IN SACCO DEGRADATION OF COWPEA HAY (*Vigna unguiculata*) AND SWEET POTATO (*Ipomoea batatas*) VINE CULTIVARS BY GOATS IN NORTH WESTERN NIGERIA

BY

AMINU JINJIRI

SPS/14/MAS/00011

NCE, B. AGRICULTURE

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DECLARATION

I hereby declare that this work is the product of my own research efforts undertaken under the supervision of Dr. Yusuf Garba and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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Aminu Jinjiri

SPS/14/MAS/00011

CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent write-up by Aminu Jinjiri (SPS/14/MAS/00011) were carried out under my supervision.

…………………………..	…………………………..
Dr. Yusuf Garba	Dr. Nuhu Bello Rano
(Supervisor)	(Head of Department)

APPROVAL

This Dissertation has been examined and approved for the award of Masters Degree in Animal Science.

…………………………………… …………………………

Dr. N. Muhammad Date

. (External Examiner)

…………………………….. ……………………

Dr. A. Nasiru Date

(Internal Examiner)

.... ………………………

Dr. Y. Garba Date

(Supervisor)

………………………………… ……………………

Dr. N. B. Rano Date

(Head of Department)

………………………………… ……………………

Dr. M. U Dawaki Date

(SPS Representative)

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This Dissertation is dedicated to my elderly grandmother Hajiya Hassana Sa'idu.

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Abstract

The objectives of the studies were to determine *in sacco* rumen degradation, nutrients disappearance, nutrients intake and digestibility of two cultivars of sweet potato vines. Two cultivars of potato and cowpea hay serving as control were collected and laid out in a cross over design. *In sacco* degradation was according to Orskov *et al.* Intake was recorded and digestibility of nutrients determined. Exponential models of Orskov and Mc-Donald were used to estimate degradation kinetics. Data generated were subjected to analysis of variance. Results from nutrient disappearances showed that potato vine cultivars have no effect ($p>0.05$) on nutrients disappearance. Cultivars have significant effect ($p<0.05$) on degradation kinetics with potato cultivars having highest CP slowly degradable fraction and effective degradability. But, potato vine cultivars have no significant effect ($p>0.05$) on CF and NDF slowly degradable fraction, degradation constant rate and effective degradability. No significant difference ($p>0.05$) was observed with respect to nutrient intake. Likewise result of nutrient digestibility showed no significant differences ($p>0.05$) among the treatments. It is concluded that the sweet potato vine cultivars are more degradable than cowpea hay (control diet). It is therefore recommended that Sweet potato vines be used as ruminant feedstuff particularly during feed scarcity for improved performance and productivity.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

In developing countries, ruminants are managed under crop-based or range based production systems. They suffer from seasonal nutritional stress (Bruinsma, 2003). Forages and crop residues are the main feed resources which are noted to be low in crude protein occasioned by seasonal fluctuations in climatic factors required for quality forage production. This has resulted in significant decrease in voluntary feed intake, general performance and digestibility of the feeds (Alemayehu, 2002). Mugerwa, Kabirizi, Zziwa and Lukwago (2012) reported that low nutritive value, high labour cost, lack of knowledge and capital are the major constraints to the adoption and utilization of crop residues in the livestock feeding system. Therefore, in order to curb the problems of feed scarcity, the use of feed resources such as sweet potato vines can mitigate feed scarcity (Hristov, Grandeen, Ropp & Greer, 2004). Sweet potato is a creeping plant with perennial vines and adventious roots, which can be easily cultivated and is relatively drought resistant and the feeding value of the vines is close to that of Alfalfa (Dominquez, 1992). Traditionally, majority of small scale farmers in Africa and Asia plant sweet potato for tubers as source of energy or fodder and as source of protein and vitamins for humans (Larbi *et al.*, 2007) and livestock (Farell, Jibril, Maldonada & Mannion, 2000). Sweet potato forages can be source of protein as it contains about 15-30% crude protein on dry matter basis. They are characterized by low DM contents, low soluble carbohydrate and high buffering capacity due to high CP contents (Bureenok, Yuangklang, Vasupen, Schonewille and Kawamoto, 2012). But the forage quality depends on the proportion of leaves and stem, the latter contains much less protein than the leaves (An, 2004). Nigeria is the second largest producer of sweet potato in Africa after Uganda with over two million metric tonnes annually (FAO, 2016). Potato is produced throughout Nigeria (Mwanja, Goler and Gugu, 2017). Sweet potato vines can be safely fed to animals without any restrictions (Dahlanuddin, 2001). Potato vines could, therefore, serve as an important ruminant livestock feed resource in the developing countries. The value of sweet potato is attributed to high yield, palatability and crude protein contents. These characteristics coupled with high moisture content (Orodho, Alela & Wanambacha, 1993) make it a suitable protein supplement for animals receiving low quality forage in the dry season.

According to FAO (2010), sweet potato vines are fed to lactating or fattened animals without any supplementation as the vines alone can provide all protein needed by these animals. Thus, sweet potato vines have been reported to provide sufficient crude protein and metabolizable energy to sustain goats in terms of meat and milk production in tropical conditions, even during periods of feed scarcity, when conventional feeds are in short supply (Katongole, Bareeba, Sabiti and Ledin, 2009). Feeding goats with sweet potato vines provide cheap nutrients and increase feed efficiency (Aregheore and Tofinga, 2004).

Since the rumen is the primary site of digestion of forages, it is important to monitor their degradation kinetics. This can be achieved by using *in sacco* technique which is quicker and cheaper than the whole animal studies. The *in sacco* nylon bag technique, when feed samples in nylon bags are suspended in the rumen, is widely used to estimate the rate and extent of degradation and digestion of feed in the rumen (Orskov & Mc-Donald, 1979). Important characteristics of digestion in the rumen with regard to forages are: effective degradability, rate of digestion and amount of digestible fibre (Larbi *et al.*, 2007). Rumen degradation is therefore regarded as a major descriptor of forage quality (Orskov & Mc-Donald, 1979).

1.2 PROBLEM STATEMENT

Local feed resources constitute the main source of ruminants feed in Nigeria which is characterized by high fibre content. This poses a big challenge to ruminant animal production (Mathis *et al.,* 2000). The National Root Crops Research Institute has introduced different potato cultivars and there is need for cultivar vines evaluation to ascertain their nutritive and feeding value. *In sacco* rumen degradation is one of the tool used in ruminant feed evaluation. The evaluation of the nutritive value of different cultivars of sweet potato vines in term of their degradation characteristics would provide useful information on the variability amongst cultivars.

1.3 JUSTIFICATION OF THE STUDY

In recent years, there has been considerable interest in the use of crop residues for feeding small ruminants in Nigeria. However, little is known about the nutritive value of such feedstuff in Nigeria and other West African countries (Murugan, Kumar & Nedunchezhiyan, 2012).

The nutritive value of a ruminant feed is determined by the concentration of its chemical components, as well as their rate and extent of digestion (Paya, Taghizadeh, Janamohamadi & Moghadam, 2008). But there are a number of techniques available to evaluate the nutritive value of feed at relatively low cost such as *In sacco and In vitro* disappearance techniques (Taghizadeh, Hatami, Moghadam and Tahmasbi, 2006). The Nylon bag technique described by (Orskov, Horvell & Mould, 1980) for the determination of the degradation of feed- stuff in the rumen at various incubation periods can be used to screen feeds at the initial stages of assessing their nutritive values. The technique provide useful information for estimating rates of disappearance and potential degradability of feedstuffs and feed constituents (Getachew, Makkar & Becker, 1998).

Determination of the feed digestibility using *in vivo* technique is laborious, expensive, requires large quantities of feed and is largely unsuitable for single feedstuff and making it routine feed evaluation (Getachew, Robinson, De Peters & Taylor, 2004). Ruminal degradability and small intestine digestibility are two important measurements to consider when determining the nutritive value of any feeds (Woods, O'Mara & Moloney, 2003). Despite the large quantities of these crop residues in Nigeria and other sub Saharan African countries, very little information is available on the degradability of these feed-stuffs that are locally used as livestock feed in the tropics.

Therefore, the need to evaluate the nutritional value of these crop residues is necessary since crop residues makes important contribution to the protein and energy consumption of ruminants (FAO, 2010). Furthermore, Nigeria is known to produce residues from different cultivars of sweet potato and their utilization by ruminants is largely dependent upon microbial degradation within the rumen of the animal. Thus, degradability of the vines varies according to species, varieties, environmental condition and stage of maturity (Osuji, Nsahlai & Khalili, 1993).

1.4 OBJECTIVES OF THE STUDY

The objectives of the study were:

i) To examine nutrients disappearance of sweet potato vines by bucks

ii) To determine rumen degradability of sweet potato vines by bucks through *in sacco* method.

iii) To assess nutrient intake and digestibility of sweet potato vines fed to bucks.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1 ESTIMATION OF THE NUTRITIVE VALUE OF RUMINANT FEED

Evaluation of feeds should provide nutritionist with the necessary information to formulate a diet from both a physiological and economical view points, in order optimize the animal performance (Theodorou, Williams, Dhaona, Mc Ailan & France, 1994). Laboratory methods to estimate nutritive value of feed have improved since the first idea in 1725, when ruminant feed were evaluated as Straw Units (Blaxter, 1986). Initially, the techniques were designed mainly to characterize nutritive value of feed stuff rather than to predict animal performance. Improvements in the methods of food evaluation have followed new concepts in chemistry, animal physiology, rumen microbiology knowledge and related field of science (Blaxter, 1986).

Feed evaluation needs to define roughage characteristics which determine animal performance, for example live weight Gain, Milk, Yield, Wool growth (Blummel, Makkar, Chisanga, Mtimuni & Becker, 1997). Prediction of the animal intake is highly relevant and important aspect related to feeding forages (Minson, 1990). In practice, the prediction of roughages intake still presents problems such as rumen environment, rumen volume and antinutritional factors (Blummel & Becker, 1997).

The future development of feed evaluation system should incorporate new information on the relationship between specific end products of digestion and performance of the animals, as well as information on animal and microbial metabolism, feed composition and effect of various factors on feed utilization (Flatt, 1988). An adequate dietary analysis of any sort requires that the methods employed are relevant to a nutritional classification of the dietary chemical components (Van Soest & Robertson, 1985). The current achievement in this field shows a very exciting new horizon in feed evaluation, with particular emphasis on roughages evaluation (Orskov, 1998).

Nowadays, the *in sacco* techniques is probably the most widely used method for feed studies, however some drawbacks have been pointed out (Michalet-Doreau & Bah, 1993). Other procedures are also in used proximate analysis, its alternative procedure for the fibre (Van Soest, 1967) and modern instrumental techniques.

2.2 *IN SACCO* RUMEN DEGRADABILITY

In sacco method, also named as nylon bag or *In situ* is based on depositing separately feed stuffs into bags which are incubated into the rumen of an animal fitted with a rumen cannula. The main objective is to measure the disappearance of dry matter and or other nutrients. In early experiments (Quin, Vanderwath & Mayburdh, 1939) silk bags were used to incubate samples. These were later replaced by other types of clothes e.g nylon, polyester or Dacron.

Initially the method was successfully used to assess different feedstuffs and to determine the effect of formaldehyde treatment on degradation of protein supplement (Demarquilly & Chemist, 1969). Results from such studies were obtained from a single incubation time of 24 and 48 hours, which later were shown to have some drawbacks such as position of the bags in the rumen and washing of the bags after incubation.

In 1977, Mehrez and Orskov proposed the use of *in sacco* methods as a routine procedure for measuring protein degradation rate, incubating several bags in order to obtain kinetic evaluation of the degradation. Van Soest, Mertens and Deimum (1978) and Orskov, Reid and Kay (1988) have suggested the use of kinetics of fermentation data to improve the estimation of nutritive value of feed when both *in vitro* and *in sacco* methods are considered. Such a dynamic approach improves markedly the potential of this technique as suggested by Orskov *et al.* (1980) in forage evaluation.

2.3 FACTORS INFLUENCING *IN SACCO* RUMEN DEGRADABILITY

2. 3.1 <u>Sample Size to Bag Surface Ratio</u>

The ideal ratio has been quoted as about 15mg/DM/CM^2 (Orskov, 1992 and Michalet-Doreau & Ould-Bah, 1992). The incubated sample should be able to move freely within the bags to avoid formation of micro environments that affect replication of the analysis. Other aspects that have to be considered in sample bag size ratio is the amount of residue required for further analysis. The number of bags at one given time should depend on the species of the host animal.

2. 3. 2 <u>Bag Pore Size</u>

The ideal pore size shall allow the entrance of rumen liquor and efflux of degraded fractions. Bag pores should also be sufficiently small to minimize losses of undegraded feed particles, maintaining an active microbial population and preventing blockage of the pores by feed components. The choice of bag porosity must be a compromise between loss of undegraded feed particles and the movement of microorganisms through the bag. A pore size between 40-60 um is adopted as a standard (Orskov, 1992 and Michalet-Doreau & Ould-Bah, 1992).

2. 3. 3 <u>Diet of the Host Animal</u>

The ideal condition for evaluating degradability of a feed is that, the feed must have similar characteristics to those under evaluation. However, finding similarity between different feed components become a limiting factor if too many feeds are to be evaluated. Formulated diets must ensure optimal rumen environment for microbial growth, with particular emphasis in cellulolytic bacteria. A stable rumen environment is an important factor for ensuring degradability of feeds. In evaluation of protein supplements of vegetable origin it is noted that when diet changes from a high concentrate to a high roughage there would be significant decrease in degradation rate. However, only little differences were observed on protein supplements of animal origin (Orskov , 1992).

2. 3.4 Number and Species of the Animal

Mehrez and Orskov (1977) observed that the greater source of variation of the *In sacco* techniques was the host animals. It has been suggested that a sample has to be incubated for atleast two periods in three animals to give an accurate estimation for a given incubation time. There are small or no differences in the *In sacco* degradation rate from samples incubated in other animals (Orskov, 1992).

2. 3. 5 Sample Preparations

As far as possible the sample should represent the materials as they would appear in the rumen had they been consumed by the animals. Therefore, the ideal sample preparations would be a masticated digesta from animals fitted with oesophageal cannula (Orskov, 1992). As this is not feasible in most cases, it is suggested that dry and milled sample is used instead. The dry sample should be milled through a 2.50-3.00 mm diameter sieve.The green forage and silage should be processed using a mincer with 5.00 mm screen. Mehrez and Orskov (1977) and Nocek (1985) recommended to presoak bags containing the sample in water, although, limited information is available on the advantage of such procedure (Michalet-Doreau & Ould-Bah, 1992).

2. 3. 6 Incubation and Withdrawal of the Bags

Bags should move freely within the digesta, both in liquid and solid phase (Orskov, 1992). The inclusion of an extra weight to ensure proper anchorage does not seem to be of major importance (Michalet-Doreau and Ould-Bah, 1992). The time that each bag stays in the rumen will depend on the characteristics of the sample which should be able to pass through 2-3mm screen. It is important that the most sensitive part of the curve is well supported by observations.

2. 3. 7 Washing the Bags

In order to eliminate other feed particle and micro organisms the bags can be washed by hand or machine (Michalet-Doreau & Ould-Bah, 1992). The residue is dried to determine the losses during incubation time. Feed samples should be placed into more than two different bags, then washed in the same way in order to determine the "washing loss". Such analysis should provide information on the presence of very fine particles and or very rapidly degradable fraction in the sample.

2.4 SMALL RUMINANT PRODUCTION IN NIGERIA

Small ruminants which include goats and sheep play a significant role in the food chain and overall livelihoods of rural households. Sheep and goats can be reared for various reasons such as income generation, religious purposes, household consumption and hobbies and as security against crop failure (Ozung, Nsa, Ebegbulem & Ubua, 2011). According to FAOSTAT (2008), sheep numbers were in excess of one billion (1,078,200,000) and goat numbers (861,900,000) were steadily approaching that number. About 22% and 17% of the total world sheep and goat population belongs to tropical Africa (Ahmed and Egwu, 2014). In Nigeria is about 70% of small ruminants are found in semi-arid zones and belongs to the agro-pastoral farmers (Ahmed and Egwu, 2014)

Among all the livestock in Nigeria, ruminants constitute the farm animals largely reared by farm families in the country's agricultural system. In Nigeria, the livestock population comprised about 73,879,561 Goats, 42,091,042 Sheep, 20,560,931 Cattle and 279,802 Camel (FAO, 2016). The larger proportion of these animals are largely concentrated in the northern region of the country. Specifically about 90 percent of the country's cattle population and 70 percent of the sheep and goat populations are concentrated in northern region of the country (Adebowale, 2012). These animals are mostly reared for meat and are also important sources of milk, skins and manure. Their fecundity, short generation interval and capability for fitting into all existing agricultural production systems, as well as the prevailing demand for mutton, place them in a unique position (Ozung *et al.*, 2011). Sheep and goats constitute a good source of family income and livelihood, assets and agricultural resources for smallholder farmers (Shittu *et al.*, 2008; Salem-Ben & Smith, 2008). This makes small ruminant farming an important and secured form of agricultural investment to the Nigerian rural and urban farmers. Despite the potentials of small ruminant, shortage of animal protein still remains a major problem confronting the ever increasing human population in the developing countries (Salami,Makinde & Garba, 2010). In Nigeria and other developing countries there is inadequate nutrition to small ruminants (Ahamefule & Udo, 2010). Feed scarcity becomes worse during the dry season when the animals are unable to meet their protein and energy requirement from available poor quality herbage leading to consequent weight loss and low productivity (Ngele, Adegbola, Bogoro, Abubakar & Kalla, 2010).

The breeds of sheep and goat as identified by Adebawole (2012) in the country are mainly indigenous, and for the sheep *(Ovis aeris)* are 'West African Dwarf (WAD) sheep, Balami, Uda and Yankasa. Out of these four major of breeds of sheep in the country, the WAD breed is common to southern region against the widespread of Balami, Uda and Yakansa breeds in the northern region of the country. A study on the breeds of sheep showed that among the Fulani pastoralists ewes had approximately 120% fertility rate, 12% rate of twinning and 25% lamb mortality rate at 3months old. Sheep productivity index puts lamb weight at 0.327 kg at a weaning age of 90 days, and 0.490 kg at a weaning age of 180days per ewe per year. Mature males of local breeds of sheep on average have a live weight of abetween 30 to 65kg and their female counter parts often weigh between 30 and 45kg (Adebowale, 2012).

The goat (*Capra hircus L.*) represents one of the most important livestock species found in many part of the world. Goats are among the first to be domesticated by man as livestock about 10,000 years ago (Muhammad, 2017). In developing countries, large amount of goat resources are obtained (Rashid, 2008). The largest number of goats is found in Asia, followed by Africa, representing about 59.7% and 33.8% respectively while lowest population is found in Oceania accounting of 0.1% of the total world population (FAOSTAT, 2008). However, the breeds of goats in Nigeria are largely indigenous which includes the West African Dwarf (WAD) goat, Sahel/desert goat- known as West African long-legged goat and Sokoto Red/Maradi. The Kalahari goat breed, which is of South Africa origin is gradually being adapted to the Nigeria's ecological zones. Distribution of goat breeds in the country showed that the West African Dwarf (WAD) goat is common to southern Nigeria while the Sahel or desert goat and Sokoto Red are common to the northern region of the country. Production characteristic of the small ruminant showed that breeds of goats in the country had low fertility rate (below 100%), 40% twins and triplets birth rates, and low mortality rates of 22% for kids and 14.4% for adults. The productivity indices for 90 and 180 days weaning age were 0.259 kg and 0.437 kg kid/kg doe respectively (Adebawole, 2012).

Rearing of small ruminant animals, in urban areas has continued to be on the increase largely due to procreative abilities of the animals. For instance both sheep and goats give birth to young ones within a relatively short time of five months. While sheep mostly give birth to between one and two lambs, goats on the other hand produce twin and triplets twice a year for both sheep and goats (Okanlade & Adebowale, 2011). Small ruminants fit into the smallholder production system, as they require low initial capital investment and low operational cost (Pollot & Wilson, 2009).

2.5 LIVESTOCK FEED SITUATION IN NIGERIA

The main reason for the poor animal production in numerous African and Asian countries is inadequate supply and low level of feeding due to serious shortage of feedstuffs, so the availability of feed resources and their rational utilization for livestock represents possibly the most compelling task facing planners and animal scientists in the world. Livestock feeds and feeding stuffs have always been production constraints in sub-Saharan Africa (Rinehart, 2008).

Nigeria has a land area of 92.4 million hectres of which about 44% are under permanent pastures, which support its domestic ruminants of over 101 million (Shiawoya & Tsado, 2011). It is estimated that only about 3% of this number are reared on improved pastures; the remaining 97% are raised on low productivity native pastures and farmlands. Forage quality and availability vary greatly from wet season to dry season which affect the performance of animals (Ogunbosoye & Babayemi, 2010). The nutritive value of pastures fall rapidly with maturity and during the dry season, the available feed is lignified, and the protein, vitamins and mineral elements are limited. In spite of the infertile soils and hostile climatic environment, ruminant survival in Nigeria has depended largely on the extensive native pastures, browses and crop residues across and within the various agro-ecological zones (Kubkomawa, Olawuye, Krumah, Etuk & Okoli, 2015). Nigeria's forage and fodder species vary widely and spread across the major agro-ecological zones of the country (Babayemi, Abu and Opakunbi, 2014).

Productivity of natural grassland is affected by many factors such as soil fertility, the amount of browse species available, density of canopy and management practices such as rotational grazing, stocking rate, fertilizer application, burning and the length of the resting period (Babayemi *et al.* 2014). Most pastures species grown are of local varieties that often have very low yields. Crop residues, by-products and browse plants remained the most outstanding feed supplements for feeding livestock in Nigeria and some parts of tropical Africa (Kubkomawa *et al.,* 2015). And although the problem with animal feed in most developing countries is the limited availability of protein sources although great efforts are being made to find alternative supplements (Obi, Ugwuishiwu & Nwakaire, 2016*).*

2.6 CROP RESIDUE UTILIZATION IN SMALL RUMINANT FEEDING

Crop residues sometimes referred to as “farm waste”, are post-harvest roughage materials or plant materials left after the removal of the primary food from the crop plant. Crop residues are distinct from agro-industrial by-products which are products obtained from factory or household processing. It was been observed that most of the crop residues are abundant during the months of September to November, while they are mostly needed and utilized between March and July (the late dry and early rainy seasons) when the available pasture is low in quantity and quality (Kubkomawa *et al,*. 2015). These crop residues are used as mulch, bedding, fuel, building materials or source of organic fertilizer. These can supply enough roughage for the ruminant population in the country if properly harnessed, processed and preserved (Kubkomawa *et al.,* 2015).

Crop residues have high fiber content and are low in protein, starch and fat. So the traditional method of increasing livestock production by supplementing forage and pasture with grains and protein concentrate may not meet future meat protein needs. Use of the grain and protein for human food will compete with such use for animal feed. These problems may be circumvented by utilizing residues to feed domesticated animals (Obi *et al., 2016).* It is an important feed resource in Sub-Saharan Africa they are becoming a dominant feed resource as rangelands are being converted into crop land. However, the level of incorporation of crop residues in the complete diet is influenced by the quality of crop residue (Anandan, Khan, Ravi, Jeethander &

Blummel, 2010). In Sub-Saharan Africa, crop residues are sometimes left on the field as standing hay or stacked on traditional structures or on trees exposing them to losses due to the effects of the weather. The problem of dry season livestock feeding in particular, has directed research efforts towards harnessing and enhancing the utilization of abundant arable by-products and crop residues (Babayemi *et al.*, 2014. The abundance of crop residues makes them cheap sources of nutrients for ruminants.

Crop residues from maize (*Zea mays* L.), sorghum (*Sorghum bicolor* L.), millet (*Pennisetum glaucum*), cowpea (*Vigna unguiculata* L.) and groundnut (*Arachis hypogaea* L.) are very important livestock feed in the savanna region particularly during the long dry season. The residues from cereal crops are relatively in abundance, but of low nutritive value compared to the leguminous crop residues, which are normally in short supply (Okanlade & Adebowale, 2011). However, crop residues, being unpalatable and low in digestibility, cannot form a sole ration for livestock, low-density fibrous materials, low in nitrogen, soluble carbohydrates, minerals and vitamins with varying amounts of lignin which acts as a physical barrier and impedes the process of microbial breakdown (Obi, Ugwuishiwu & Nwakaire, 2016).

In West African region, farmers mostly feed their livestock with sorghum, millet and maize stovers as basal diet, while cowpea and groundnut haulms are fed as protein supplement and other agricultural by-products such as bran, oilcakes are also fed to livestock as energy and mineral supplement (Okanlade & Adebowale, 2011). The knowledge of the availability and utilization of crop residues and agro-industrial by-products in the agro-ecological zones of Nigeria is important for assessing the potential of these resources (Onyeonagu & Njoku, 2010).

However, large quantities of crop residues were produced in Nigerian farms are wasted year after year, some are left to rot in the field, which may improve soil fertility anyway, but most are burned. Integration of livestock and crop residue allow resources to be recycled more effectively in livestock production enterprises. There is evidence that livestock fed with crop residues and agro-industrial by-products could achieve substantial weight gains (Onyeonagu & Njoku, 2010). Meeting the nutritional requirements of animals need processing and enriching the residues with urea and molasses, and providing supplements such as with green fodders.

2.7 NUTRITIONAL COMPOSITION OF CROP RESIDUES

Crop residues have high fiber content and are low in protein, starch and fat (Obi *et al. 2016)*. It was observed that crop residues are characterized by high content of fibre usually above 40%, low content of nitrogen (0.3 to 1.0%) and low content of essential minerals such as sodium (Na), phosphorous (P) and calcium (Ca). Cell wall estimated by neutral detergent fibre (NDF) accounts for at least 72% of the dry matter and represents a large source of potential energy for ruminants and the ability of rumen microorganisms to digest cell polysaccharides, consisting mainly of cellulose and hemicelluloses limited by lignin (Kubkomawa *et al.* 2015).

It is well recognized that cereal crop residues are of low nutritive value this is because of their relatively low digestibility (<500 g digestible organic matter (DOM) per kg dry matter (DM), low crude protein content (<50 g/kg DM) and low content of available minerals and vitamins (Minson, 1990). These deficiencies combine to make crop residues unpalatable, thus their consumption is also low (usually less than 15 g DM/kg live weight daily). According to Van Soest (1991), since fibre is often used as a negative index of nutritive value in predicting the total digestible nutrient (TDN) and net energy, the available energy from crop residues is likely to be low in relation to crop residue yield. Therefore, crop residues, being fibrous in nature require that their quality be upgraded for effective utilization by livestock. They are characterized by low levels of one or more key nutrients which limit their utilization by livestock so when fed to ruminants their intake is low and their utilization is limited by the slow rate of, and total degradability and the rate at which particles breakdown to a critical size small enough to leave the rumen. However, leguminous crop residues are usually better and may be used to complement forages if they are in adequate quantities (Kubkomawa *et al.*, 2015)

2.8 PERFORMANCE OF SMALL RUMINANTS FED CROP RESIDUES

Sheep and goats are efficiently reared on marginal lands and are good users of crop residues (Ahmed and Egwu, 2014). Sweet potato is grown exclusively for the production of the tubers and the foliage was considered as a waste and therefore underutilized.

However, at present sweet potato is grown by smallholder livestock farmers as a dual-purpose crop. The vines are fed to livestock, whereas the tubers are used for human food. It was reported that sweet potato vines are one of the major feed sources for goats (Tadesse, 2012). However, the level of incorporation of crop residues in the complete diet is influenced by the quality of crop residue (Anandan *et al.,* 2010). The cereal crop residues could be effectively used as roughage source at a per cent level in complete rations for the feeding of small ruminants to obtain optimum gain than sole grazing where adequate quantities of cereal crop residues are available (Venkateswarlu, Ramana Reddy & Sudhakar Reddy, 2013). The complete feed system provides stable rumen environment, reduced fermentation losses and less fluctuation in release of ammonia. Feeding small ruminants with complete rations by incorporating crop residues appears to be the promising feeding system for improving their productivity in developing countries (FAO, 2012). Such crop residues after fortification of deficit nutrients provide adequate balanced diet to the animals as well as overcome associated problems of handling and storage (Devasena & Rama Prasad, 2014). Proportionate intake of roughage and concentrate might have resulted in optimum rumen environment and hence animals had better performance (Dhuria, Sharma & Purohit, 2009).

Venkateswarlu *et al*. (2013) also reported significant effect on feed conversion efficiency of ram lambs fed crop residue based complete ration. Another positive results was obtained by Devasena and Rama Prasad (2014) indicated that converting the crop residues like groundnut haulms into complete feeds resulted in enhanced intake without affecting digestibility, which positively affected nitrogen balance improved growth performance and feed conversion efficiency in bucks

2.9 POTENTIAL AND UTILIZATION OF SWEET POTATO AS ANIMAL FEED

Sweet potato contributes about 20% of total crop residues provided by roots and tuber crops. The sweet potato by products that are currently used as feed resources include sweet potato vines (SPV), non commercial sweet potato roots (SPR) and sweet potato peels (SPP) (Khalid *et al.* 2013). One of the major attribute of sweet potato is that although it is a good source of energy (roots) and protein (vines), they are highly perishable (Woolfe, 1992).

In order to minimize their losses farmers often feed sweet potato vine and foliage to pigs, goats and cattle in many countries like China, India, Indonesia, Korea, Philippines, Papua New Guinea, Taiwan, Uganda and Vietnam two month after harvest. This practice is wasteful as it does not allow farmers achieve production in proportion with the large quantity of feed used as protein supplement (Sankaran, Suresh & Maniyam, 2012). Recent researches conducted by the International Potato Centre (CIP) in Uganda (Woolfe, 1992) showed that sweet potato farmers waste about 599 kg of vines per acre per season (Mutetikka, Lule, Lukuya, Kyalo & Naziri, 2016). About one third of sweet potato production in developing countries is used for animal feed on the farm itself. The crop is almost always used, in some form and amount, as animal feed as both the tubers and vines are used as feed or supplements for cattle, pigs, chickens and small ruminants wherever it is produced in developing countries (Kebede & Tadesse, 2011).

The leave meal has a high protein content of between 26 to 33%, with high amino acid score. It has good mineral profile and rich in vitamins like A, B2 and C (Babalola & Apata, 2012). Sweet potato is grown by smallholder livestock farmers as a dual-purpose crop, the vines are fed to livestock, whereas the tubers are used as human food (Khalid *et al.,* 2013). This attributed to its high yield, palatability and crude protein content coupled with high moisture content. Results obtained by Khalid *et al*. (2013) on nutritional properties of sweet potato leaves indicates that it has the potentials to improve dietary protein and amino acid supply in low fibre diets for ruminants.

Fresh sweet potato vines can be fed to cattle without any restriction (Dahlanuddin, 2001). When sweet potato vines are fed to milking animals or fattening animals, there is little need to provide protein supplement as vines alone can supply much needed protein needed by the animals (Dahlanuddin, 2001).

Yacout *et al.* (2016) describe sweet potato silage as excellent feed. The CP contents could be increased by ensiling and at the same time reduce crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF), hemicelluloses and cellulose contents. Moreover, it improve effective degradability of DM, CP and CF.

Nutritionally, sweet potato vines (SPV) are a rich source of protein, fiber, vitamins with moderate to good quantities of all the essential amino acids (Yacout *et al.* 2016). The DM content of fresh SPV is 11.9% with crude protein content of 19.8% of DM. It was reported that SPV could be used as an alternative supplementary feed for calves and small ruminants during dry season and can be fed to dairy cattle as well (Yacout *et al.* 2016). The sweet potato vines (SPV), commonly left unused can also be used as a protein feed for animals. The vines do not have as much protein as cassava leaves, but they do have more protein than several grasses.

100kg of SPV can supply 10-12kg of protein (Lebot, 2009). Grasses that commonly in grown tropical climates supply much less protein than sweet potato. SPV have no substances that are bad for animals and hence they can be safely fed to animals (Sankaran *et al.*, 2012). Dry matter (DM) production potential per hectare of certain varieties of sweet potato vines can be as high as 4.3-6.0 tons per crop (Dominquez, 1992) and the forage (leaf, petiole and stem) accounts for approximately 64% of fresh biomass. The forage contains 11-17 crude protein but the digestibility is less than 62% (Baker, Ruiz, Munoz and Pinchinat, 1980). The vines include the leaf and stem, with crude protein content in the leaves of between 260-330g/kg DM compared to 100-140g/kg DM in the stems (Woolfe, 1992).

However, due to the presence of anti-nutritional compounds such as trypsin inhibitor, hallucinogens, saponins, tannins, phytate and oxalates, it can have potentially a negative effects on livestock feeding; which includes reduction in palatability, digestibility, utilization of nutrients and rumen fermentation, resulting in not only decreased production but also low quality of meat and milk products due to the presence of such hazardous residues (Lebot, 2009).

2.10 NUTRIENT INTAKE

Feed intake is one of the most important factors for the productivity of small ruminants. It is generally measured in dry matter terms. DM is the amount of food remaining when the water components has been removed. When voluntary intake is too low, the rate of production will be depressed, resulting in increased requirements for maintenance, poor energy consumption and efficiency (Forbes & Frence, 1995). High dry matter intake (DMI) is very important. The quantity of feed voluntarily taken by the animal to meet its nutritional requirement depends on the palatability, digestibility and nutrients density of the feed. The amount of feed eaten by livestock determine productivity. This is the cause for higher feed intake by lactating animals over dry animals, and by a milk producing animals over a meat animals (Adeloye, 1998).

Animal nutrition is dependent on one of the animal factors affecting, the animal's nutritive requirement. Variances in the voluntary forage intake are undeniably the main dietary factor determining level and efficiency of ruminant production. It is affected by animal aspects; environment and forage factors (Maita, Aban and Gonzales, 2015). While environment affects voluntary intake in such a way that it is affected by stress factors causing fatigued in seeking, ingesting, chewing and ruminating their feed. When ruminal pH decreases below uncomfortable level, fiber digestion declines dramatically and, therefore, decreases voluntary feed intake (Beauchemin, 2011). Forage quality is an expression of a characteristic that refers to how well animals eat a forage and how efficiently the nutrients in the forage are changed into animal products (Fulgueira, Amigot, Gaggiotti, Romero and Basilico 2007).

The greatest measure of forage quality is the productivity of animal, which is affected by feed nutrient intake, digestibility and utilization efficiency (Fulgueira *et al.,* 2007). The characteristic of feedstuffs such as pH, starch content and availability, moisture, crude protein and fat content, can have a marked effect on Volatile fatty acids (VFAs), ruminal pH, and microbial protein production, and eventually growth of the animal. Daily Dry matter intake (DMI) showed significant difference and forages having highest pH level that approximate the ideal rumen pH of 5.5 to 7.0 for faster microbial growth and better fiber digestion (Solaiman, 2010). It was also observed by Maita *et al*. (2015) that organic matter (OM), neutral detergent fiber (NDF), and crude protein (CP) of goats fed with different tree/shrub forages with varying pH contents affect intake and digestibility of feed material. However, three types of factors affecting feed intake of ruminant can be distinguished: Animal, feed and environmental factors (McDonald *et al.,* 1995)

2.11 NUTRIENT DIGESTIBILITY

Digestibility of a feed is the ability of the animal to breakdown or utilized the feed such that it provides the necessary nutrients required for the animal growth. It is defined as the proportion of food which is not excreted in the faeces and which is, therefore, assumed to be absorbed by the animal (Mc Donald *et al.*, 2002). It is simply a measure of the amount that is actually absorbed by the animal and therefore the availability of nutrients for growth, reproduction etc. The potential value of a food for supplying a particular nutrient can be determined by chemical analysis. But, the actual value of the food to the animal can be arrived at only after making allowances for the inevitable losses that occur during digestion, absorption and metabolism (Mc Donald *et al.* 1995).

The stage of maturity of forage can affect the pattern of utilization of grasses and legume forages. Grasses cut and ensiled at early stage of maturity exhibit rapid fibre and OM degradation in the rumen and higher digestibility (Saleh *et al.* 2014). Processing is always expected to increase rumen and total tract digestibility of cereal grains. Processing can be physical, chemical or a combination of both depending on the nature of the material and the purpose (Minson, 1990). Maize grains can be fed without processing because the pericarp of maize kernels is not resistant to mastication. Physical processing may include grinding, cracking and rolling, which all reduce the particle size of grains and increase potential exposure to bacterial and enzymatic action. Other processing methods may involve grinding or cracking in association with heat and moisture. The digestibility of sweet potato fraction is reported to be above 90% (Dahlanuddin, 2001).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 EXPERIMENTAL SITE

The experiment was conducted in the Livestock Teaching and Research Farm and the Laboratory of the Department of Animal Science, Faculty of Agriculture, Bayero University which is located between Latitude 10^0 33’ and 12^0 27’ North of the equator and Longitude 74^0 34’ and 9^0 29’ east. There are two seasons and two vegetation zones in the State (KNARDA, 2006). Kano state occupies a total land area of 24,400square kilometres with human population of 9,383,682 (NPC, 2006).

3.2 SOURCES OF THE EXPERIMENTAL ANIMALS AND THEIR FEED

Three bucks with an average initial body weight of 19.43 kg were purchased from Getso and *Yan awaki* markets of Gwarzo and Tarauni Local Government areas of Kano state respectively. The cowpea vine was obtained from Tudun Wada Dankadai town, *Danchina* vine from *Gulu* town in Rimin gado Local Government area and *King J* vine from Department of Agronomy, Bayero University, Kano.

3.3 MANAGEMENT AND RUMEN CANNULATION OF THE EXPERIMENTAL ANIMALS

Prior to commencement of the experiment, the animals were stabilized for adaptation for two weeks. Food was withheld for 24 hours and water for 12 hours. The operation was carried out in recumbent position and the operated animals were positioned on the right side (Aziz, Mohammadi and Hasani, 2007).

The operated animals were injected intramuscularly with diazepam 0.5% in a dose of 2mg/kg body weight and ten minute later the animals were injected with Xylazine at 0.22mg/kg body weight. Local anaesthetic (Xylocaine) was used to infilterate the surgical site thereby blocking the nerves supplying the region (Abdel-fattah *et al.*, 2007).

According to Abdel-fattah *et al.* (2007), the surgical site of the animals were aseptically shaved and washed with soap and water and scrubbed with antiseptic solution severally before the initial skin incision commenced. An initial skin incision was made few centimetres inferior to the tuber coxae and extended ventrally. The length of incisions of the skin, underlying layers and the rumen, were made large enough for insertion of the cannula.

Another ruminal incision was made 7-10cm cranial to the original one and created parley wide for the neck of the cannula to be exteriorized through it. The cannula was positioned into the rumen through the initial incision and pushed from inside the rumen through the second ruminal incision, and 4-6 interrupted sutures were stitched through the rumen and cannula by silk, then a purse string suture was sewed around the edge of the second ruminal incision and drawn tight and tied around the neck of the cannula.

3.4 MANAGEMENT AND FEEDING OF THE CANNULATED ANIMALS

The animals were offered concentrates during the recovery period. The three bucks fitted with permanent rumen cannula were fed with *King J, Danchina and Cowpea* ***vines*** in three different cycles and supplemented with concentrate feed in the ratio of 60:40 roughage/ concentrate ratio in order to meet with their maintenance requirements for crude protein and energy (AFRC, 1993). Water was also provided *ad libitum* throughout the experimental period. Three types of concentrate diets were formulated in order to meet their basic nutrients requirements (Table 1). Whenever *King J* vines is to be offered to the buck, there would be concentrate diet formulated in conformity with the requirement of the buck, in the same manner if *Danchina* vine is to be fed there would be a formulated concentrate to meet its requirements. The same procedure was adapted for cowpea vines. The feeds were exchanged between the buck at the end of each incubation period.

Table 1: Gross Composition of the Experimental Diets (%)

Feed ingredients	T1	T2	T3
Maize	03	24	09
Wheat offal	30	14	22
Cowpea husk	20	07	15
Groundnut cake	07	28	21
Rice bran	12	10	10
Rice milling waste	26	15	21
Salt	02	02	02
Total	**100**	**100**	**100**
Total CP (Forage 60%)	10.92	8.53	9.85
Total CP (Conc. 40%)	7.47	6.75	5.08
Total CP (%)	16.00	16.00	16.60

The period of each cycle was 20 day duration comprised an adaptation period of 14 days and 6 days for incubation. The feeding regime of the experimental animals was presented in Table 3. 2. At the inception and termination of each cycle, the animals were weighed to determine live weight (Kg).

Table 2: Feeding Regime of the Experimental Animals

	West African Dwarf	Sahelian	Red Sokoto
Cycle I	Danchina	Cowpea	King J
Cycle II	Cowpea	King J	Danchina
Cycle III	King J	Danchina	Cowpea

3.5 EXPERIMENTAL DESIGN

Cross-over experimental design was used in the study, in which the three dietary treatments were assigned to the same animal, but at different periods. Each animal serving as treatment and was measured more than once and each measurement corresponded to a different treatment, the order of treatment assignment was random. With three treatments, the animals were randomly assigned to the group. Each of the three feeds were assigned to a particular animal in a cycle and then exchanged in another cycle.

3.6. *IN SACCO* RUMEN DEGRADATION PROCEDURE

Before the incubation, the feed samples was prepared by grounding it in order to facilitate handling and to also ensure more homogenous and representative material for the incubation, and however to reduce particle size just to stimulate the comminution occurring normally by mastication and rumination (Nasiru *et al.*, 2018). Dried sample of the vines were milled to pass through a 2 mm sieve. Approximately four (4) grams of the vine samples were weighed and transferred into the nylon bags and incubated into the rumen of three bucks with a permanent cannula in triplicate and removed after 8, 12, 18, 24, 32 and 48 hours in accordance to Orskov *et al*., (1980) procedure. Table 3.

The nylon bags were immersed into the rumen using a drawstring with a weight attached. All the bags were placed in the rumen simultaneously and removed simultaneously. After removal from the rumen, the bags were washed under running tap water for 15 minutes until the water became clear. The bags were then oven dried at 60°C for 48 hours and weighed in grams. Disappearance for each feed sample at ‘0’ time was obtained by washing the bags containing feed sample with tap water for 15 minutes. The empty bags and bags containing residues following each incubation were then oven dried at 60°C for 48 hours and weighed in grams. The rumen incubated residues were analyzed for chemical composition.

Table 3: Incubation Schedule

Insertion Time	Removal Time	Removal Time
Monday 08:30 am	Tuesday 08:30 am	24 hours
Tuesday 08:30 am	Tuesday 16:30 pm	8 hours
Tuesday 16:30 pm	Thursday 16: 30 pm	48 hours
Thursday 16:30 pm	Friday 10:30 am	18 hours
Friday 10:30 am	Saturday 18:30 pm	32 hours
Saturday 18:30 pm	Sunday 6:30 am	12 hours

3.7 DATA COLLECTION

3.7.1 Determination of Dry Matter Disappearance

Dry matter disappearance (DMD) was estimated as described by (Osuji et al., 1993)

$$DMD= \frac{(SWa - BW) \times (SWb - BW) \times DMb}{(SWa - BW) \times DMa}$$

Where: SWa = weight of original sample + nylon bag

BW = weight of empty nylon bag

SWb= weight of the sample + nylon bag after incubation

DMa = dry matter of feed sample

DMb = dry matter of residue sample

The difference between the amount of DM, CP, CF, ADF and NDF in the original sample and remaining on the nylon bag after incubation, was expressed as a percentage of the initial sample as a measure of the fraction of DM, CP, CF, ADF and NDF that was truly water soluble (TWS). Particle loss was calculated as the difference between the fraction of feed loss through the pores during washing and TWS fraction (Nasiru, Badamasi and Hakimi, 2018). Disappearance was assumed to be due to degradation in the rumen.

3.7.2 Degradation Kinetics

The exponential model of Orskov and Mc Donald (1979) was used to estimate the rate and extent of DM, CP, CF, ADF and NDF degradation according to the equation: $p = a + b (l – ^{e})^{-ct}$

Where, p = potential disappearance at time t

a = readily degradable fraction

b = the slowly degradable fraction

c = degradation rate constant of b

t = degradation time

e = Exponential

The *In sacco* effective degradability (ED) of the DM, CP, CF, ADF and NDF was calculated using the following equation (Orskov and McDonald, 1979);

$$ED = a+bc/(k+c) \quad X\ e^{-KL}$$

Where k is the estimated rate of the outflow from the rumen and a, b, and c are the same parameters as described above, while L is the lag phase. The outflow rate of 0.05/h was the representative for medium feeding levels (AFRC, 1993).

3.7.3 Feed Intake

Daily feed intake was measured and recorded as the difference between feed offered and left over (kg).

3.7.4 Digestibility Trial

During the period of feeding trial, one animal per treatment was separated individually. Faeces were collected during the incubation period (6 days) after the adaptation period (14 days).

The faeces voided by each animal were weighed and recorded and 5% of the faecal samples were taken to the laboratory for proximate analysis as outlined by AOAC (2005). Nutrients digestibility (%) was calculated as difference between nutrient intake and nutrient voided in the faeces divided by nutrient intake and multiplied by 100

$$\text{Nutrients digestibility (\%)} = \frac{\text{Nutrient intake} - \text{Nutrient out put}}{\text{Nutrient intake}} \times 100$$

3.8 CHEMICAL ANALYSIS

The samples of the feed and the incubated vines were analyzed for Dry matter (DM), Crude protein (CP), Crude fiber (CF), Ether extract (EE) Ash and Nitrogen free extract (NFE) according to AOAC official method (AOAC, 2005). While the acid detergent fibre and neutral detergent fibre of both the feed diets and the incubated vine samples were determined in accordance with Vansoest *et al.* (1991).

3.9 STATISTICAL ANALYSIS

The data were subjected to a two way analysis of variance (ANOVA) Model Procedures of SAS (Version 9.3) (SAS, 2009). Least difference (LSD) was used to separate means at $P \leq 0.05$.

CHAPTER FOUR

4.1 RESULTS

4.1.1 Proximate Composition of the Experimental Diets

The results of the proximate composition and fibre fractions of the experimental diets are presented in Table 4:

Table 4: Proximate Composition of the Experimental Diets (%)

Nutrient (%)	T1	T2	T3	Cowpea hay	Danchina	King J
DM	91.24	90.97	90.00	86.98	92.12	91.26
CP	16.01	16.05	16.08	13.01	13.74	14.71
CF	22.47	21.17	20.73	20.40	19.08	18.00
EE	4.15	4.75	4.60	4.38	4.26	3.95
ASH	12.93	13.55	12.38	8.33	7.46	9.23
NFE	41.86	42.47	45.33	40.86	47.58	45.37
ADF	29.28	29.13	29.10	25.95	27.53	27.16
NDF	36.85	35.59	32.10	33.06	35.09	35.27

DM: Dry matter, CP: Crude protein, CF: Crude fiber, EE: Ether extract, NFE: Nitrogen Free Extract, ADF: Acid detergent fibre, NDF: Neutral detergent fiber

The dry matter contents ranges from (86.98%) in Cowpea having to (91.26%) in *King J* and (92.12%) in *Danchina*. The ash content varied, *King J* was found to have the highest ash content (9.23%), then *Cowpea* (8.33%) and finally *Danchina* (7.46%). The crude protein contents indicated that *King J* had the highest CP content (14.71%) followed by *Danchina* (13.74%) and then *Cowpea* (13.01%). The crude fibre content ranged from 18.00% for (*King J*), followed by 19.08% for (*Danchina*) and 20.40% for (*Cowpea)*. The variation in ether extract between the feed samples was not much *King J* had the lowest (3.95%), *Danchina* (4.26%) and *Cowpea* (4.38%).The nitrogen free extract values obtained were similar cross the treatments with

Danchina having the highest (47.85%) then *King J* (45.37%) and *Cowpea* (40.86%). The acid detergent fibre value was higher in *Danchina* (27.53%) followed by *King J* (27.16%) and then *Cowpea* (25.95%). The composition of neutral detergent fibre indicated that, *Danchina* had the highest value (35.09%) while *Cowpea* had the lowest (33.06%).

4.1.2 <u>*In sacco* Nutrient Disappearance of Sweet Potato Vines</u>

Nutrients disappearance of sweet potato vines revealed the possible degradation of nutrients incubated *in sacco* after certain period of time. Sweet potato vines cultivars have no effect ($p>0.05$) on DM disappearance (76.74 vs 80.41 %) for *Danchina* and *King J* respectively. However, *in sacco* DM disappearance of cowpea (66.05%) was lower ($p<0.05$) when compared with the two potato cultivars. The disappearance of *in sacco* CP disappearance did not follow the same pattern with the *in sacco* rumen DM disappearance (Figure 2). There was significant effect ($p<0.05$) between *in sacco* rumen CP disappearance for sweet potato vines (80.08 and 90.14%) for *Danchina* and *King J* respectively) and Cowpea hay (72.10%). Sweet potato vines had increased ($p<0.05$) CP *in sacco* rumen disappearance than Cowpea hay.

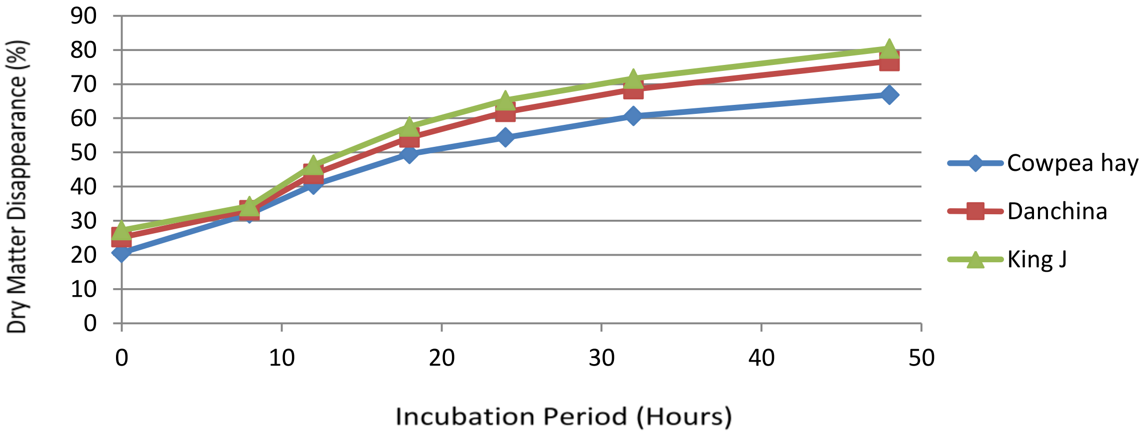

Figure 1: Effect of Sweet Potato Vines on Dry Matter Disappearance

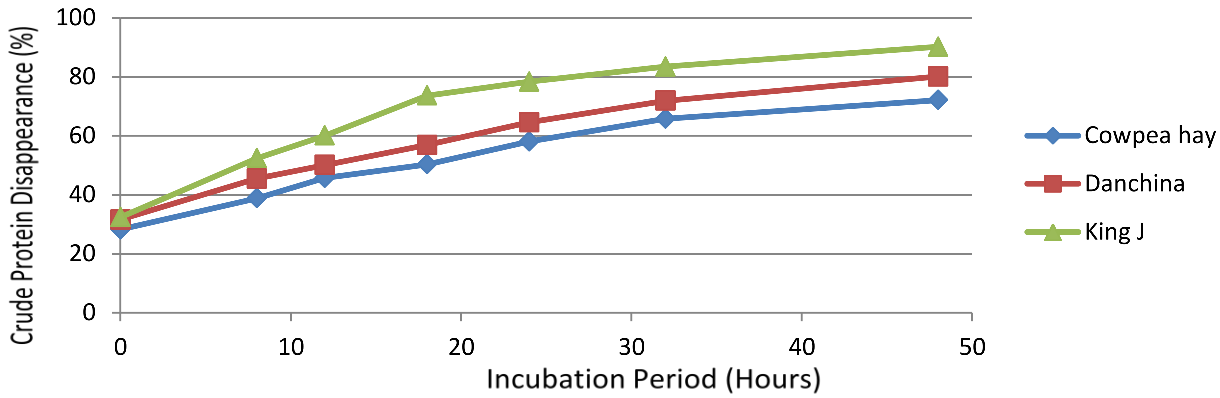

Figure 2: Effect of Sweet Potato Vines on Crude Protein Disappearance

Figure 3 shows the crude fibre disappearance of two sweet potato vine cultivars and cowpea hay during *in sacco* rumen incubation. Potato vine cultivars have no effect on the *in sacco* rumen CF disappearance. There was no significant difference ($p>0.05$) in the CF *in sacco* rumen disappearance between the two sweet potato vine cultivars and cowpea hay.

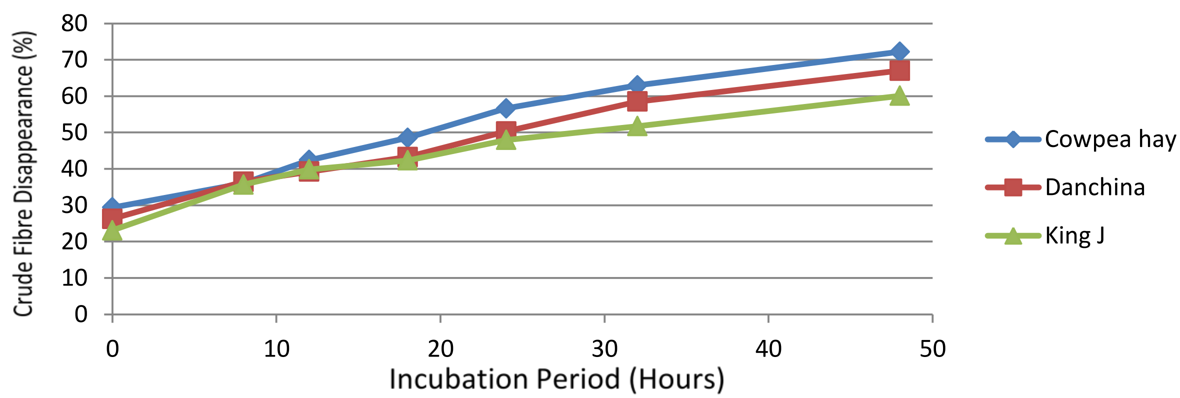

Figure 3: Effect of Sweet Potato Vines on Crude Fibre Disappearance

Figure 4 revealed the disappearance pattern of acid detergent fiber (ADF). Sweet potato vine cultivars have no effect ($p>0.05$) on *in sacco* rumen ADF disappearance. Moreover, there is no significant difference ($p>0.05$) on *in sacco* rumen ADF disappearance between the cowpea hay and the two sweet potato vine cultivars (68.50, 65.39 and 64.38 for cowpea, *Danchina* and *King*

J respectively). The disappearance of *In sacco* rumen NDF disappearance follows similar pattern with *In sacco* ADF disappearance (Figure 5)

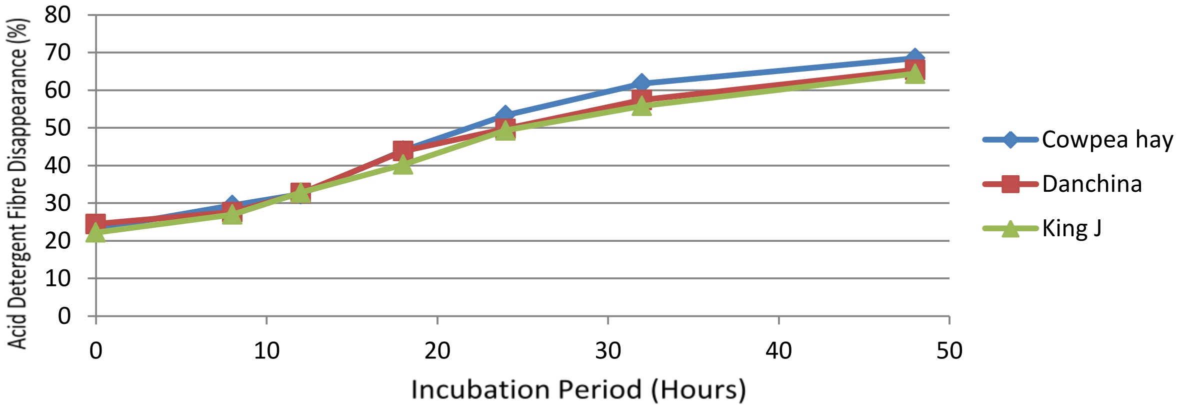

Figure 4: Effect of Sweet Potato Vines on Acid Detergent Fibre Disappaearance

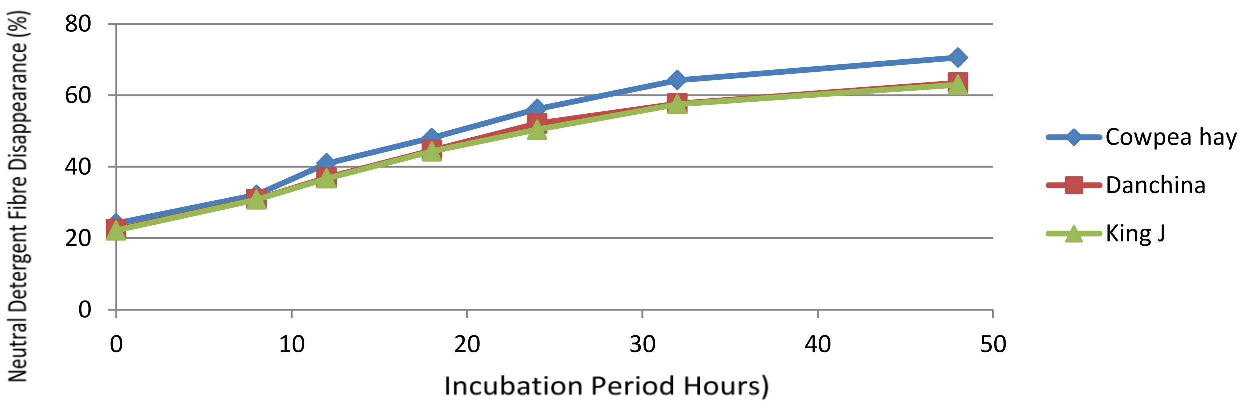

Figure 5: Effect of Sweet Potato Vines Neutral Detergent Fibre Disappearance

4.1.3 Effect of Sweet Potato Vines on Dry Matter *in sacco* Degradation Kinetics

The effect of sweet potato vines on *in sacco* dry matter degradation kinetics is presented in table 5. Sweet potato vine cultivars have significant effect ($p<0.05$) on the *in sacco* dry matter degradability parameters. From the results obtained, the two potato vine cultivars have the highest slowly degradable fraction 'b', degradation rate constant 'c' and effective degradability compared to cowpea hay. There was significant ($p<0.05$) difference on DM degradation kinetics between the two potato vine cultivars and the cowpea hay. *Danchina* and *King J* sweet potato vines cultivars has significantly ($p<0.05$) higher degradation rate constant 'c' when compared with cowpea. No significant ($p>0.05$) difference was observed between the two potato vine cultivars and cowpea on DM potential degradability (PD) but cowpea had lower potential degradability. Moreover, *Danchina* and *King J* vines recorded higher DM *in sacco* effective degradability 'ED' and lag time than cowpea hay.

Table 5: Effect of Sweet Potato Vines on Dry Matter *in sacco* Degradation Kinetics

	Vines			
Parameters	Cowpea	Danchina	King J	SE
a (%)	2.10[a]	-3.93[b]	-15.73[c]	0.86
b (%)	78.43[c]	90.67[b]	104.77[a]	1.32
c (%)	0.034[c]	0.046[b]	0.054[a]	0.00
A (%)	15.17[a]	10.63[b]	17.20[a]	0.50
B (%)	65.37[b]	76.10[a]	71.80[a]	1.01
PD (%)	80.53	86.74	89.04	1.06
ED (%)	35.60[b]	41.10[a]	43.67[a]	0.29
LT (H)	1.2	2.0	2.3	0.00

Values differ (P <0.05) significantly. a: quickly soluble fraction; b: slowly degradable fraction; c: degradation rate constant (fraction/hour); PD: potential degradability; ED: effective degradability (%); LT: lag time; SE: Standard error

4.1.4 Effect of Sweet Potato Vine on Crude Protein *in sacco* Degradation Kinetics

The effect of sweet potato vine on crude protein *in sacco* degradation kinetics is presented in Table 6. The two potato vine cultivars have effect (p<0.05) on some *in sacco* crude protein degradation parameters. Potato vine cultivars recorded higher value of slowly degradable fraction ‘b’ when compared with cowpea hay. Significant effect (p<0.05) was also observed between sweet potato vine cultivars and cowpea on CP degradation rate constant ‘c’ with the potato cultivars having higher value. Cowpea hay had higher potential degradability ‘PD’ compared to the potato vine cultivars. Results showed that for degradation kinetics, potato cultivars have higher CP effective degradability.

Table 6: Effect of Sweet Potato Vines on Crude Protein *in sacco* Degradation Kinetics

	Vines			
Parameters	Cowpea	Danchina	King J	SE
a (%)	40.07[a]	8.77[b]	10.37[b]	1.66
b (%)	60.00[b]	73.20[a]	76.60[a]	1.47
c (%)	0.28[b]	0.053[a]	0.051[a]	0.00
A (%)	22.37	18.20	21.57	0.16
B (%)	77.63	63.87	65.27	0.94
PD (%)	100	81.97	86.97	1.10
ED (%)	38.70[b]	46.90[a]	49.80[a]	0.26
LT (H)	0.06	0.66	1.27	0.00

Values differ (P <0.05) significantly. a: quickly soluble fraction; b: slowly degradable fraction; c: degradation rate constant (fraction/hour); PD: potential degradability; ED: effective degradability (%); LT: lag time; SE: Standard error

4.1.5 Effect of Sweet Potato Vines on Crude Fibre *in sacco* Degradation Kinetics

The effect of sweet potato vine cultivars on crude fiber *in sacco* degradation kinetics is presented in table 7. Results shows that potato vine cultivars have no effect (p>0.05) on the crude fiber degradation kinetics on the slowly degradable CF fraction “b”. No significant difference (p>0.05)was observed in the degradation rate constant fraction “c” and the effective degradability (ED) between the potato vine cultivars and the cowpea hay.

Table 7: Effect of Sweet Potato Vines on Crude Fibre *in sacco* Degradation Kinetics

	Vines			
Parameters	Cowpea	Danchina	King J	SE
a (%)	7.07[a]	16.07[b]	0.60[c]	0.35
b (%)	70.27	66.13	58.47	1.53
c (%)	0.040	0.039	0.038	0.00
A (%)	16.27	19.43	13.10	0.09
B (%)	61.03[a]	62.77[a]	46.00[b]	1.61
PD (%)	77.34[b]	82.20[a]	59.07[c]	1.70
ED (%)	39.17	45.17	27.30	0.17
LT (H)	1.30	0.47	2.10	0.001

Values differ ($P < 0.05$) significantly. a: quickly soluble fraction; b: slowly degradable fraction; c: degradation rate constant (fraction/hour); PD: potential degradability; ED: effective degradability (%); LT: lag time; SE: Standard error

4.1.6 Effect of Sweet Potato Vines on Acid Detergent Fibre *in sacco* Degradation Kinetics

The effect of sweet potato vine cultivars on acid detergent fiber degradation kinetics is presented in table 8. The result revealed that, potato vine cultivars have no effect on the slowly degradable fraction “b”, degradation rate constant ‘c”, potential degradability and effective degradability compared to *c*owpea hay.

Table 8: Effect of Sweet Potato Vines on Acid Detergent Fibre *in sacco* Degradation Kinetics

	Vines			
Parameters	Cowpea	Danchina	King J	SE
a (%)	3.37	3.93	5.87	0.86
b (%)	74.60	68.93	68.37	1.02
c (%)	0.045	0.046	0.041	0.002
A (%)	13.13	14.40	12.23	0.09
B (%)	64.90	58.43	62.07	1.27
PD (%)	77.97	72.86	74.24	1.36
ED (%)	39.43	37.97	36.90	0.11
LT (H)	1.03	1.23	0.63	0.002

Values differ (P <0.05) significantly, a: quickly soluble fraction; b: slowly degradable fraction; c: degradation rate constant (fraction/hour); PD: potential degradability; ED: effective degradability (%); LT: lag time; SE: Standard error

4.1.7 Effect of Sweet Potato Vines on Neutral Detergent Fibre *in sacco* Degradation Kinetics

The effect of sweet potato vine cultivars on neutral detergent fiber (NDF) degradation kinetics is presented in table 9. Result shows that potato vine cultivars have no effect (p>0.05) on the NDF degradation kinetics compared to the cowpea hay. However, there was a significant (p<0.05) difference in the slowly degradable fraction ‘b’, with cowpea hay having a higher value (76.23%). The rate of degradation constant ‘c’ fraction obtained indicated a significant (p<0.05) difference between the experimental diets. The effective degradability (ED) of the potato vine cultivars and the cowpea hay recorded non significant difference (p>0.05).

Table 9: Effect of Sweet Potato Vines on Neutral Detergent Fibre *in sacco* Degradation Kinetics

	Vines			
Parameters	Cowpea	Danchina	King J	SE
a (%)	3.40	-0.30	2.10	2.38
b (%)	76.23[a]	59.07[b]	57.37[b]	1.46
c (%)	0.048[b]	0.053[a]	0.035[c]	0.00
A (%)	12.50[b]	12.20[b]	14.13[a]	0.10
B (%)	46.93[b]	46.63[b]	65.50[a]	0.99
PD (%)	78.33[a]	58.77[b]	60.77[b]	1.09
ED (%)	36.17	31.10	31.23	0.19
LT (H)	1.2	1.47	1.0	0.003

Values differ (P <0.05) significantly. a: quickly soluble fraction; b: slowly degradable fraction; c: degradation rate constant (fraction/hour); PD: potential degradability; ED: effective degradability (%); LT: lag time; SE: Standard error

4.1.8 Effect of Sweet potato Vines on Nutrients Intake

The effect of sweet potato vines on the performance characteristics are presented in the table 10 below. Results of the average feed intake, dry matter intake, crude protein intake, crude fibre intake, ether extract intake, nitrogen free extract and ash intake did not differ significantly (p>0.05) across the treatments. Sweet potato vine cultivars therefore have no effect on the nutrients intake. Higher feed intake was recorded in the potato vine cultivars compared to cowpea hay. The result further showed increased intake in DM, CP, EE, Ash and NFE for potato vines compared to the cowpea hay.

Table 10: Effect of Sweet Potato Vines on Nutrients Intake

Parameter	Cowpea hay	Danchina	King J	S. E
Initial weight (kg)	22.55	21.14	21.09	234
Final weight (kg)	23.39	21.96	21.95	229
ADG (g/day)	50.59	49.01	49.73	4.44
Weekly weight gain (g)	311.71	342.97	348.13	42.48
Av. Feed intake (g/day)	883.33	906.66	988.66	147.43
DM intake	831.33	893.33	916.00	70.08
CP intake	107.33	111.67	120.00	11.78
CF intake	210.00	210.00	200.00	16.83
EE intake	33.00	34.33	34.00	4.26
Ash intake	74.00	97.33	94.00	7.25
NFE intake	407.00	440.00	456.00	63.33

ADG: Average Daily Gain, DM: Dry matter, CP: Crude protein, CF: Crude fibre, EE: Ether extract, NFE: Nitrogen free extract

4.1.9 Effect of Sweet Potato Vines on Nutrients Digestibility of Goats

The effect of sweet potato vine cultivars on nutrients digestibility are presented in table 11. Results of the digestibility study revealed non significant difference ($p>0.05$) in all the evaluated digestibility indices; dry matter digestibility (DMD), crude protein digestibility (CPD), crude fibre digestibility (CFD), ether extract digestibility (EED), ash digestibility and nitrogen free extract digestibility (NFED).

Table 11: Effect of Sweet Potato Vines on Nutrients Digestibility

Parameter	Cowpea hay	Danchina	King J	Standard error
DM digestibility (%)	75.67	75.67	78.67	1.7
CP digestibility (%)	87.00	76.00	80.33	4.28
CF digestibility (%)	68.33	67.67	69.00	3.64
EE digestibility (%)	51.00	56.67	58.00	10.54
Ash digestibility (%)	68.00	71.67	71.00	3.66
NFE digestibility (%)	80.00	83.67	87.00	3.78

DM: Dry matter, CP: Crude protein, CF: Crude fiber, EE: Ether extract, NFE: Nitrogen Free Extract

4.2 DISCUSSION

4.2.1 Experimental diets

The experimental diets offered to the animals met the 16% required for CP as recommended by AFRC (1993). For the chemical composition of the sweet potato vines cultivars refer to *Baba et al.*, (2018). The chemical composition of the cowpea hay showed that crude protein (CP) contents of the diets (13.01%) was similar to diet (12.10% CP) reported by Mohatla, Mokoboki, Sebola and Jacob, (2016) but lower than 23-27% reported by Ravhuhali, Ngambi and Norris, 2010 and Anele *et al.,* (2011) respectively. The variation in the cowpea hay CP content between the present study and the subsequent one was due to differences in crop management and environmental characteristics (Singh, Nag, Kundu & Mity, 2010).

The neutral detergent fibre (NDF) value of the cowpea hay obtained in the present study (33.06) is close to 33.33% reported by *Mohatla et al.,* (2016) less than 45% obtained by Ravhuhali *et al.* (2010). The acid detergent fibre (ADF) component (25.95%) obtained in the present study falls within that ensure optimum digestibility (Belyea & Ricketts, 1993) and thus would not have negative impact on the bio-availability of crude protein. The crude fibre (CF) composition of the diets (20.40%) was comparable to 23.30% reported by Pousga *et al.*, (2019). Ether extract values obtained in the current study (4.38) is greater than the values (1.2 and 3.66) reported by Mohalta *et al.*, (2016) and Pousga *et al.,* (2019) respectively.

4.2.2 *In sacco* Nutrients Disappearance of Sweet Potato Vines

Based on the findings, sweet potato vine cultivars had more than 50% dry matter disappearance at 48 hours of incubation. This indicated that all the cultivars could be used as feed for livestock due to the forage quality that meet the requirements for feeding livestock as observed by Larbi *et a.*,(2007).

The *in sacco* nutrients disappearance indicated that the disappearance features of *Cowpea*, *Danchina* and *King J* vines differed slightly among themselves. This is similar to the report of Chumpawadee, Sommart, Vongpralub and Pattarajinda (2005). Results of dry matter disappearance observed values are in accordance with the values reported by Chumpawadee *et al.* (2005) but higher than those reported by Fadel, Niemat and Amasaib (2007). The CP disappearance values obtained were comparable to those obtained by Chumpawadee *et al.*

(2005). Greater CP disappearance was reported by Bayourthe, Moncoulon and Eljalbert (2000) for Pea (*Pisum sativum*) flour. Lower CP disappearance value was obtained by Danesh, Mesgran and Stern (2005). The result for the CP disappearance of sweet potato vines in this study showed that nutrient disappearance was comparatively higher. The CP nutrients of *King J* and *Danchina* vines disappeared faster in the rumen than that of the Cowpea. This could be due to greater proteolytic activities of the ruminal microflora there by evoking a higher disappearance (Antwi, Osafo, Donkoh & Adu-Dafah, 2014). The Acid detergent fibre and neutral detergent fibre disappearance obtained in this study were comparable to the values reported by Pawelek, Muir, Lambert and Wittie (2008). The disappearance parameters measured in this study are of paramount importance as they influence rumen fill and hence feed intake (Van Soest, 1987)

4.2.3 <u>Effects of Sweet Potato Vines on Nutrients Degradation Kinetics</u>

Result indicated that sweet potato vine cultivars have significant effect on the dry matter fermentation. This contradicted the findings of Fernandes *et al.* (2013) and Nasiru *et al.*(2016) who reported no significant effect of peanut forage hay and cattle manure vermicast on rice straw diets on degradation parameters. This could be due to the nature of the diets used.

The dry matter slowly degradable fraction ‘b’ of sweet potato vine cultivars in the present study (90.67 and 104.77) was greater than 42.30 and 40.20 obtained by Phesatcha and Wanapat (2012) and Yacout *et al.* (2016) respectively. The range of dry matter degradation rate constant ‘c’ of the sweet potato vine cultivars obtained in this study (0.046 and 0.054) were in comparable to those reported by Kariuki *et al.* (2001) but lower than 0.071 reported by Phesatcha and Wanapat (2012). Differences in the rate of degradation “c” could be due to the amount of intracellular components and digestibility. It has been documented that ‘c’ fraction is a good predictor of intake (Chenost, Aufrere & Macheboeuf, 2001). The effective degradability of the sweet potato vine obtained in the present study (41.10 and 43.67) were similar to (41.66 and 42.85) reported by Yacout *et al.* (2016) but lower than (84.90) those obtained by Phesatcha and Wanapat (2012). The low dry matter effective degradability contents of feed resources used in this study, despite high potential degradability values are likely as a result of low rate of degradation suggesting low intake and animal productivity. According to Turki and Atcham (2011), effective degradability of feed in the rumen depended on the length of retention of the feed in the rumen, which is also a function of the quantity and quality of the feed given to the animals.

The variation in the ruminal CP degradation can be used in two ways, either to maximize substrate available for microbial and protein synthesis or to enhance the intestinal amino acid supply. The crude protein slowly degradable fraction 'b' of sweet potato vine cultivars in this study (73.20 and 76.60) was lower than 41.54 and 43.93 reported by Yacout *et al.* (2016). Differences in the effective degradability among forage crops can be explained by differences in the amount of fraction a, b and c. Therefore, forage crops that showed higher 'a' or lower 'b' fractions displayed higher effective degradability values and were less affected by outflow rate. Feedstuffs with higher effective degradability are those which are more degradable in the rumen of goats. Therefore the effective degradability of the present study was higher than those recorded by Yacout *et al.* (2016), and the differences in the effective degradability of the vines could be due to differences between varieties (USDA, 2004). The CF slowly degradable fraction 'b' of the present study was much higher than the CF slowly degradable fraction recorded by *Yacout et al.* (2016).

The neutral detergent fibre 'b' value was higher than those reported by Phesatcha and Wanapat (2012). The rate of degradation 'c' of the present study was in agreement with the report of

Nasiru *et al.* (2016) but lower than the report of Phesatcha and Wanapat (2012). Effective degradability was comparable with the report of Nasiru *et al.* (2016). The acid detergent fibre of slowly degraded fraction 'b' of the present study was not in agreement with Khorshidi *et al.* (2013).

4.2.4 Effect of Sweet Potato Vines on the Nutrients Intake

Differences in the average feed intake of the three forages could be explained by the differences in forage palatability (Van Soest, 1987). The author observed that when fibrous fraction of the forage exceeds 55-60% of the dry matter it limits the voluntary feed intake. This contradicted the findings of this study because the three forages investigated had crude fibre contents less than that limi. The low intake of *Cowpea* and *Danchina* resulted in low nutrients consumption. Differences in intake between the forages might be related to the rate of cellulose digestion in the rumen. Khalid *et al.* (2013) reported that intake predictions are more sensitive to animal parameters than feed parameters. In the present study, individual variations in intake between the experimental animals and daily variations in the intake of each animal were observed and could be attributed to the different physiological conditions of the animals. The results of the feed intake in this study agree with the finding of Van Soest, (1982) who reported that high intake is probably related to faster rate of fermentation in the rumen. The intake of sweet potato vine cultivars was high when compared with *Cowpea.*

The dry matter intake, crude protein intake, crude fibre intake, ash intake, ether extract intake and nitrogen free extract intake did not differ significantly ($p>0.05$). The DM and CP intake values obtained in this study were higher than those reported by Lam and Ledin (2004), Ifut *et al.* (2011) and Mediksa (2017). The differences among the studies might be as a result of variations in the quality of the feed used, animal's age and physiological status, rumen fill and rate of degradation.

4.2.5 Effect of Sweet Potato Vine Cultivars on Nutrients Digestibility

The nutrients digestibility were not significant (p>0.05) among the treatments. Higher digestibility of the experimental diets could be improved fermentation by rumen microbes. Eniolorunda *et al.* (2008) opined that high digestibility of cell wall fractions demonstrate the ability of a ruminant to process structural carbohydrates and obtain nutritional benefit from them. The DM digestibility values recorded in the present study were comparable with the values reported by Maigandi and Nasiru (2006) for *Faidherbia albida* Pods and higher than those reported by Phesatcha and Wanapat (2012) for sweet potato, Saleh *et al.* (2014) for sweet potato and Yacout *et al.* (2016) for fresh and sun dried sweet potato vines but lower than the DM digestibility values obtained by Gian, Ly and Ogle (2004). The DM digestibility follows the assertion of Preston (1986) that feedstuffs should be considered as feed for ruminants when its dry matter coefficient is above 50%. The higher DM digestibility observed in this study could be attributed to the ingredient of the DM which was characteristically lower in DM contents. Lam and Ledin (2004) stated that the digestibility of sweet potato vines are expected to be higher due to higher cell contents. The rumen system have been efficient with sweet potato vines.

The crude protein digestibility was not significant (p>0.05) between treatments. The CP digestibility observed in this study is attributed to the CP contents of the sweet potato vines. Aye and Adegun (2010) reported that digestibility of nutrients varies with the nutrient composition of the diets and their degree of utilization. The CPD values of this study contradicts those obtained by Phesatcha and Wanapat (2012) and Yacout *et al.* (2016). The CF digestibility was not different (p>0.05) between diets. CF digestibility obtained in this study was higher than those reported by Gian *et al.* (2004), Abonyi *et al.* (2012) and Yacout *et al.* (2016). The differences could have been influenced by physical and chemical composition of the diet, level of feeding, age, weight of the animal, adaptation to diets and individual variation among the animals (Hansen, Chwalibos & Tawson, 2007).

The Ether extract digestibility values were comparable to those reported by Okoruwa and Bamigboye (2015). This indicated that the diets were more effective in improving the utilization of ether extract for *King J* than *Cowpea* hay and *Danchina*. The findings also confirms the report of Okoruwa *et al.* (2012) who affirmed that ether extract content of a diet is essential for the assessment of its digestibility. The ash and nitrogen free extract digestibility were the same (p>0.05) across all the treatments, although lower than the values obtained by Maigandi and Nasiru (2006) and Yacout *et al.* (2016) respectively.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

Two varieties of sweet potato vines namely *Danchina* (local variety) and *King J* (improved variety) and also Cowpea vine (Control diet) were fed to three cannulated goats with an average live weight of 19.43 kg at the small ruminants unit of the teaching and research farm Faculty of Agriculture, Bayero University, Kano. The aim of the study was to determine nutrients disappearance, rumen degradation kinetics and the performance of the goats fed sweet potato vines. Cross over experimental design was used in the experiment. Data on degradability characteristics of dry matter, crude protein, crude fibre, acid detergent fibre and neutral detergent fibre, feed intake and digestibility parameters were subjected to analysis of variance (ANOVA) using the general linear model procedure of SAS statistical package (SAS, 2009). Significant differences between individual means were identified using least significant difference. Result of the study showed that, the basal experimental diets indicated a little variation in chemical composition. Result from nutrients disappearance of DM, CF, ADF and NDF revealed no significant difference ($p>0.05$) between the treatments.

Degradation kinetics showed a significant ($p<0.05$) differences between the slowly degradable fraction 'b', rate of degradation 'c' and effective degradability of DM, CP, CF, ADF and NDF. The results further indicated no significant difference ($p<0.05$) in feed intake and digestibility indices.

5.2 CONCLUSION

It was concluded that *King J* and *Danchina* sweet potato vine cultivars can be fed to animals as a replacement of Cowpea hay as they were proven to be nutritionally good in term of disappearance, rumen degradation characteristics, nutrients contents and performance indices.

5.3 RECOMMENDATIONS

1. It is recommended that Sweet potato vines be used as a suitable feed stuff for small ruminants during feed scarcity to improve the performance and also productivity of the ruminant animals.
2. Feeding trial should be conducted further with a view to ascertaining the nutritive value of sweet potato vines.

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