DIGESTIBILITY AND GROWTH PERFORMANCE OF FEMALE RABBIT FED *Tithonia diversifolia* LEAF MEAL

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DECLARATION

The report presented in this thesis is the results of the research carried out by the author. The thesis has not been submitted in whatever form to any other institution, organization, or body for the award of any degree. All inclusion from the work of others has been duly acknowledged.

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DEDICATION

I dedicate this work to my late father, Mallam Abubakar

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ABSTRACT

A ten–week feeding trials was conducted to investigate the effect of wild sunflower leaf meal (WSLM) on the digestibility and growth performance of cross–bred female rabbits aged between 6–8 weeks. Twelve rabbits were randomly allocated to four dietary treatments of three rabbits per treatment in a Completely Randomised Design experiment. The WSLM was included at 0%, 5%, 10% and 15% levels in diets 1, 2, 3 and 4 respectively. The performance of the rabbit showed that, the digestibility of crude protein, crude fibre, ether extract were significantly ($p>0.05$) different among the 4 dietary treatments. Feed intake and life body weight gain were also statistically different. The study showed that WSLM can be included in the diet of rabbit at 5% inclusion.

CHAPTER ONE

0.1 **INTRODUCTION**

The agriculture dependant rural population in Ghana like most West African countries constitutes about 70% of the national population. Majority of these farmers practice slash and burn-, and slash and no burn agriculture (Quansah *et al*., 2000).The threat to forest resources and biodiversity conservation is likely to worsen unless measures are taken to improve land use strategies, which will allow farmers to produce food, fodder, wood fuel and building materials on the same farm without resulting to new land for bush fallow cultivation (Asare, 2004). In Ghana, agriculture policies and practices have gradually shifted to embrace the introduction and intensification of modern agroforestry practices as outlined in the national policy of 1986. The overall objective of the policy was to promote agroforestry practice for sustainable land use (MOFA/AFU, 1986).

Agriculture production in Ghana experienced a steady decline until the early 1980s when it came to a virtual standstill. Although this trend has since reversed and food production is growing at 2.8% annually (GPRS, 2002), it still falls behind Ghana's population growth rate of almost 3% (Assenso-Okyere, 2001). This is especially serious with animal protein production and intake. In most developing countries, the daily dietary intake of animal protein (3.24g) falls grossly short of the recommended 27g animal protein per caput/day (Ajayi *et al*., 2007). The 2003 demographic and health surveys in Ghana indicated that 30% of Ghanaian children under 5 years are stunted, and that was an increase of 4% point from the 1998 survey (GNA, 2005).

This prompted the lunch of a project known as 'Enhancing child nutrition through animal sources and food management (ENAM)' in 2005, to improve the animal protein intake of children and to give caregivers access to animal source of food for child feeding through income generating activities (GNA, 2005). The observed low animal protein consumption may be attributed to the declining animal production as a result of high cost of livestock (traditional) production especially the cost of feed which usually account for up to 70% of the total cost of production. A remedy to this situation is the adoption of a productions system that will allow for the combined production of food stuff, fodder and a fast maturing animal that does not require huge capital for establishment and can be reared at a reduced feed cost (Oppong-Anane *et al*., 2009).

In recent years, there has been rising global awareness on the virtues of rabbit meat production in developing countries as an alternative means of alleviating world food shortage (Cheeke and Lukfahr, 1991). This basic understanding is largely attributed to the rabbit's high rate of production and early maturity, rapid growth rate and high genetic selection potential, efficient use of feed and land utilization, limited competition with humans for similar foods and high quality nutritious meat (Cheeke and Lukfahr,1991).

1.1 PROBLEM STATEMENT

Livestock production is important in the attainment of food security in Ghana (Oppong-Anane *et al.,* 2009). People today are concerned about energy, protein, population pressure and land resources as they relate to animal agriculture. Animal agriculture has been criticized for wasting food and land resource that could otherwise

be used to provide persons with adequate diets (Taylor and Bolgart, 1988), all because of land scarcity. The need to increase food production to meet the demand of rapid population increase is a major problem faced in most part of the world especially in developing countries. The problem has been aggravated by shortages of arable land for agricultural activities because of biophysical and environmental constraints.

Interestingly, the availability of meat in a country is closely related to the economic status of the people and their agricultural technology. However, there has been a decline in animal protein production in most developing countries including Ghana due to high cost of feed (Ajayi *et al*., 2007). The traditional livestock (goat, sheep, cattle, pig, etc) production has not been able to meet the protein requirement of the increasing population in the country due to so many challenges. Some of the challenges listed by Oppong-Anane *et al.,* (2009) are;

Destruction of grazing land by fire.

Poor quality feed/feed ingredient.

High cost of inputs.

There is the need to look for an alternative or additional source of protein (i.e. livestock) and feed source that can be established with ease and produce an economically viable end results in a relatively short period. A production system that will allow for the integration of fast growing tree/shrub, that can produce fodder and a fast maturing animals, that would make use of the fodder in the same production system without resulting to additional land is a possible remedy to the challenges mentioned above.

1.2 JUSTIFICATION

There are many trees and shrubs that have potential as a source of high quality feed for domestic animals, but for many of these sources, there is little information about them and they are not well utilized. More research is needed to access the opportunities offered by trees/shrubs and the constraint to their utilization. One such shrub that grows wild and about which little is known is *Tithonia diversifolia* (Patoummalangsy, 2007).

The integration of this shrub into farm land can help improve the nutrient status of the soil and the leaves as well can be used as fodder to feed animals so as to reduce the total production cost thereby ensuring sustainable land use. The basis of my research is to investigate the nutritive value of *Tithonia diversifolia* and its effect on animal (rabbit) growth.

1.3 RESEARCH OBJECTIVES

The general objective was to determine locally available fodder (MPT) that can be used as a cheap source of protein for rearing rabbit.

The specific objectives were:

To study the effect of *Tithonia diversifolia* (wild sunflower) leaf mixture on the growth performance of rabbit.

To determine the nutrient content of the experimental diet.

To assess the dry mater and nutrient digestibility of the diets.

1.4 RESEARCH HYPOTHESIS

H_0-*Tithonia diversifolia* (wild sunflower) can be used as a protein source for herbivores.

H_a-*Tithonia diversifolia* cannot be used as protein source for herbivores.

H_0-Wild sunflower can enhance the growth performance of rabbits

H_a- wild sunflower cannot enhance the growth performance of rabbit

1.5 RESEARCH QUESTIONS

What is the nutritional content of wild sun flower *(Tithonia diversfolia)?*

At what percentage level can *Tithonia diversifolia* positively affect weight change in rabbit?

What is the effect of feed (WSFL) intake on growth rate?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 USE OF UNCONVENTIONAL FEED RESOURCE IN LIVESTOCK FEED

The rapid increase in human population has necessitated a corresponding increase in animal products to provide adequate quantities of animal protein. Shortage of feed stuff is one of the major limiting factors for increasing animal production. Feeding costs are the most significant expenses in animal production including rabbit production, and forms 70% of the total cost of animal production (Mehez and Mousa, 2011). Feed formulated should be cost effective, considering the cost of ingredients as well as their digestibility efficiencies to meet nutritional requirement of the animal. Alternative protein source can be competitively priced relative to fish meal on a unit protein basis. The feed formulated should not have any negative impact on the animal's general performance or the product quality (Gaye and Muammer, 2010).

Animal nutritionist have often tried to incorporate less expensive, more plentiful plant protein source in animal diets for centuries now. Considering the use of *Tithonia diversifolia* as protein source, numerous studies have been carried out to determine its feeding value and chemical composition. There has been studies on the use of Tithonia on ruminants (Farinu *et al*., 1992; Akinlade *et al*., 2004; Pathoummalangsy and Preston,2007 ; Ngugen *et al*.,2010), poultry (Odunsi *et al*.,1996, Togun *et al*.,2006) and pigs (Olayini *et al*.,2006). Specifically, the effect of Tithonia on male rabbit has been researched into in Nigeria by Farinu *et al*., 2006 and Ajayi *et al*.,

2007. Results of these researches have shown that, Tithonia can partially or even fully replace fish meal. Cereal based feed are generally also expensive for use as supplements (Humn, 1988). Alternatively non-cereal feed supplement have been successfully developed for many livestock species using locally available agro-industrial by-product (Gaye and Muammer, 2010; Mehez and Mousa, 2011). Surprisingly, no such feed has been devised for rabbit in Ghana, particularly Tithonia, though its successful l use has been reported in the sub-regions especially in Nigeria.

2.2 AGROFORESTRY AND ANIMAL NUTRITION

Decrease in grazing land and biodiversity attributed to the expansion of cropping area have affected livestock production (Graham, 1998). In most part of the world, animal production is based on pasture and fodder rather than concentrate (Graham, 1998).

Adequate feeding is essential to realizing the potential of livestock to alleviate poverty among smallholder farmers. Agroforestry is the only alternative to pasture and fodder production (Graham, 1998). It involves the use of fodder trees and shrubs that are permanent and which will replace annual grasses, provide their own nitrogenous fertilizers, and extend their roots deep beneath the ground to the water table to tap nutrient. Agroforestry is the use of trees that give high feed yield all year round (Graham, 1998). Fodder tree can improve the output from existing property and make them viable once again. Many of the trees that are planted as source of fodder make ideal windbreak and modify the microclimate beneath their canopy.

In Africa trees have been used for centuries as sources of feed for livestock. Scientists have researched into the potential of some trees and shrubs that have potential for

animal production. For fodder production, Silvipastoral and Agrisilvipastoral are predominant. These systems are recognized as 'animal agroforestry (Torres, 1983). The significant development in animal Agroforestry is the expanding role of trees as a component in fodder production. This has largely contributed to meeting the growing demand for food and subsequently enhances the socioeconomic condition of rural population.

In Ghana MOFA and some Non-Governmental Organization promoted some technologies such as urea treatment of straw, hay/silage making, pasture and fodder bank development to enhance feeding of livestock, but realized low adoption rate (Stephane *et al*., 2010).Therefore agroforestry is an important form of land use that should be promoted in view of its potential in helping to meet the increasing demand for food, fodder, energy and environmental conservation (Devenda, 1989).

2.3 QUALITY FODDER FOR ANIMAL PRODUCTION

Feeding of high quality and scientifically balanced ration to livestock for economic return is the primary objective of every animal nutritionist (Ranjhan, 1999). High quality fodder is one that is rapidly digested by the microbes in the rumen (Chesworth, 1992). Forage quality can be assessed in terms of the animal performance that is elicited when forage is offered to the animal. Feeds are also rated on their productive energy and protein content (Van Soest, 1994).

Various types of foods that are available to animal are divided into three on the basis of their composition. These are roughages, energy concentrates and protein concentrates (Chesworth, 1992). Those food materials that are high in fibre content

(≈ 150g/kg of dry food) are the roughages. Those that have high values of metabolizable energy are the energy concentrates (> 10MJ/kg of dried food) and the protein concentrates are those that supply large amount of high quality protein (over 250g/kg of dry food) (Chesworth, 1992).Conventionally scientists have classified the nutritive value of feed into 3 general components; digestibility, feed consumption and energy efficiency (Raymond, 1969). But digestibility is more often measured than feed intake and efficiency, even though the latter is more responsible for total animal response.

The major factor that affects forage or fodder quality is plant maturity. Forage quality declines with increase in age as a result of decrease in the leaf-stem ratio (Fahey, 1994; David, 2006).Therefore forage needs to be cut as soon as they begin to flower so as to capture the highest leaf production and harvest the stems before its quality decreases below acceptable level. Other factors that affect the quality of fodder as stated by Lassiter and Hardy (1982) are as follows:

Species of plant from which fodder is collected.

Stage of growth; young actively growing forage/tree is high in leave moisture, protein, mineral, low in fibre and lignin and more palatable.

Nutrient lost during curing and.

Loss through storage.

2.4 DIGESTIBILITY

The chemical composition of feed gives only the potential value of the food but it does not give the actual nutritive value of the feed-stuff until the losses of nutrient in

feed, urine, gases, etc from the animal during digestion, absorption and metabolism are also taken into consideration (Ranjhan, 1999). This is because nutrient present in feed-stuff are not completely available to the animal's body. Larger proportion of the nutrient is excreted in the faeces because of not being digested in the alimentary tract. Therefore, digestion of feed-stuffs is that proportion of feed which has been absorbed by the animal (Ranjhan, 1999). In other words it is that proportion which is not excreted in the faeces and therefore assumed to be absorbed by the animal (McDonald *et al*., 1988; Ranjhan, (1999). This is usually expressed in dry matter and as coefficient or percentage.

The nutrients found in the faeces are not only the undigested nutrient from the feed eaten, but also include small proportion of nutrients from the previously utilized food in the form of mucosal debris, unspent enzymes, undigested microorganism, etc. This makes the digestibility coefficient determined to be an apparent digestibility and not a true digestibility (Ranjhan, 2001; McDonald *et al*., 1988). Another cause is that, for instance in ruminants, the methane arising from the fermentation of carbohydrates is lost by eructation and not absorbed which thus leads to overestimation of the digestion of carbohydrate and digestible energy content of ruminant food.

Digestibility of feed-stuff by an animal is determined through feeding trial or digestion experiment. The feed under investigation is given to the animal in known amount and the output of faeces measured. There are so many methods of determining digestibility. These include;

The indicator method, involves the use of a substance (indicator) which is known to be completely indigestible, with the test feed. The ratio between the concentration in

the feed and that of the faeces gives an estimated of digestibility (Ranjhan, 2001; McDonald *et al*., 1988; Leonard and John, 1965).

The purified–diet method also involves the use of a diet which consists of a purified source. Such diet makes it possible to include or withdraw a given nutrient with a minimum of disturbance of any of the other nutrient relations (Pond *et al*., 1995; Leonard and John, 1965).

The conventional method, involves feeding the animal a diet of known composition over a period of time during which the faeces are collected and analyzed for the component of interest (Pond *et al*., 1995).

The in vitro digestion (laboratory method) gives a direct and realistic estimation of digestibility but is lengthier, more expensive and less reproducible. Determining digestibility by difference is where a basal diet is fed alone and the basal diet plus the test feed are fed at one or more levels to the animal. Faeces from the two trials are analyzed separately. By taking the difference in nutrients value between the two faeces, the digestibility coefficient for the test feed is then calculated (Ranjhan, 2001; Pond *et al*., 1995).

In many digestibility measurements, it is desirable to obtain more specific information regarding the effect of a given ration, than the common measure of weight and size. For example, it is important to know the specific effect in terms of protein tissue formed since the increase in body as a whole is due to water, fat, and minerals as well as protein. The slaughter experiment is often adopted to achieve these. The slaughter experiment involves killing of an animal and the analysis of certain specific tissues or

of the body as a whole. A group of animals are selected and part of them are slaughtered and analyzed at the start of the experiment. The others are fed a test diet for a given period and then slaughtered and analyzed. The difference in their composition from that of the check diet reveals the effect of the diet fed (Leonard and John, 1965).

In all feeding trials, feed records are a desirable feature even when the feed cost of the physiological performance is not of primary concern. From the standpoint of equipment needed and labour cost, animals have been fed in groups especially, farm animals. This however introduces complication in the interpretation of results particularly when there is a wide variation in the individual behaviour as to both production and feed consumption. Individual feeding is therefore more appropriate in order to eliminate these disadvantages and for easy statistical treatment. Nonetheless, there are types of feeding experiment in which feed records of the group as a whole are sufficient or may be acceptable (Leonard and John, 1965).

As adopted in this research, and in most cases, feed is offered ad libitum to the animal in feeding trails, and this gives unbiased results for direct practical application as distinguished from controlled feeding. But in many instances there is an advantage in using some system of controlled feeding. This helps to eliminate the uncertainties like whether an animal under experiment grew because it ate more or the other failed because it ate less.

There are some limitations to the determinations of digestibility coefficient. The first limitation is that nutrients in faeces do not represent the undigested fraction of food

residues for which the digestion coefficients are being determined. Part of the nutrient excreted in the faeces comes from unspent enzymes, cellular material abraded from the gut and other secretions of the gut which actually represent utilized nutrients of the previous diets. In practical, the digestion coefficients which are determined do not take into account the metabolic faecal nitrogen coming into the faeces not directly from the feed. The second limitation of the digestion trial is that the carbohydrates are broken down to volatile fatty acid, carbon dioxide and methane. The latter two do not give any energy to the animals but are computed as digestible carbohydrates since they are not recovered in the faeces. This loss leads to the over estimation of digestible carbohydrates (Ranjhan, 2001).

2.5 FACTORS AFFECTING DIGESTIBILITY

Digestibility of feeds is not constant for a given feed or species and are influenced by several variable factors. Therefore, when utilizing digestibility figures for calculation of energy values of a feed-stuff, the following factors may be considered.

2.5.1 Chemical Composition of Feed and Digestion

One of the factors affecting digestibility is the chemical composition of the feed. The chemical composition of forage is affected by a number of factors like soil and fertilization, stage of maturity and climate.

2.5.1.1 Soil and fertilization

The type of soil may influence the composition of pasture and forage especially its mineral content. Plants normally react to mineral deficiency in the soil either by limiting their growth or by losing concentration of a particular mineral in their tissue

or both. The acidity of soil is an important factor which can influence the uptake of many trace elements by the plant (Olanite *et al*., 2010).

Fertilization on the other hand affects the mineral content of the plant. Nitrogen fertilizer is known to increase the leaf area and rate of photosynthesis (Olanite *et al*., 2010). Consequently, the crude protein content subsequently increases. Nitrogen fertilizer also depresses the water soluble carbohydrate content of temperate grasses which may have an adverse effect on fermentation if the crop is used and preserved as silage. Fertilizer may also indirectly affect the nutritive value of plants by altering the botanical composition (McDonald *et al*., 1988).

2.5.1.2 Stage of growth

This is the most important factor affecting the composition and nutritive value of forages. Young actively growing forage is high in leaves, moisture, protein and minerals and corresponding low in fibre and lignin (McDonald *et al*., 1995). As plant grows, there is the need for fibrous tissue and therefore the main structural carbohydrate and lignin increase. As the plant ages, the concentration of protein decreases and the fibre content increases. Therefore, there is a reciprocal relationship between the protein and fibre content at any given stage (Olanite *et al*., 2011,).

2.5.1.3 Climate

Climate and season may influence the nutritive value of forage. Rainfall can affect the mineral content of soils; for example, calcium may tend to accumulate in plant during drought period but tend to be present in smaller concentration when the soil is moist (Olanite *et al*., 2011,).

2.5.2 Fibre and Digestibility

The fibre fraction of a feed has the greatest influence on its digestibility. Crude fibre tends to exert a protective influence against the digestibility of all nutrients due to faster rate of passage of the digester through the alimentary tract (Leonard and Loosli, 1965). Fibre affects the digestibility of organic matter and the net energy in the food. The apparent digestibility of organic matter and the gross energy of feed are negatively correlated with the content of the fibre fraction (Kay *et al*., 1998).

2.5.3 Protein and Digestibility

The apparent digestibility coefficient of crude protein is dependent upon the content of crude protein in the feed. Feed-stuff that are low in protein mostly have low digestibility coefficient because more protein is excreted in the faeces from metabolic faecal nitrogen (Ranjhan, 1999). Higher levels of protein may improve the apparent digestibility. This is due to decrease in the ratio of metabolic faecal nitrogen to the undigested nitrogen of the feed and so the apparent digestion coefficient of protein is improved and supply of more essential nutrient to the rumen microbes. High level of protein also increases the digestibility of crude fibre because the activity of microorganism is increased on high protein ration and they attack the crude fibre more vigorously (Gupta *et al.,* 1971). The quality of protein present in the feed also affects its digestibility and the ratio of by-pass protein and fermentable nitrogen affects the dry matter digestibility (Ranjhan, 2001).

2.5.4 Carbohydrate and Digestibility

The type and quantity of carbohydrate in the ration or their addition to the ration, affect the digestion of other nutrients. The higher the percentage of crude fibre in

forage the lower the digestibility of other nutrients because of the faster rate of passage of digester through the alimentary tract. As the level of crude fibre increases, the content of crude protein and dry matter digestibility decrease (Ranjhan, 2001).

2.5.5 Fat and Digestibility

Addition of fat to feed improves the digestion coefficient of ether extract as the fat is more digestible. Although higher levels of fat in ration increase the digestibility of fat, it usually decreases the digestibility of other nutrient especially crude fibre (Ranjhan, 2001).

2.5.6 Minerals and Digestibility

Deficiency of salt only affects feed consumption but does not influence digestibility. However, higher levels of salt decrease the digestibility of nutrients. The deficiency of any mineral element in diet causes other more severe systematic adverse effect before the digestibility is influenced (Ranjhan, 2001). Saxena and Ranjhan (1978), however, reported that, copper and cobalt significantly improved the digestibility of crude fibre, cellulose and ether extract in zebu calves and the effect was more marked when they added other trace elements.

2.5.7 Animal Species and Digestibility

The most important animal factor is the species of the consumer (McDonald *et al*., 1988). Foods given to different animals are digested to different extent. Roughages and fodder with high crude fibre are better digested by ruminant than by non-ruminant due to low excretion of metabolic faecal nitrogen in non-ruminants. The age of the animal also influence digestibility. Smaller animals, especially ruminants, have low

fibre digestibility because they have not yet developed rumen and microflora are not established (Ranjhan, 1999).

2.5.8 Feed Processing and Digestibility

The way roughages and concentrates are processed affects the digestibility of its nutrient. For example, grinding of roughage reduces its digestibility since it increases the rate of passage (McDonald *et al*., 1988). Also, alkaline treatment of straws breaks the lignocelluloses complex of the cell wall and thereby permitting thorough enzyme action and hence improve digestibility of the straw (Ranjhan, 1999). Digestibility of cereals grains is higher when given crushed to cattle and ground to pigs Other processing methods like chaffing, pelleting, cooking, soaking, and chopping affect the digestibility coefficient of the feed (Ranjhan, 1999; McDonald *et al*., 1988).

2.5.9 Amount of Feed and Digestibility

An increase feed intake by an animal generally causes a faster rate of passage of digester and thereby allowing for a shorter period of digestive enzyme action (Pond *et al*., 1995). Level of feeding by an animal is often expressed in multiples of the quantity of food required by the animal for body maintenance. The greatest reduction in digestibility with increasing feeding level is found with ground and pelleted roughage and other fibrous by-product, but for conventional feeds there is little effect of feeding level on digestibility (McDonald *et al*., 1988; Ranjhan, 1999; Leonard and John, 1965).

2.5.10 Composition of Feed and Digestibility

The composition of a ration also has an influence on its digestibility. This associative effect is a common phenomenon observed with the determination of digestibility, and it is as a result of the different environment available to rumen microbes. For instance the addition of molasses to a diet may modify the rumen environment and depress the digestibility of cellulose and other fibre component (Ranjhan, 1999; McDonald *et al*., 1988). It is observed that the mixture of feed stuff do not always give results that would be predicted from the digestibility value of the individual components. Undoubtedly, there are other unknown factors that alter digestibility, but it is clear that all animals do not digest a given diet to the same extent and therefore, vary in their absorptive capacity.

2.5.11 Nutrient Intake and Digestibility

The main function of the digestive system is toreduce complex feed by hydrolysis to components that can be absorbed and metabolized. Digestion of feed by the animal depends on various factors such as the enzymes present, the physiological environment in which they function, properties of the feed and the total processing capacity of the animal's digestive tract. The three groups of enzymes which are secreted by the digestive tract to catalyse the various stepwise hydrolysis in the digestive tract are carbohydrase, proteases, and lipases (Ranjhan1999).

2.6 DRYMATTER DIGESTIBILITY

The daily quantity of dry matter that is consumed by an animal is a measurement critical to making nutritional inferences about feed and subsequent animal responds. Accurate measurement of dry matter intake has been used to provide the basis for

application of nutritional requirement of an animal and its digestibility (Burns *et al*., 1994). Reid (1961) listed the amount of forage or feed eaten as the first factor limiting the usefulness of forage or feed testing schemes. Nutritive value of feed is a function of the feed intake and the efficiency of extraction of nutrient from the feed during digestion.

Feed intake in ruminants is primarily determined by the level of rumen fill which intern is directly related to the rate of digestion and passage of fibrous particles from the rumen (Fuler *et al*., 1994). The acceptance or edibility (palatability) of feed has been related to both the physical characteristics and the presence of compounds (e.g. tannin) which may affect taste and appetite ` (Sao *et al*, 2010).The quality of the diet can also influence the feed intake through its effect on digestion in the rumen. If the feed is easily digestible to the animal, the efficiency of converting the feed to animal tissue is high (Pond *et al*., 1995). Total efficiency of production can be increased greatly if feed intake can be maintained at high level without creating health problem. However there is sometimes the need to limit intake of feed especially those with high digestibility coefficient to prevent obesity (Pond *et al*., 1995).

Palatability of feed, hunger, and high digestibility coefficient are factors that trigger feed consumption. Nonetheless, animals on their own have means of controlling feed intake (long or short term). This is clearly demonstrated by the fact that, when there is adequate feed of an acceptable nature available, wild animals do not starve or over eat. Determination of feed intake includes body weight of the animal, individuality, type and level of production, climatic environment and digestive capacity of the animal.

Expected feed intake is important when diets are formulated for a specific purpose. Whenever consumption is lower than anticipated, then, digestible energy concentration must be higher in order to meet nutritional needs (Pond *et al*., 1995). Protein and energy consumption are interlinked. When protein content of forage is inadequate, food intake drops and digestibility of energy is reduced (Campling *et al*., 1992). It was found out that, the intake of sheep decreased when the crude protein content of their diet fell to 7% (Pond *et al*., 1995). Improved digestibility means that greater proportion of the feed is actually absorbed by the animal. Lower digestibility leads to higher voluntary intake in the temperate zone (Campling *et al*., 1992).

The various types of carbohydrase are sucrase, maltase, lactase, trehalase, etc, which act on glycosidic linkage between monosaccharide units and they are specific. Thus, sucrase hydrolyses sucrose, maltase for maltose, lactase for lactose, and so on. Protease, on the other hand hydrolyses protein and peptides to amino acids while lipases break down fats into fatty acid and glycerol (Pond *et al*., 1995).

Properties of feed which may affect its digestion include its susceptibility to enzymatic hydrolysis and the action of inhibitory substances which the feed may contain like glycosides, tannin etc. The processing capacity of the animal's digestive tract can cause chemical degradation, emulsification of solution and colloidal suspension and synthesization. This is as a result of chemical reaction between the feed ingredients, enzyme action and other chemical secreted from the animal's body or by microorganism and physical action (Ranjhan, 2001).

Part of the feed which has no significance for the purpose of the animal's nutrition constitutes the un-dissolved or undigested portion and is excreted as dung or faeces. The portion of the nutrients digested and taken into the body is the digestible nutrients. These are the digestible crude protein (DCP), digestible ether extract (DEE), digestible crude fibres (DCF) and digestible nitrogen free extract (DNFE) (Ranjhan, 2001).

2.7 FACTORS AFFECTING FEED INTAKE (CONSUMPTION)

The total efficiency of production can be increased greatly in growing, finished or lactating animal if their feed intake can be maintained at high level without creating health problems. The maintenance requirement of animal gaining weight at low rate represent a much greater percentage of the total feed consumed than that of animal gaining at more rapid rates. Additional costs are incurred at low level of production including greater labour requirement to maintain animal over a longer period of time, longer tie up of invested capital and less efficient use of facilities. The need to attain high level of productivity clearly provides the impetus for studying and understanding the factors that influence feed intake (Pond *et al*., 1997). There is the need to sometimes restrict feed consumption of the daily ration for the animal to, for example prevent obesity in a pregnant rabbit. Consequently, more information is constantly sought on factors that tend to inhibit feed intake as well as ones that tends to stimulate it.

2.7.1 Palatability and Feed intake

Palatability is one of the factors that affect feed consumption, and it is the degree of acceptability of the feed to the taste of the animal. A palatable feed is determined by

its appearance, taste, texture, temperature, odour, etc. of the feed. A number of feeds are unpalatable to livestock. Animals will avoid such feeds, and may reject the whole feed mix if they cannot select more palatable feeds from it. Feeds are sometimes unpalatable because they are toxic, but this is not always the case. If an unpalatable feed has been included in the diet because it provides a particular nutrient that is otherwise limiting in the diet, then the unpalatable feed needs to be well mixed with the rest of the feed if it is to be eaten. Feeds with strong (palatable) smells and tastes may need to be added to mask the unpalatable feed (McDonad *et al.*, 1995).

2.7.2 Feed Presentation and Intake

Feed presentation can also affect feed intake. For example, sheep and goats prefer succulent feeds (fresh grasses and leaves) to dried forages like straw. With all livestock, chopping (or in the case of poultry, grinding) the feed will also make the animals eat more. This of course assumes that there is a plentiful supply of feed, and high intakes are wanted so that animal productivity can be increased. There are many times of the year (particularly at the end of the dry season) when feed is in short supply, and it is more important than that the feed provides ‘gut fill’ so that the animal feels satisfied. Also feed offered at regular interval can enhance good intake. Feeds should be presented in such a way that animals are able to eat it in the way that they naturally feed. Goats browse, and so prefer a feeder that holds the feed at a height where they need to reach up to get it rather than a trough on the floor. Sheep on the other hand prefer a trough on the ground (LPP, 2006).

2.7.3 Hunger and Feed intake

Another factor affecting intake is hunger. The physiological need of the animal to get satisfied arouses its hunger and the animal is prompted to eat. Appetite also determines the rate of feed consumption by the animal. It is a factor that can stimulate or inhibit hunger and is usually satisfied by palatability. In general, animals tend to regulate their daily feed intake by complex physiological responses to diet, environment, and by their need for energy (Pond *et al*., 1997). An animal's appetite changes as its requirement for nutrients changes. Young, growing animals have a greater appetite than adults. Lactation brings about a big increase in appetite because of the demands of milk production (LPP, 2006).

2.7.4 Protein content and Feed intake

Protein and energy consumption are interlinked. When protein content of forage is inadequate food intake drops and digestibility of energy is reduced. It was found out that the intake of sheep decreased when the crude protein content of their diet fell to 7% (Campling *et al*., 1962). Improved digestibility means that a greater proportion of the feed nutrients are actually absorbed by the animal. The end product of digestion is either absorbed into the body proper, volatilized as heat and/or gases through the mouth or anus or, appear in the faeces (Campling *et al*., 1962).

2.8 ANALYSIS OF FORAGES AND FEEDSTUFFS

Dietary protein is always deficient among livestock in many parts of the world (Moir, 1963). Forage and feedstuff are often analyzed to ascertain their quality and maximize usage. Proximate analysis which gives the information on the quality of the feed is the first step in estimating the nutritive value of a feed before even digestibility trials is

carried out. Robert and Ralph, (1988) define proximate analysis as a system device through which the value of a feed can be approximated by separating feed component into groups according to their feeding value. This system has been used for more than 100 years. The inorganic and organic component resulting from proximate analysis are water, crude protein, crude fat (ether extract), crude fibre, nitrogen free extract and ash (mineral).Knowledge of the water content of the feed is also very important. It gives the information about the characteristics of the feed, whether it is succulent and how it can be stored.

2.8.1 Crude Protein

Determination of the crude protein content of the feed is very important because most feeds are classified according to their protein content. It also gives indirect information about the digestible energy of the feed. Where protein content is high, crude fibre is usually low and digestibility of fodder is high (Ranjhan, 1999). Protein is used by the animal in building new cells and replacing worn out tissues. It is the main source of enzyme and hormone synthesis which regulates the body functions (Ranjhan, 1999).

Crude protein content is calculated from the nitrogen content of the food determined by a modification of a technique originally devised by Kjeldahl (McDonald *et al*., 1988). In this method, food is digested with sulphuric acid which converts all nitrogen present to ammonia except nitrate and nitrite. It is assumed that the nitrogen is derived from protein containing 16 per cent nitrogen and by multiplying the nitrogen figure by 100/16 or 6.25 an approximate protein value is obtained.

2.8.2 Crude Fibre

Crude fibre is one of the fractions of carbohydrate. When the residual food from ether extraction is subjected to successive treatments with boiling acid and alkali of defined concentration; the organic residue is the crude fibre (McDonald *et al*., 1995).The major proportion of crude fibre is the cellulose, which is highly digestible by ruminants.Crudefibre, also includes hemicelluloses, lignin and some mineral matter. Crude fibre mainly adds bulk to the feed. The magnitude and direction of crude fibre figure is valuable because of the correlation that exists between it and digestibility of food (Kundu *et al*., 2005).

2.8.3 Nitrogen-Free Extract (NFE)

The carbohydrate of the food is contained in two fractions, the crude fibre and the nitrogen free extractive (NFE). Nitrogen free extract (NFE) is found by difference and not by actual analysis. The percentages of water, ash, protein, fibre, and fat are added together, and subtracted from 100; the difference is designated to NFE (McDonald *et al*., 1995). NFE fraction is therefore a heterogeneous mixture of all those component not determined in the other fractions. It made up primarily of readily available carbohydrates such as the sugars and starches, but it may contain some hemicelluloses and lignin particularly in such feedstuffs as forages (Kundu *et al*., 2005; McDonald *et al.*, 1995).The main function of carbohydrates in the animal's body is the production of energy and formation of structural materials.

2.8.4 Ether Extract

Ether extract fraction is determined by subjecting the food to a continuous extraction with petroleum ether for a defined period. The residue after evaporation of the solvent is the ether (Richard and Church, 2002). As well as true fat it contains waxes, organic acids, alcohols and pigments. Ether extract (lipids) in the animal's diet is a source of energy, heat and serves as solvent for the fat soluble vitamins (McDonald *et al.*, 1988).

2.8.5 Ash (Minerals)

The ash content is determined by ignition of a known weight of the food at 600^0C until all carbon has been removed. The residue is the ash and is taken to represent the inorganic constituents of the food (A.O.A.C 1990). Ash may however, contain materials of organic origin such as sulphur and phosphorus from proteins. Some volatile materials in the form of sodium, chloride, potassium, phosphorus, iodides and sulphur may be lost. Minerals are required in small quantities in the animal's diet (Kundu *et al*., 2005).

2.9 ABSORPTION AND METABOLISM OF NUTRIENTS

Digestion of feedstuff is carried out by enzymatic and microbial means. The enzymatic digestion is carried out by the enzymes secreted by the various glands into the lumen of the gastrointestinal tract (GI). The microbial digestion of food, also enzymatic, is brought about by various enzymes secreted by bacteria, protozoa, and fungi present in the GI tract. However, microbial digestion is more important in ruminant because of digestion of cellulose, hemicelluloses, etc and it precedes the enzymatic digestion in alimentary tract (Ranjhan, 2001).

2.9.1 Absorption of Carbohydrates

Carbohydrates are broken down to simple sugars by the enzymes secreted in the small intestine in non- ruminant. The simple sugars are absorbed into the portal blood system and then to the liver. For ruminants, the major portion of their diet consist of polysaccharides or structural carbohydrates like cellulose, pentosants, etc which cannot be hydrolyzed by the enzymes secreted by the animal in the digestive tract. About 70-75% of the digestible organic matter is digested by the rumen microorganisms, with the production of volatile fatty acid, carbon dioxide and methane. Most of VFA are absorbed from the rumen, reticulum, and omasum. Only small amount may pass to abomasums and small intestine from where they are absorbed (Ranjhan, 2001).

2.9.2 Absorption of Fats

In monogastrics, part of the ingested fat is hydrolyzed in the intestine into mono- and di-glycerides and is hydrolyzed up to fatty acids and glycerol. The digestion mixture consists of free fatty acids, di- and mono-glycerides and unsplitted (or resynthesized) triglyceride with a diameter of 0.5 microns. This mixture passes through the epithelium of the villus and free fatty acids are converted into triglyceride. In this resynthesis, the free fatty acid combines with either simultaneously absorbed mono-or di-glyceride or with endogenous glyceride precursor (Leonard and Loosli, 1969).

The chylomicrons synthesized in the wall of the villus, are transferred mainly to lacteal where they enter the lymph and are transported to the thoracic duct and then to the main blood stream. In ruminants however, extensive hydrolysis of esterified lipids including phospholipids occurs under the action of microbial lipases and free fatty

acids are progressively hydrogenated to various isometric C18 dienoic and monoenoic acids, and eventually to stearic acid. Major portion of the lipids entering the small intestine is the free fatty acid fraction which consists mainly of palmitic, stearic and monoenouc acid (Leat and Harrison, 1972). Most of the digester lipids are absorbed in the upper half of the small intestine (65-87%) with an appreciable percentage being absorbed in the upper jejunum (Ranjhan, 2001).

2.9.3 Absorption of Proteins

The main products of protein digestion are amino acids which are absorbed from the small intestine to the portal blood and to the liver. There is no storage of protein as is in the storage of fat and carbohydrates. However small amount of protein is deposited in body tissues like increase of blood plasma, liver, kidney, and other tissues increase in size after protein feeding and absorption. Protein quality is dependent upon on its amino acid composition and this is very important in the case of non-ruminant. The total quantity of protein is not adequate to express the protein value of a diet but is important to know how much of the absorbed protein is used by the animal's body (Ranjhan, 2001).

The percentage of the protein absorbed and utilized by the animal is termed as the biological value (BV), and this depends on the amino acid composition of the protein. For ruminants, the significance of poor quality protein is very limited in low producing animal since all the essential amino acids are synthesized by the microorganisms. Food protein is very much altered through the agency of this microflora. As a matter of facts poor quality protein are improved by BV whereas high quality proteins are degraded (Ranjhan, 2001).

2.9.4 Digestion in monogastric herbivores

Monogastric herbivores such as the rabbit are strict herbivores and consequently well adapted to the use of high roughage diet. They have uniquely different digestive strategy from ruminants. The digestive capacity of the rabbit depends not only on the endogenous enzyme activities and digestion by the microbial population, but also on the rate of passage of the feed (Richard and Church, 2002). Dietary fibre plays a dominant role in the retention time. Large amount of dietary lignified fibre stimulate the motility and reduce the mean retention time mainly as a results of reduced ileorectal retention time. After the enzymatic digestion in the stomach and small intestine, the undigested fraction enters the cecum.

The presence of microbial population permits the rabbit to digest the less digestible feed component and to obtain additional energy, amino acid and vitamins. However, because of selective separation in the proximal colon, the rabbit eliminates fibre from the gut as rapidly as possible, and employs its fermentation process on the breakdown of the non-fibre constituent in the cecum and colon. The large fibre-rich particles are excreted in the normal faeces. Due to an antiperistaltic action in the haustra, the particles and fluids move continuously back to the cecum but this depends on the feed intake pattern. Caecal contents now enter the proximal colon and are covered by mucus envelope. This excretion is soft and therefore named soft faeces of caecotrophs. The soft faeces consist of small pellets that are excreted as a cluster that rabbit recognise. The faeces are recognised and taken by the rabbit directly from the anus, which is called caecotrophy. Soft faeces are swallowed without mastification and stored intact in the stomach until the mucus is dehydrated. Finally they are mixed with the other digesta and follow the normal digestive process.

2.10 METABOLISM

Metabolism involves the utilization of the nutrients absorbed and the excretion of the end product from the body. It involves two stages. The first one known as anabolism and the second is called catabolism (Ranjhan 2001).

2.10.1 Metabolism of Carbohydrate

Carbohydrate is burnt to CO_2 and water to provide energy to the animal's body. 180g of hexose yields 686 kcal of heat when burnt to CO_2 and water; $C_6H_{12}O_6+6O_2 \rightarrow 6H_2O+$ 686kcal.Degradation synthesis of carbohydrates in the cell is done through a number of path ways by the various enzymes which are mostly specific. The three path way sequences that are more prominent in mammals are glycolysis, citric acid cycle, and the pentose phosphate pathway (Leonard and Loosli, 1969).

2.10.2 Metabolism of Fat

Lipids occur as essential constituents in every cell in the body. Depot fat serves primarily as source of energy. Fats are highly digestible but their digestibility is somewhat influenced by the length of the carbon chain and the state of saturation. In humans, fat digestibility decreases as the chain increases as the content of saturated acid of 18 or more carbon increases. In the case of farm animals, over all digestibility of fat containing feed influences the extent of fat digestion irrespective of the chemical makeup of the feed (Leonard and Loosli, 1969).

Most of the dietary fats enter the lacteals as chylomicrons, fatty acids, and glycerol resulting from the complete hydrolysis of triglycerides (Ranjhan, 2001). Lipids in the blood arise either from the intestinal absorption of dietary lipids or come from the

metabolization of stored fats in the body or may come from synthetic process in the liver. Fat may also be synthesized from non-lipid source such as carbohydrate (Leonard and Loosli, 1969).

The oxidation of fatty acids is a stepwise process involving the cleavage of 2-carbon fragment starting from the carboxyl end chain through a mechanism known as β-oxidation. The intermediate in fatty acids oxidation are all acy (R-C-S-CoA) derivative of coenzyme. The net results of β-oxidationis the production of acetyl CoA molecules. These enter the Krebs cycle and are oxidized to CO_2 and H_2O (Ranjhan, 2001; Leonard and Loosli, 1969).

The glycerol is first converted to dehydroxy acetone phosphate which is then converted to acetyl CoA which enters the Kreb's cycle. When 1mole of caproic acid is oxidized to carbon dioxide and water, there is a net gain of 45 moles per mole of ATP. Also the complete oxidation of butyric acid to carbon dioxide and water yields 27 moles of ATP. This confirms clearly that a product of carbon fermentation serves as source of energy for body processes and the formation of body fat as in the case for simple sugar resulting from digestion by enzymes secreted in the alimentary canal (Leonard and Loosli, 1969).

Digestible fat that have escaped the action of digestive juice and lipids which are not absorbable are found in the ether extract from faeces. The faeces may also contain metabolic fat which is ether soluble faecal material of body origin such as residues of digestive juices as distinguished from undigested or unabsorbed food lipids. In herbivores, fat digestion is much less complete due to the protective action of

undigested cellulose surrounding the fat which serves as a barrier against digestive action in general (Leonard and Loosli, 1965).

2.10.3 Metabolism of Protein

The end product of protein metabolism in the digestive tract is largely amino acids produced by the action of proteolytic enzymes in the intestine. In ruminants, microbiological processes in the rumen play a dominant role in protein nutrition. The amino acids are absorbed through the small intestine into the portal blood. They are transported to the liver and then to the systemic blood system. In the blood, there is an amino acid pool which is in dynamic equilibrium with the tissue amino acid which are intern constantly incorporated into and release from the fixed protein of animal tissue. The amino acid of blood pool serves as the major source of tissue protein synthesis (Leonard and Loosli 1965).

There is no storage of protein as in the case of fat and carbohydrates in the form of glycogen. Excess amino acids not required by the body are catabolised by the liver. Nonetheless, small amount of protein is deposited in the body tissue like increase of blood plasma, kidney, liver, etc. In ruminants the dietary need of essential amino acids is less important since the rumen microorganisms are able to synthesize both the essential and non-essential amino acid in adequate quantities. For non-ruminants, the amino acid composition and the quality of protein is very important. There are eight amino acids that are essential to growth in all animals and their tissue cannot synthesize them in adequate quantities the carbon chain or certain ά-ketoacids (Ranjhan, 2001; Leonard and Loosli, 1969).

2.11 WILD SUN FLOWER (Tithonia diversifolia)

Tithonia diversifolia commonly called wild sunflower is a shrub that belongs to the family Astaracea. Tithonia originated from Mexico and can now be found in the humid and sub-humid tropics in Central and South America, Asia and Africa (Sonke, 1997). It was introduced in Africa as an ornamental plant and it became an indigenous fallow in Kenya, Malawi, Nigeria, Rwanda and Zimbabwe. It is also common in Cameroun, Uganda and Zambia (Nguyen *et al*., 2010).

2.11.1 Botanic Description

Wild sunflower is a perinea shrub that grows 1.5 to 3m high. The leaves are ovate to triangular from 15 to30cm long (fig 2.1). The flowers resemble the single dahlia and are 5-8cm across with brightly yellow colour (fig 2.1) (Ngugen *et al*., 2010). Tithonia needs a well-drained soil which is moist to dry. It is a drought tolerant and easily sprouts. It does very well when planted by cuttings derived from the lower more fibrous part of the stem. It can also be established from seed which germinates of about 16% when planted immediately and about 90% when planted after 4 months of storage. Under practical condition, over 75% of seeds germinated when they were planted in the field during the rainy season (Muogahu and Chuba, 2005).

Fig 2.1*Tithonia diversifolia* plant Source: Journal of Enthrophamacology V 90 (2-3) 2004

Tithonia indicated a high yield potential in Columbia when it was planted from cutting at a distance of 0.75× 0.5m (26000plt/ha); the fresh biomass yield was 3kg/ plant in 110 days, equivalent to 92 tones/ha of fresh foliage. The fresh biomass was 51 tones/ha at 75 days when planted at spacing of 1.0× 0.5m (Katto and Salazer, 1995). When planted in pure stand, tithonia produces 172 tons/ ha/year in fresh form which is equal to 25 tons in dry matter with 6 tons of crude protein per hectare per year. These data show that, tithonia is a shrub that is easily established and grows faster with a very high biomass production.

2.11.2 Nutrient Composition of *Tithonia diversifolia*

Various studies have been conducted to determine the feeding values of wild sun flower. It is reported to be highly rich in protein. The crude protein level in the leaves was found to be as high as 28.5% in DM (Katto and Salaza, 1995), 23.7% (Nguyenetal, 2010), 18.9% DM (Olayini *et al.,* 2006), greater than 20% (in dry matter (Patoummalangsy, 2010), 26.2% in DM (Ngugen *et al*. 2010). It has 11% crude fiber, 5.5% ether extract and 18.2% ash (Olayini *et al*., 2006). The leaves and petioles are low in lignin and have dry matter degradability of 90%in 48 hours (Premarante *et al.*, 1998 as reported by Patoummalangsy, 2007). It is rich in phosphorous and low in NDF 38.4% (Ngugen *et al*., 2010). It is reported to be rich in vitamins especially the B-complex vitamins (Day and Levin, 1994).

2.11.3 Reported Use of Wild Sun Flower

Tithonia is a multipurpose shrub, the foliage from which has many uses. Green biomass of tithonia has been identified as source of nutrient for low land rice cultivation in Asia for the cultivation of maize and vegetable in Eastern and Southern Africa. It rapidly restores soil fertility in degraded land by increasing the plant available phosphorous. It is used as compost and it effectively checks erosion (Ngugen *et al*., 2010).

Tithonia is used as building material and shelter for poultry (Otuma *et al.,* 1998). Extract from tithonia protects crops from termites (Adayo *et al.,* 1997) and other insects (Dutta *et al*., 1993). The extract is also used for the treatment of hepatitis (Kuo and Chen, 1997) and can control amoebic dysentery (Tona *et al*., 1998). The leaves are used as supplementary diet for laying hens and also a cheap means of enhancing

egg yolk coloration (Odunsi *et al*., 1996). The leaves are browsed by nomadic cattle, sheep and goat in Nigeria. Farmers fed the harvested forage to these animals as well as rabbits (Akinola *et al*., 1999).

Many researches and feed trials have been done on wild sunflower especially in Nigeria. Olayini *et al*., 2006 used the leaf meal at 20% level of the diet of weaned pigs and reported no reduction in growth. The leaves were used as basal diet for goats and was discovered that it is rich in protein and highly digestible but the protein in the leaves is rapidly degraded in the rumen to the extent of 85% in 24 hours. Research shows that tithonia is a renowned component of agroforestry in Kenya, as it is rich in NPK which are essential for soil fertility (Jema *et al*., 2000 as reported by Patoummalagsy, 2007).

2.12 RABBIT

Rabbits are small mammals in the family Laporidae of the order Lagomorpha. They are found in several parts of the world. There are 8 different genera in the family classified as rabbits including the domestic rabbit (*Oryctogus cuniculus*) (Patton *et al*., 2008).Rabbits have very rapid productive rate. The breeding season for most rabbit is between the months of February to October. It has 30 days gestation period. Average size of litter is between 4 and 12 litters (fig 2.2) .A litter can be weaned at about 5 to 8 weeks of age. A buck is ready to breed at about 6 months and doe 7 month (Fielding, 1992).

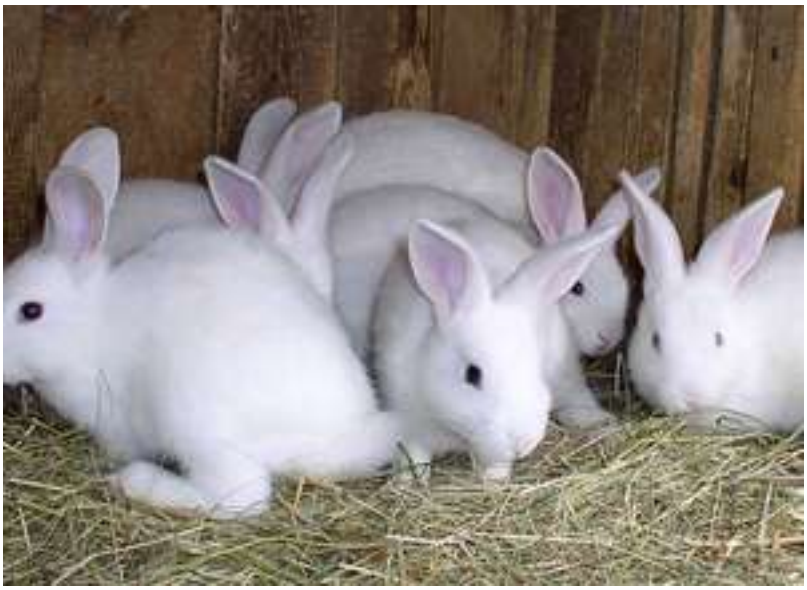

Figure 2.2 Cross-bred domestic rabbits

Rabbits are herbivores and therefore their diet contains large amount of cellulose which is hard to digest. This problem is solved by passing two different types of faeces; hard droppings and soft viscous pellets, the latter of which is immediately eaten, this is known as coprophagy. Rabbit therefore re-ingest their droppings rather than chew the cud as done by other herbivores (Wikipedia, 2010). Four major nutrient; protein, carbohydrates, minerals and vitamins should be present in the diet of the rabbit which contains 65-66%of total digestible nutrient (TDN) to enable the rabbit obtain as much energy as it needs (Robert *et al*., 2013).

Feed stuff for rabbit can be obtained from variety of sources. Wild indigenous plant, cultivated forage, farm crop residue, farm food surplus, agricultural by-product, kitchen waste and market source (Lukfahr *et al*., 1992). Rabbits, like other animals, like very clean environment. Dirty and poorly ventilated hutches retard growth and

promote diseases. Some of the diseases that affect rabbits are coccidiosis, myxomatosis, ear and skin mange, snuffles (Richard and Church, 2002).

Rabbits are reared for so many purposes amongst which the obvious and well known one is for meat. The pelts are used for clothing and accessories such as scarves and hats. The milk is used for medicinal purpose and some keep rabbit purposely as pet. Culturally, rabbits are used as symbols of fertility, innocence and playful sexuality. The foot carried as an amulet, is believed to bring good luck. In folklore, rabbit appears as the trickster archetype as it uses its Cunning to outwit its enemies (Fielding, 1992).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY AREA

The study was conducted on the Agroforestry research farm, KNUST, Kumasi Ghana. The research farm is located on Latitude 06' 41°N and Longitude 01' 36°W. The vegetation is the moist semi deciduous forest type. Rainfall pattern is bimodal with major season occurring between March and July. Annual rainfall ranges between 1250mm-1500mm. Mean annual temperature is 26.6°C with annual humidity of 67.6% (Ghana meteorological department, 2008). The study was conducted between May and July.

3.2 PREPARATION OF TEST INGREDIENTS

Wild sunflower plant was harvested from the uncultivated plots of the horticulture research farm (mango lane) at the university. The leaves and succulent stalks were harvested when the first inflorescence had opened in 50-80% so as to capture the highest leaf production before its quality decrease (Fahey, 1994). Wild sunflower leaf meal was prepared by air-drying the leaf and the succulent stalkson a concrete floor inside a well-ventilated roofed house to preserve its nutritive value as much as possible (Fahey, 1994). The dried leaves were then milled into wild sunflower leaf meal (WSLM). The milled leaves were mixed with other agro-by-products at various percentages using Pearson's square method of ration formulation (Wagner and Stanton, 2010).

3.3 EXPERIMENTAL DIET

Four (4) experimental diets containing 0%, 5%, 10%, 15% wild sunflower leaf meal were formulated (Table 3.1).

Table 3.1: Percentage composition of experimental diet

	Diet composition			
Ingredients	Diet 1(0%)	Diet 2(5%)	Diet 3(10%)	Diet 4(15%)
Maize	19.5	18.5	15.5	12.5
Corn bran	37.0	37.0	37.0	37.0
WSLM	-	5.0	10.0	15.0
Groundnut husk	16.0	12.0	10.0	8.0
Palm kernel cake	20.0	20.0	20.0	20.0
Fish meal	2.0	2.0	2.0	2.0
Bone meal	3.0	3.0	3.0	3.0
Premix	2.0	2.0	2.0	2.0
Salt	0.5	0.5	0.5.	0.5
Total	100.0	100.0	100.0	100.0

Premix composition per kg feed; vita,15001U, vit$D_{3,}$ 2500IU, vitEIIIU; vit$B_2$10mg; $B_3$40MG; $B_6$20mg, cholinchloride400mg; Mn120mg; Fe70mg; Cu10mg, Iodine2.2mg. Se 0.2, Zn45mg, Co 0.02mg

3.4 EXPERIMENTAL ANIMALS AND THIER MANAGEMENT

Twelve (12) cross-bred, 6-8 weeks old female weaned rabbits with a balanced initial weight range of between 633.33-666.66g were used. The animals were randomly allocated to four dietary treatments groups in a completely randomized experimental design. There were three rabbits per treatment and each rabbit constitute a replicate.

The formulated feeds were offered and the left over were collected and weighed to determine feed intake of the animals. After the initial weight, weekly weights were taken. These records were used to monitor and determine the performance parameters in terms of mean weight gain and feed intake.

The animals were managed intensively and housed one each in specially constructed concrete cages with metal floor and metal gate. Facilities for drinking, feeding and tray for collection of faeces were provided. A total of 100g feed was given to each animal per day. The animals were fed for two week with the experimental diets to get them acclimatized, and data was collected for eight weeks.

3.5 DIGESTIBILITY TRIALS

Faecal sample were collected daily for one week during the 8^{th} week of the experiment and sundried. The dried faeces were analyzed for the proximate constituent and the results were used to determine digestion of the feed nutrient by the rabbit. Digestibility of the nutrients was determined by the formula:

$$\text{Digestibility coefficient} = \frac{\text{Nutrient digested}}{\text{Nutrient intake}} \times 100$$

3.6 CHEMICAL ANALYSIS

The proximate component of the test ingredient, sample of the diet and faeces were determined by the AOAC (1990).

3.6.1 Ash determination

Feed sample (5g) was weighed into porcelain crucible in duplicate. The crucible plus the sample was put into furnace (550^0C) for 4 hours by which the sample had turned into ash. The temperature in the furnace was reduced 200^0C and maintained for 20 minutes. The ash was removed from the furnace and allowed to cool in desiccators so that it does not absorb any moisture. The ash and the crucible were then weighed. The value of the ash was determined by;

(A + B) – A = B

(A +C) – A = C

% ASH =C/B X100

Where A = Crucible weight, B = Sample weight, and C= Ash weight

3.6.2 Ether extract

The ether extract of the samples were determined by extracting the dry sample with petroleum ether as the reagent. The weight of the extract was determined after distilling the ether and weighing the residue using the Soxhlet apparatus, Whatman No 45 filter paper and absorbent cotton wool. The ether extract was given by;

(A + B) – A = B

Therefore, % EE = B/A X 100s

3.6.3 Crude Fibre Determination

The determination of crude fibre was an attempt to separate the more readily digestible carbohydrates from those less readily digestible. The Crude fibre refers to the organic residue of the feed that is insoluble after successive boiling with an acid and alkali solutions according to specified procedures. The sample was boiled in an electric furnace (at 550^oC) with dilute acid (0.255 N: 1.25 % H_2SO_4/100 ml distilled water)and alkali (0.312 N: 1.25 g NaOH/100 ml distilled water) using the following;750ml Erlenmeyer flask, Filtering cloth, Air-tight sample containers, Anti-foaming agent (N-tributyl citrate) 95% ethanol and Gooch crucible. This is an attempt to imitate the process that occurs in the digestive tract based on the supposition that carbohydrates, which are readily dissolved by this procedure, will also be readily

digested by animals and those not soluble under these conditions are not readily digestible. The percentage crude fibre is given by;

% crude fibre = $\frac{A - B}{C} \times 100$ where A = wt. of dry crucible and sample

B = wt. of incinerated crucible and ash, C = sample weight.

3.6.4 Crude Protein Determination

The crude protein content is calculated from nitrogen (N) content of the food, determined by the micro-Kjeldahl technique. This method involves three main steps; digestion of sample, distillation of digest, and titration of distillate. The N in the feed was converted to ammonium sulphate by H_2SO_4 digestion (using digestion tablet) in a digestion tract. This salt, on steam-distillation, liberated NH_3 which was collected in boric acid solution and titrated against standard acid. Since 1ml of 0.1N acid is equivalent to 1.401mg of N, calculation is made to arrive at the N content of the sample. It is assumed that the N is derived from protein containing 16% N, and multiplying the N figure by 100/16 or 6.25, an approximate protein value was obtained. The N content of the sample was calculated by the formula:

$$\%\text{nitrogen} = \frac{ml\ acid \times normality\ of\ acid}{weight\ of\ sample} \times 100$$

Therefore; % crude protein (CP) = Total Nitrogen (N_T)$\times$ $6.25(Protein\ factor)$

3.6.5 Nitrogen-Free Extract

The calculation of nitrogen-free extract (NFE) was made after completing the analysis for ash, crude fibre, ether extract and crude protein. The value was made by adding the percentage values on dry matter basis of these analysed contents and subtracting them from 100.

NFE (%) on DM basis = 100% - [(%ash on DM basis) + (% crude fibre on DM basis) + (% ether extract on DM basis) + (% protein on DM basis)]

3.7 STATISTICAL ANALYSIS

All the data collected on weight gain, feed intake, and nutrient digestibility was subjected to analysis of variance (ANOVA) according to Steel and Torrie (1980) using SAS software (2000). Where there was a significant difference, LSD test was used to separate the means.

CHAPTER FOUR

4.0 RESULTS

4.1 PROXIMATE CONPOSITION OF EXPERIMENTAL DIETS

The result of the proximate analysis of the test ingredient and the four (4) experimental diets are presented in table 4.1. Crude protein and crude fibre content of WSLM in this study were 22.31% and 3.16% respectively. Ether extract level was 10.00% and Ash content was 14.00%. Nitrogen free extract was however 36.53%.

Diet 1 (0%WSLM) had the lowest crude protein level (15.10%) whiles diet 4 (15% WSLM) had the highest (16.2 %.) level. Crude protein level in diet 2 (5% WSLM) and diet 3(10%WSLM) were 15.2% and15.8% respectively. It was observed that diet 3(10%WSLM) recorded the highest crude fibre content (4.81%) and diet 4(15%WSLM) rather had the lowest crude fibre content (4.12%). Diets1 (0% WSLM) and diet 2 (5%WSLM) had 4.17% and 4.14% level of crude fibre respectively. The value of ether extract in diet 1(0% WSLM) was 15.80%. The level decreased to 14.9% in diet 2(5% WSLM), decreased further to 14.7% in diet3 (10% WSLM) and 14.4% in diet 4 (15% WSLM).

The 0% inclusion level of WSLM (diet 1) recorded the lowest ash content (8.22%) whiles diet 4(15% WSLM) recorded the highest level (9.62%). Ash value for diets 2(5% WSLM) and diet 3 (10% WSLM) were 8.91% and 9.01% respectively. Nitrogen free extract content in the diets also decreased with increasing WSLM. The value ranged between 48.61% for diet 1(0% WSLM) and 47.01% for diet 4(15%

WSLM). Diet 2(10% WSLM) recorded 48.23% and diet 3(10% WSLM) recorded 47.41%.

Table 4.1: proximate composition of experimental diet and test ingredients

		Diet			
Nutrients(%DM)	WSLM	1	2	3	4
Crude protein	22.31	15.10	15.20	15.80	16.20
Crude fibre	3.16	4.17	4.14	4.81	4.12
Ether extract	10.00	15.80	14.90	14.70	14.40
Ash	14.00	8.22	8.91	9.01	9.62
NFE	36.53	48.61	48.23	47.41	47.01

WSLM –wild sunflower leaf meal, NFE –nitrogen free extract

4.2 PERFORMANCE CHARACTERISTICS OF RABBIT

The performance characteristics of the rabbit are presented in table 4.2. The mean daily intake was significant between rabbits on diet 1and 4 only which ranged from 58.53 to 71.06g respectively. The variations observed though not significant among the rest of the treatments, feed intake increased with increase in WSLM level.

Table 4.2: Performance characteristics of rabbit fed wild sun flower leaf meal

	Diet						
Parameters(g)	1(0%)	2(5%)	3(10%)	4(15%)	SME	LSD	SIG
Dwg	13.57[a]	17.50[b]	14.07[a]	13.87[a]	1.26	1.71	S
Growth rate	14.90[a]	16.10[b]	14.30[a]	12.50[a]	2.89	5.44	S
Mean intake	58.53[b]	60.43[ab]	67.43[ab]	71.06[a]	6.01	11.32	S

*means along the same row with the same superscript are not significantly different ($p<0.05$)
SME-standard error of the mean, LSD-least significant difference, SIG-significant level, NS- not significant.Dwg –daily weight gain

4.3 DIGESTIBILITY OF NUTRIENTS

There was significant ($p < 0.05$) difference among treatment in the digestibility of crude protein, crude fibre as well as ether extract (Table 4.3).Drymatter digestibility was however not significant among the four dietary treatment.

Table 4.3: Digestibility of nutrient by rabbit fed WSFL meal

	Diet						
Nutrients(%DM)	1(0%)	2(5%)	3(10%)	4(15%)	SME	LSD	SIG
Drymatter	49.60[a]	48.90[a]	44.30[a]	60.46[a]	10.72	20.19	NS
Crudeprotein	0.55[d]	2.94[a]	1.30[c]	1.71[b]	0.01	0.02	*
Crude fibre	8.33[c]	9.35[b]	12.28[a]	9.39[c]	0.03	0.07	*
Ether extract	10.79[b]	10.89[a]	9.70[d]	9.89[c]	0.01	0.01	*

*Means along the same row with different superscript are significantly different ($p<0.05$)
SIG=significant level,*= significant, NS=not significant.

The digestibility values of the nutrients (Table 4.3) were generally lower than those reported by Ajayi *et al*., (2007) and Olabanji *et al.*, (2007) when rabbits were fed WSFL-blood mixture. The difference could be as a result of the blood protein present as compared to the low digestibility of protein in leave meals which tends to depress the overall nutrient digestibly in a meal if it forms a significant proportion of the diet (Tangendjaja *et al*., 1990).The significant ($p<0.05$) difference in digestibility recorded however corroborates that of Ajayi *et al.*, (2007)who observed significantly different values and disagree with that reported by Olabanji *et al*., (2007) who recorded non-significant values for the digestibility of nutrient by rabbits.

CHAPTER FIVE

5.0 DISCUSSION

5.1 PROXIMATE COMPOSITION OF EXPERIMENTAL DIET

Crude protein content of wild sun flower leave meal (22.3%) (Table 4.1) in this study was higher than the value reported by Togun *et al*. (2006) and Ajayi *et al*. (2007) and lower than the value reported by Katto and Salaza (1995). The value was however similar to that reported by Nguyen (2010) and Olabanji *et al*. (2007). The differences in the values of protein obtained may be attributed to the differences in soil nutrients in the soils on which the plants were grown. It may also be due to the difference in the stage of growth of the plant at harvest.

The value of ash (14%) (Table 4.1) obtained in this study was higher than the values reported by Olayini *et al,* (2006). It was however similar to that reported by Togun *et al* and Ajayi *et al,* (2007). The ether extracts value (10%) (Table 4.1) was similar to the value reported by Olabanji *et al,* (2007) and higher than the value reported by Olayini *et al,* (2007).The differences in ether extract and ash values may be due to lost of some volatile minerals due to excessive heat during the analysis. However, the values obtained for crude fibre was lower than the value reported by Ajayi *et al,* (2007) and Olanbanji *et al,* (2007). The differences in crude fibre value may be due to the stage of growth of the plant at harvest as well as the method used in the processing of the meal

5.2 PERFORMANCE CHRACTERISTICS OF THE RABBITS

The mean daily intake (Table 4.2) was significant between rabbits on diet 1 and 4 only, which ranged from 58.53 to 71.06g respectively. The variations observed though not significant among the rest of the treatments, feed intake increased with increase in WSLM level. The daily feed intake values obtained were lower than the values reported by Pathoummalangsy and Preston (2007), but similar to those reported by Aderinola *et al*. (2008) and Ajayi *et al*. (2007).

There was a marked decrease in daily weight gain at the 15% inclusion level (13.87). The gradual increase in feed intake from diet 2(5%) to diet 4(15%) with the corresponding decrease in life weight gain across the dietary treatment groups(Table 4.2) is similar 1to the observations made by Togun *et al.(*2006) when WSFL was fed to Isa brown cocks. It was also found that, the crude protein level increased as the level of WSLM increased whiles weight gain decreased. This is as a result of a decrease in metabolizable energy as explained by Ajayi *et al. (*2007), that generally, animals eat to meet their energy requirement if fed ad libitum. Since increase in WSFM level decreased the metabolizable energy and increased the crude protein level, the animals therefore ate more so as to meet their energy requirement. This could also be attributed to the nature of protein present in Tithonia leaves. As explained by Tangendjaja *et al*. (1990), the digestibility of crude protein in many leaves is low which tends to depress the overall nutrients digestibility when leaf meal constitutes a significant proportion of the diet. That is why daily weight gain deceased from 5% inclusion level to 15% inclusion level, even when feed intake increased (Table 4.2). The reduction in growth could also be due to the anti-nutrients in WSLM (Dutta *et al*., 993).

The average daily live weight gain per rabbit ranged from 13.57 for diet 1 to 13.86g for diet 4. These values though not significant, were slightly higher than the values recorded by Ajayi *et al.,(*2007) when WSFL-blood meal mixture was fed to male weaner rabbit and that of Olanbanji *et al*.,(2007) when WSFL-blood meal mixture was fed to male and female weaner rabbits. This observation is also similar to that reported by Togun *et al*.(2006) and Odunsi *et al*., (1996).

5.3 DIGESTIBILITY OF THE NUTRIENTS

Rabbits on diet 2 (5% WSFL meal) (Table 4.3) recorded the highest digestibility values for crude protein and fat which is essential for growth and energy respectively. These results showed marked improvement in the digestibility of nutrient by animals on diet 2. Thus 5% inclusion level of WSFLM meal, reflecting efficient utilization of nutrient and hence recording the highest daily weight gain (Table 4.3). This observation conforms to that of Togun *et al*., 2006 who reported that, the inclusion of WSFL meal at 5% level in the diet of commercial cocks was adequate for better growth. On the contrary, the result observed does not agree with the findings of Olabanji *et al.,* (2007) who reported a better growth for rabbit at 20% inclusion of WSFL-blood, and that of Ajayi *et al* who reported a better growth of male rabbit fed on diet containing 15% level of SFLM-blood meal mixture.The difference in the percentage levels could be due to the absence of the blood meal in the feed mixture in this study.

The digestibility values of the nutrients (Table 4.3) were generally lower than those reported by Ajayi *et al*., (2007) and Olabanji *et al*., (2007) when rabbits were fed WSFL-blood mixture. The difference could be as a result of the bloodprotein present

as compared to the low digestibility of protein in leave meals which tends to depress the overall nutrient digestibly in a meal if it forms a significant proportion of the diet (Tangendjaja *et al*., 1990).The significant ($p<0.05$) difference in digestibility recorded however corroborates that of Ajayi *et al*. (2007)who observed significantly different values and disagree with that reported by Olabanji *et al*.(2007) who recorded non-significant values for the digestibility of nutrient by rabbits.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

This study was conducted with the aim of evaluating the effect of supplementation with Tithonia as protein source on feed intake, digestibility, and live weight change of rabbit. The problem with Tithonia observed in this study seems to be in digestibility of crude protein and the other nutrients. Although the voluntary feed intake increased with increasing Tithonia leaves in the diet, there was a decline in the weight gain. However, it can be conclude that Tithonia is high in protein but the protein is highly degradable ,and that, the inclusion of Wild Sunflower Leave Meal at 5% level in the diet of female weaner rabbit did not adversely affect performance and improve its digestibility.

6.2 RECOMMENDATION

In future research, the addition of animal by-product to Tithonia leaves can be looked at to increase the digestibility of protein and other nutrients in the leaves. It was also discovered that Tithonia contains some anti-nutrients (bitterness) which inhibits nutrients digestibility. Any study that will look at reducing the anti-nutrients of the leaves is highly recommended.

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