growth of livestock. The study revealed that *Moringa oleifera* and *Cajanus cajan* are liked by livestock with a percentage of 75% whilst 25% said no. This implied that farmers could be encouraged to use *Moringa* *oleifera* and *Cajanus cajan* as supplementary feed for dry season animal production as the study revealed their potentials to increase the performance of animals with regards to the parameters tested

5.2 Effect of *Moringa oleifera* and *Cajanus cajan* on the white blood cells of animals

White blood cell performs a defensive function in the body system especially when transported to the body tissues. As indicated in figure (4.5) the control recorded the highest in terms of white blood cells followed by *Cajanus cajan* with *Moringa oleifera* having the least value. The lower level of white blood cell with regards to the *Moringa oleifera* feed might be due to some constituent in the *Moringa oleifera* leaf like glycocides and tannin which are associated with toxicity. In the case of *Cajanus cajan* it contains protein inhibitors which are typsin and chymotrypsin in addition with amylase inhibitors which affect the activity of digestive enzymes thereby causing digestive losses These may have contributed to the decreasing haematological parameters therefore affecting the values of the white blood cell.

Another implication of this finding might be that there was no stimulating effect from the *Cajanus cajan* feed that could trigger production of white blood cells of the immune system of the animals. These cells such as monocytes and neutrophils belong to the family of defense cells and share similar mechanisms that consist of ingesting the foreign material (bacteria) through phagocytosis and killing infectious agents by producing reactive oxygen species

5.3 Effect of *Moringa oleifera* and *Cajanus cajan* on the growth of livestock

The results show an increase in weight and for that matter an improvement in the growth of animals. Animals on a supplementary diet of *Moringa oleifera* recorded the highest weight gain followed by animals fed a supplementary diet of *Cajanus cajan* with those on control diet recording the lowest. This study demonstrates that sheep fed supplemented diets performed better than those fed control diet. This suggests that the *Moringa oleifera* and *Cajanus cajan* have the tendency of improving rumen fermentation which provides a better balance of nutrients to the animals for absorption (Mahmoud 2013) and so can be used as supplemental diets to increase growth rates of sheep under confinement sheep management.

The results from this study is in line with Mahmoud 2013) when *Moringa Oleifera* leaf was used to feed lanbs. A 100% replacement of the cotton seed cake with *Moringa oleifera* resulted in better final live weight, body weight gain, average daily weight and feed conversion efficiency. The best results were obtained with 99 g/kid/day of sundried *Cajanus cajan* leaves in all the parameters under consideration.

Again, the results in this research are in agreement with (Mahmoud, 2013). He stated that there was positive relationship between *Moringa oleifera* stem (MS) inclusion and both daily and total BWG is probably a reflection of increasing quality of the diets with increasing level of *Moringa oleifera* which will probably enhance the utilization and the availability of essential nutrients especially protein, energy and mineral of the dietary organic matter. Makkar and Becker (1996) reported similar results when West African Dwarf goats were fed graded levels of *Moringa oleifera* leaf meal. There were correlation between increased inclusion level of *Moringa oleifera* leaf meal and better performance.

The diffrences in results could be attributed to analytical method employed in analysing of the samples

5.3.1 Haemoglobin concentration

The high level of blood haemoglobin observed on animals fed with *Cajanus cajan* supplements may be attributed to the level of methionine and cystine (Sing U. and Jambunathan, 1982) that are essential for protein synthesis. The seed of *Cajanus cajan* contain high level of iron which coincided with haemoglobin synthesis and may enhance the level of haemoglobin on animal fed *Cajanus cajan*. *Moringa oleifera* recorded the second highest in terms of haemoglobin level. Similar observation was reported by Terzungwe *et al.* (2013) who had a numerical increase in haemoglobin level than the control. This implies that *Moringa oleifera* proteins are of high quality. S

5.3.2 Blood sugar

A test of glucose or blood sugar was performed to evaluate the rate of carbohydrate metabolism in the sheep. Although there was no significant difference in the blood as of the animals under the various treatments, *Cajanus cajan* had the highest value of blood sugar. This result can be attributed to the presence of high amount of both digestible and non-digestible starch in the *Cajanus cajan* which can be controlled by either boiling or soaking (Nilegaonkar *et al*., 2014). *Moringa oleifera* having the second highest value has already been noted by Esubonteng (2011) who reported an average amount of 3.9mmo/L of blood sugar in rabbit. This is an indication that both *Cajanus cajan* and *Moringa oleifera* may be a hyperglycaemia agent when used for a long period of time on the animal despite its numerous nutritional benefits.

5.3.3 Tannins

Tannis can be advised in ruminant diets at low to moderate condensed tannin levels of 3 – 4%. More than 4% condensed tannins in diet may sometimes lead to reduced nutrient digestibility. The results therefore indicate that *Moringa oleifera* has acceptable level of tannins for nutrient digestibility while that of *Cajanus cajan* is high, and may affect nutrient digestibility in animals. (Waterman *et al* 1994)

5.3.4 Proximate analysis

From the proximate analysis done in this study, the crude fibre content of 3.45 % agrees with Chongwe (2011) who reported similar values of sun-dried moringa leaves. Contrary, the value of 3.45% in this current study is much lower than those reported in other works. The reported values of 16.98 % (Odetola, Adetola, Ijadunola, Adedeji, & Adu, 2012), 35.0% (Aja *et al.*, 2013) and 14.04 % (Tona et al., 2014). The ether extract value tallied with Chongwe (2011) (8.00 %) (check this because not in results) but lower than that of Aja *et al*. (2013) (20.0%) and Tona et al. (2014) (14.58 %). In the same vein, the ether extract content was higher than those reported by Moyo, Masika, Hugo, and Muchenje (2011) and Odetola et al. (2012). This means that moringa leaf meal can provide considerable fat in the diet of the ruminant animal.

The dry matter content of 74.50% in this report is higher than the value reported by Odetola et al. (2012) (21.48%). But in the contrary, the dry matter in this study was lower. In the case of ash content, this work recorded the least value in contrast with earlier works by Chongwe (2011), Moyo et al. (2011), Odetola et al. (2012), Aja *et al.* (2013) and Tona et al. (2014). The lower value in this study is attributable to low contamination (check name of contaminant) during processing and /or lower mineral content of the sample used. The moisture content in this work is higher than those results from Chongwe (2011), Moyo et al. (2011)Moisture in food determines the rate of food absorption and assimilation in the body (Sodamade *et al.*, 2013). It also determines the keeping qualities of food. The value reported indicated that moringa leaves are susceptible to fungal attack if stored at room temperature for a long period of time. The variation is due to the differentials in processing methods and the stage at which the samples were harvested.

The values for the nitrogen-free extract (NFE) and dry matter (DM) were 25.60 and 74.50 % respectively. The carbohydrate content is comparable to Moyo. (2011), who reported a value of 23.60 % of carbohydrate content. Again, the NFE content is lower than that Odetola et al. (2012) (The NFE value is also lower than those reported by Salah and Yagi (2011) when dried moringa leaves were used. They reported a value of 52.6%. The appreciable level of carbohydrate (25.50%) could serve as energy to experimental animals. Nevertheless, the variations in the NFE contents are due to climatic conditions They asserted that even though photosynthesis and respiration are both affected by higher temperatures, photosynthesis drops before respiration. Due to that at any temperature above the plant compensation point, photosynthesis cannot replace carbon used as substrate for respiration and as a result, carbohydrates reserves decline. Hence higher levels of carbohydrates in moringa leaves sample from semi-deciduous forest zone than those from guinea savannah.

The crude protein content of the *Cajanus cajan* (9.8%) in this study was lower than those reported by Moyo *et a*l (2011)

The ether extract content of 3.00% is lower than those reported in other works. (Cheva-Isarakul, 1992) reported a value of 7.3 % while Fagbohun *et al*. (2010) and Sahu et al. (2014)

5.4 Body weight and weight gain

The highest body weight of sheep fed with *Moringa oleifera* on all weight parameters (final weight, final weight gain and average daily weight gain) supports earlier reports that *Moringa oleifera* is of a high nutritional value (Makkar & Becker, 1996). The increase in all body weight parameters of sheep might be due to the fact that *Moringa oleifera* is rich in vitamins, amino acids and minerals particularly iron and also this effect could be attributed to higher protein content of the *Moringa oleifera* diets which were efficiently metabolized for growth . The significant increase in body weights parameters of sheep might also be attributed to captivity, where energy expenditure is minimal (Foidl *et al.*, 2010). This significant increase also agrees with earlier reports that *Moringa olifera* leaves are rich in nutrients like iron, potassium, calcium, and multivitamins, which are essential for livestock weight gaining and milk production.s

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the results and discussion, it can be concluded that;

1. *Moringa oleifera* and *Cajanus cajan* are readily available to farmers as 85 % of the respondents indicated their availability and could be used as a supplementary dry season feed for livestock in the Yendi Municipality of the northern region
2. At least 40 % of farmers have knowledge that moringa (*Moringa oleifera*) and pigeon pea (*Cajanus cajan*) can be used as livestock feed and have been using them to feed their livestock.
3. The use of *Cajanus cajan* and *Moringa oleifera* as supplements resulted in higher growth rates in terms of daily, average and total body weiht gained and better feed conversion efficiencies in Djallonke sheep. The *Moringa oleifera* had better composition of both micro- and macro-minerals than that of *Cajanus cajan*. All the blood parameters were similar for all the dietary treatments. The study also revealed that sheep fed with *Moringa oleifera* diet out-performed their counterparts in all the parameters such as general growth rate, daily, average and total body weight gained It can therefore, be concluded that the use of *Cajanus cajan* and *Moringa oleifera s*upplements can save the rural farmer from weight loss of their animals during the dry season.
4. *Moringa oleifera* and *Cajanus cajan* as feed supplements contain appreciable amount of macro nutrients, especially protein and carbohydrate which enhance the average weight gain and also support normal blood profile of West African Dwarf Sheep. The study also revealed that, there was the presence of M*oringa*

oleifera and *Cajanus cajan* available in the Northern parts of Ghana for feeding even though only 60% of farmers interviewed are aware of their potential as animal feed.

6.2 Recommendation

It is recommended that Djallonke sheep can be fed with both *Cajanus cajan* and *Moringa oleifera* diets during the dry season since they both performed better than the control diet in terms of daily, average and total body weight gained in this present study.

Further research should also be conducted to assess the appropriate pre-treatment methods of the *Cajanus cajan* and *Moringa oleifera* to minimize the anti-nutritional factors present in them.

It is also recommend that follow-up experiments be conducted in this work and should include the determinations of carcass quality of the animals and digestibility of the *Cajanus cajan* and *Moringa oleifera.*

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APPENDICES

Appendices 1: World sheep population.

	Sheep (x 10)	World proportion (%)
Asia	416	40.6
Africa	244	23.8
Oceania	138	13.5
Europe	139	13.6
North America	7	0.7
South America	70	6.8
Central America and Caribbean	10	1.0
Worldwide	1024	100.0

6

Source Zygoyiannis (2006)

Appendices 2:Sheep numbers in Ghana for the period 2006 – 2009

	2006	2007	2008	2009
Sheep (x 10^6)	3.314	3.420	3.529	3.642

Source: VSD (2010)

Appendices 3: Analysis of nutritional value of Moringa oleifera pods, fresh (raw) leaves and dried leafy powder per 100 g of edible portion.

Components	Pods	Leaves	Leaf powder

Moisture (%)	86.9	75.0	7.5
Calories	26	92	205
Protein (g)	2.5	6.7	27.1
Fat (g)	0.1	1.7	2.3
Carbohydrates (g)	3.7	13.4	38.2
Fibre (g)	4.8	0.9	19.2
Minerals (g)	2.0	2.3	-

Appendices 4: Chemical composition of extracted and un-extracted *Moringa oleifera* leaves

Type of leaf	Crude Protein	Lipid	Ash	NDF	ADF	ADL	Gross energy (MJkg-1)
Extracted leaves	43.5	1.4	10.0	47.4	16.3	2.2	17.7
Un-extracted leaves	25.1	5.4	11.5	21.9	11.4	1.8	18.7

All values except gross energy are expressed as percentage dry matter. NDF = Neutral Detergent Fibre, ADF = Acid Detergent Fibre, ADL = Acid Detergent Lignin Source: Fuglie (2001)

Appendices 5: Carotenoids in different parts of Moringa oleifera

Carotenoid	**Part (mg/kg DM)**		
	Leaves	**Stem**	**Seed**
Alpha-carotene	6.5	N.D.	N.D.
Beta-carotene	401	N.D.	3.8
EchinenonFucoxa	N.D.	N.D.	N.D.
nthinLeutinMyxu	N.D.	N.D.	N.D.
xanthophyllNeox	702	21.8	4.0
anthinViolaxanthi	N.D.	N.D.	N.D.
nZeaxanthinXant	219	5.9	N.D.
hophylls	76.5	1.3	N.D.
Carotenoids	19.4	N.D.	N.D.
Chlorophyll	83.1	1.6	N.D.
	1508	34.4	4.0
	6890	271.1	N.D

Source: The Potential of *Moringa oleifera* for agricultural and industrial uses. What development potential for *Moringa oleifera* products? (Foidl *et al*., 2001) Note: N.D. denotes not detected.