EFFECT OF INCLUSION LEVELS OF FIG (*Ficus sycomorus*) LEAF MEAL IN CONCENTRATE DIETS ON THE PERFORMANCE OF YANKASA RAMS FED *Digitaria smutsii* HAY

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MAY, 2014

DECLARATION

I declare that the work in this dissertation entitled "**Effect of inclusion levels of fig (*Ficus sycomorus*) leaf meal in concentrate diets on the performance of Yankasa rams fed *Digitaria smutsii* hay**" has been written by me, it is a product of research work executed by me. It has not been accepted in any application for higher degree in any University. All quotations are indicted and the sources of information are specifically acknowledged by means of references.

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Suleiman Makama YASHIM Date

CERTIFICATION

This dissertation titled "**EFFECT OF INCLUSION LEVELS OF FIG (Ficus sycomorus) LEAF MEAL IN CONCENTRATE DIETS ON THE PERFORMANCE OF YANKASA RAMS FED Digitaria smutsii HAY"** by Suleiman Makama YASHIM, meets the regulations governing the award of the degree of Doctor of Philosophy of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

Dedicated:

To my late parents Mr. Makama Yandiok Yashim and Mrs. Martha Makama Yashim who sacrificed their time and resources to bring me up.

To my late Uncle Rev. B.B. Yashim, for his tremendous contribution to my success in life.

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ABSTRACT

A study was conducted to evaluate the effect of inclusion level and feeding regime of *Ficus sycomorus* leaf meal on the growth performance, nutrients digestibility, nitrogen balance and rumen metabolites of Yankasa rams. A total of 36 rams weighing on the average 15.39kg were randomly assigned to four diets, containing 0%, 5%, 10%, and 15% inclusion level of *Ficus sycomorus*, respectively. Each of the animals was fed 2% body weight of the experimental diet in three feeding regimes: daily, skip-a-day and skip-2-days in a 4x3 factorial arrangement in a completely randomized design. Total feed intake, total weight gain, average daily weight gain, faecal output, urine output; rumen fluid pH, total volatile fatty acids (TVFA) and ammonia nitrogen (NH_4-N) were recorded. Results obtained showed that there was a significant (P<0.05) decrease in Dry matter intake (DMI) as the level of *F. sycomorus* leaf meal increased in the diets. Animals fed supplementary diet with 10% inclusion significantly (P<0.05) had higher total body weight gain (3.54kg) compared to rams given diets with 0, 5, and 15% inclusion levels. Also, animals on 10% inclusion had significantly (P<0.05) higher average daily gain (39.78g), followed by animals on 15% inclusion. Effect of feeding regime on feed intake and weight gain showed a significant (P<0.05) decline in supplement intake as the feeding regime changes from daily feeding (385.27g/day) to skip-2-days feeding (367.08g/day). Feeding the animals at different feeding frequencies resulted in weight gain. Animals on skip-a-day supplementation had a significantly (P<0.05) higher weight gain than those on a daily feeding and skip-2-days supplementation (2.82kg compared to 2.11 and 1.98kg respectively). The effect of inclusion level and feeding regime on feed intake and weight gain showed no significant (P<0.05) interaction between level of supplementation and feeding frequency. However, there was significant interaction (P<0.05) between inclusion level and feeding regime on total intake. Level of inclusion and frequency of feeding significantly (P<0.05) influenced the final weight, total weight gain and average weight gain. The effect of *F. sycomorus* supplementation on nutrient digestibility and nitrogen balance revealed that dry matter (DM), organic matter (OM) and crude protein (CP) digestibility were significantly (P<0.05) affected by the inclusion level. Nitrogen (N) retention and N retention as percent intake were affected significantly (P<0.05). Percent DM, OM and CP digestibility were influenced (P<0.05) by feeding regime, with daily feeding recording higher values (67.80, 63.05 and 62.23 respectively) when compared to skip-a-day and skip-2-days. The result of comparative cost analysis showed a significant (P<0.05) decline in cost of feeding the rams as the inclusion level of *F. sycomorus* increased from 0% inclusion (₦505.31/ram) to 15% inclusion level (₦439.10/ram). Also, the cost of feed per kg gain (₦/kg) of feeding the rams was significantly (P<0.05) lower in 10% inclusion level of *F. sycomorus* as compared to other inclusion levels. There was a significant decline in cost per kg feed as the feeding regime changes from daily feeding (₦62.21/kg feed) to skip-2-days supplementation (₦52.11/kg feed). Feeding frequency was observed to significantly (P<0.05) affect the cost of feeding the rams. The animals on daily supplementation had a higher cost of feeding (₦ 376.11/ram) than those on skip-a-day (₦359.70/ram) and skip-2-days (₦336.67/ram). A significant difference (P<0.05) in cost of feed per kg gain across the feeding regime was observed in this study. Skip-a-day supplementation was better in cost of feed per kg gain (₦127.55/kg gain) as compared to other feeding regimes. Results of the rumen metabolites trial showed that there was a significant (P<0.05) increase in rumen fluid pH as the level of *F. sycomorus* inclusion increased in the diets. Animals fed supplementary diet with 10% inclusion significantly (P<0.05) had higher rumen pH (6.68). Also, animals on 10% and 15% inclusion were similar and significantly (P<0.05) higher in TVFA (14.16 and13.47mm/100ml respectively). Effect of feeding regime on TVFA showed a significant (P<0.05) decline as the feeding regime

changes from daily feeding (14.04mm/100ml) to skip-2-days feeding (12.27mm/100ml). Animals on daily supplementation had a significantly ($P<0.05$) higher NH_3-N concentration than those on skip-a-day and skip-2-days supplementation (32.60 mg/l compared to 31.68 and 30.24mg/l respectively). The effect of sampling time on rumen fluid variables showed a significant($P<0.05$) rise in rumen pH from 6 hours post feeding (6.54) to 18hours post feeding (6.92) and then a decline in 24hours (6.93) post feeding. Total volatile fatty acids concentration was not affected ($P>0.05$) by the sampling time. The effect of inclusion level and feeding regime on rumen pH, TVFA and NH_3-N concentration showed no significant ($P>0.05$) interaction between inclusion level and feeding frequency. Effect of inclusion level of *F. sycomorus* and sampling time on rumen pH revealed that sampling time at 6, 12 and 24hours post feeding was significantly ($P<0.05$) influenced. Inclusion level and sampling time on TVFA concentration showed a significant ($P<0.05$) difference in TVFA concentration across inclusion levels at 12 and 18hours post feeding. Ammonia nitrogen concentration was significant ($P<0.05$) at 10% (36.74 mg/l) and 15% inclusion (35.15 mg/l) than 0% (16.80 mg/l) and 5% inclusion level (21.84 mg/l) at 12 hours sampling time. Effect of feeding frequency and sampling time on the rumen pH was influenced significantly $P<0.05$) across the feeding frequencies at 6, 12 and 24hours sampling time. Effect of feeding regime and sampling time on TVFA concentration had significant influenced. Feeding regime had a significant ($P<0.05$) influence at 12 and 18 hours sampling time post feeding. Feeding regime did not significantly ($P>0.05$) affect the concentration of NH_3-N at the various sampling time. It was concluded that inclusion of *Ficus sycomorus* leaf meal up to 10% in the diet of rams improves the performance and gave the optimum rumen metabolites profile of the animals and skip-a-day feeding frequency gives better performance in weight gain, average daily gain, N retained as % of intake and optimum rumen metabolite profile. Supplementation of *D. smutsii* with 10% inclusion level of *F. sycomorus* leaf meal lowered the cost of feed per kg body weight gain. Cost of feed per kg body weight gain was lower and better on skip-a-day feeding regime.

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CHAPTER ONE

1.0 INTRODUCTION

One of the major bottlenecks limiting productivity of livestock in Nigeria is inadequate supply and poor quality of feeds. This problem is even more aggravated in arid and semi-arid areas given the erratic and unreliable rainfall pattern. Low and erratic rainfall severely affects the growth of grasses, other forages as well as quantity of crop residues available for livestock feeding. Thus, animals in these areas survive mainly on range vegetation of low nutritive value for most part of the year. Amaning-Kwarteng(1991) reported that the crude protein (CP) content of range vegetation range between 8-12% DM at the beginning of the rainy season, and drops to 2- 4% at the peak of the dry season, this leads to prolonged period of under-nutrition and malnutrition with its attendant adverse effect on livestock productivity.

Increasing demand and subsequent high cost of conventional feed ingredients in the tropics has created the need for sustainable alternatives, particularly natural feed resources indigenous to the regions (Sodeinde *et al*., 2007; Wanapat 1995)). This need has over the past few decades rekindled research interest in the use of tropical

browse plants as sources of nutrients for livestock (D'Mello 1992; Aletor and Omodara 1994). Browses are more stable in nutrient composition than grasses.

Browses constitute an abundant biomass in farmlands in the tropical environment of Northern Nigeria. They are commonly utilized by smallholder livestock farmers for feeding ruminants (Okoli *et al.,* 2002). Orji and Isilebo (2000) had recognized the potential of leaf meals from tropical browses to yield relatively higher levels of crude protein, minerals and lower crude fibre.

Trees are playing an increasingly important role in agricultural production systems in the tropics. They have beneficial effects on soil fertility (by protecting soil from erosion and supplying nutrients through nitrogen fixation and incorporation of organic matter); they provide shade for grazing animals in hot and humid areas; and they are an important alternative forage source, due to their high production of edible, highly-acceptable biomass and drought resistance (Otsyina and McKell, 1985; Preston and Murgueitio, 1987).

Tree leaves have an appreciable protein content (11-26% crude protein on average), some of which have low rates of degradability in the rumen (Espinosa, 1984). These characteristics, along with those mentioned above, make them an alternative source of protein drawing research interest to their evaluation as a supplement for ruminant production systems in the tropics.

Okoli *et al.*, (2002) had indicated that over the 5000 trees and shrubs listed as being suitable for livestock feeding in Africa, only 80 are documented for real fodder value. This probably underscores the lack of adequate information on the feed value of many of these plants and the need to scientifically evaluate their nutrient status. Kumar

(2003), however, indicated the presence of anti nutritional factors (ANFs) such as non-protein amino acids, glycosides, phytohemagglutinins, polyphenolics, alkaloids, and oxalic acid have been implicated in limiting the utilization of browses.

Also the International Livestock Centre for Africa (1988) research showed that the content of insoluble and soluble tannins in legumes is related to nitrogen digestibility. The concentration of ammonia (a key metabolite in nitrogen metabolism) in the rumen is an important factor that determines the utilization of nitrogen in the ruminant. Egan and Kellaway (1971) suggested that rumen ammonia and blood urea may serve as effective indices of nitrogen utilization. Volatile fatty acids are the main energy sources for ruminants feeding mainly on roughages. Their levels in the rumen, therefore, give an indication of the energy value of the feed.

Crop residues also form major component of feed resource for ruminant livestock during the dry season. Despite the fairly large availability of these residues (about 71 million tonnes) (Alhassan *et al.*, 1986), their utilization by animals is limited by low voluntary intake due to bulkiness, low dry matter digestibility and poor nutrient status. Crop residues are also known to be high in lignocelluloses, low in available carbohydrate and nitrogen (Sodeinde *et al*., 2007).

Several methods of supplying energy and nitrogen to the rumen synchronously have been reported in literature (Kaswari *et al*., 2007; Hersom 2008). This involved supplementation with energy or protein sources and the use of index values and change in feeding frequency or pattern. Rotger *et al*., (2006) synchronized energy and nitrogen supply to the rumen by changing feed composition.

Synchrony achieved by energy or nitrogen supplementation resulted in a positive effect on microbial protein synthesis (MPS), (Lardy *et al*., 2004; Elseed, 2005).

Hersom (2008) suggested several strategies to elicit optimal synchrony, the most frequently applied supplementation strategies are controlling the timing of feed offered, and the form of nutrients supplied; and supplement types as well as the balance of energy to protein ratio.

JUSTIFICATION

Excessive supply of feed results in increase in waste excreted to the environment. The possible environmental pollutants produced by livestock are nitrogen, phosphorus and other organic compounds (e.g. methane and nitrous oxide). Excretion of these components to the environment may be increased by inefficient digestion and utilization of feed metabolites. In ruminants, this inefficiency may occur in the rumen due to complicated and competitive metabolic pathways which depend on rumen microbial metabolism (Khezri *et al*., 2009). Therefore, better understanding and manipulation of rumen function is necessary for efficient animal production, lower nutrient losses as a result of inefficient digestion/ metabolism and reduce environmental pollution.

Manipulating rumen fermentation through strategic supplementation with concentrate and forages could improve rumen efficiency by maintaining higher pH and optimum rumen ammonia-nitrogen (NH_3-N) concentration, thus reducing methane (CH_4) production and increasing microbial protein synthesis and essential volatile fatty acid (VFAs), for enhanced ruminant production in the tropics (Khampa and Wanapat, 2007). The manipulation of the animals' diets through the use of strategic feeding regime has not been extensively investigated.

Adequate nitrogen (N) supply to the rumen has been one of the biggest concerns in ruminant animal nutrition because conventional protein sources are expensive and

excessive N supply in the form of Non Protein Nitrogen (NPN) has resulted in large amounts of N excreted in animal manure causing unacceptable air and water pollution (Kaswari *et al*., 2007). While the restriction of carbohydrate and protein supply in the rumen has been suggested as one possible solution to achieve this (Kaswari *et al*., 2007), controlling the timing of feed offered to ruminants has been proposed as a means of increasing ruminal MPS, improve efficiency of N usage and animal performance, and decrease urinary N excretion (Cole *et al*., 2008). There is need therefore, to further investigate the use of *F. sycomorus* in relation to quantity and frequency of offer to Yankasa rams to determine the efficiency of usage at farm level.

Objectives of the study:

This study was carried out to evaluate the nutritive value of *Ficus sycomorus* leaf meal as supplement to *Digitaria smutsii* fed to Yankasa rams at different levels and frequencies. The specific objectives are:

i. To determine the nutritive value and antnutritive factors of *Ficus sycomorus* leaf meal.
ii. To determine the effect of inclusion levels of *F. sycomorus* leaf meal in concentrate diets and feeding frequency on growth performance of Yankasa rams fed a basal diet of *D. smutsii* hay.
iii. To determine the effect of inclusion levels of *F. sycomorus* leaf meal in concentrate diets and feeding frequency on nutrients digestibility and nitrogen balance in Yankasa rams fed a basal diet of *D. smutsii* hay.

iv. To assess the effect of inclusion levels of *F. sycomorus* leaf meal and feeding frequency on rumen metabolites profile and levels in Yankasa rams fed a basal diet of *D. smutsii* hay.

v. To evaluate the economics of production of Yankasa rams fed graded levels of *F. sycomorus* leaf meal in concentrate diets at different feeding frequencies.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Sheep Production in Nigeria

The population of sheep in Nigeria has been estimated at 23 million (Food and Agricultural Organisation, 2006). This population is largely centralized in the northern part of the country. They are predominantly found in the drier region of the north. These areas contain a wide variety of plants, shrubs and trees which provide a varied supply of feed for animals at different times of the year. The most common breed of sheep in North Central, Nigeria is the Yankasa. They are short-haired; the coat colour is white with black patches around eyes, ears and nose (Okorie, 1978). However, many strains of this breed of sheep have evolved as a result of intensive breeding for various purposes.

Although sheep are naturally multi-purpose animals, most traditional sheep in the tropics are maintained as subsistence animals supplying meat, skin, hair, manure and

to some extent wool whereas selectively bred animals are more often narrowly specialized (Devendra and Mclerory, 1982).

There are four main breeds of sheep native to Nigeria. They are; Balami, Uda, Yankasa and West African Dwarf sheep. These breeds differ considerably in size, coat colour and other characteristics. Based on these characteristics, they can be grouped into large long legged types found in the northern part of the country and the dwarf found in the hot humid coastal areas (Adu and Ngere, 1979; Oni, 2002).

2.2 Significance of Sheep Production

Sheep play an important role in the socio-economic life of the people of Nigeria and make a significant contribution to the national economy. They constitute about 35 % of meat supply (Oni, 2002). They also feature prominently in socio-cultural function, like ceremonies and religious festivals. The rams in particular are favourite slaughter animals during Sallah festivals at which time rams command very high market prices (Oni, 2002). In addition to the numerous advantages which sheep have over cattle and other livestock species, such as ease of acquisition, rapid growth, prolificacy, easy management and disposal for cash, source of soil enrichment through the manure and household food protein source (Gefu, 2002).

Gefu, (2002) reported that small ruminants are also used as gifts to relatives and friends. Some are given to relatives and members of the family to enable them own and keep livestock in order to improve their livelihood sources. Jaitner et al. (2001) also indicated that small ruminants are kept mainly to generate income, as saving, for ceremonial purposes and to obtain manure.

Small ruminant produce lower absolute quantities of milk than cattle. However, on body weight basis, their milk yield is higher than that of other species, with the

possible exception of camels (Wilson, 1991). Milk from sheep and goats is accepted in most parts of the world, especially in the developed countries as an alternative to cow milk. They contribute about 46% of the total world production of 7.3million tonnes for sheep and 40% of the total world production of 7.2million tonnes for goats in both the tropics and sub-tropics (Joseph and Olafade, 1999).

Sheep are good producers of meat for human consumption. The animals are excellent meat producers in view of their short generation intervals and the absence of religious taboos associated with their meat. The Yankasa sheep has been reported to be superior to the WAD sheep, which is indigenous to the rain forest region in terms of yearling weight, live weight productivity per animal and annual rate of return (Ehoche *et al.*, 1993)

2.3 Small ruminant production system

Small ruminant production systems vary according to the ecosystem (CTA 1986). Two main types of production systems can be observed: the purely pastoral system and the agro pastoral system (CTA, 1986). Kondombo (2005) indicated that two main subsystems of small ruminant production could be distinguished: the breeding system and the fattening system. Ehoche *et al.* (1993) reported that sheep are largely managed under the traditional system in Nigeria. Slingerland (2000) classified small ruminant production into three systems. These are the agro-pastoral in which crop production is dominant; agro-pastoral in which animal production is dominant and a semi-intensive production system. Otchere *et al.* (1985) reported that pastoralist in Northern Nigeria allow sheep to accompany cattle for grazing but tethered their goats under shelter. Similar management systems have been described by Wilson (1982).

2.4 Legumes and their uses in livestock production

Forage legumes have become increasingly important as protein-rich forages to supplement a basal diet of either grass or poor quality roughage for ruminant livestock. For smallholder milk production in particular, legumes are needed to provide a balanced diet. In recent years a large number of species of either herbage or shrub legumes have been identified and there is a need to assess their suitability for ruminant production systems especially with respect to the efficient utilisation of dietary protein.

2.4.1 Significance of forage legumes as protein supplement

To overcome constraints to the efficient utilization of agricultural by-products as animal feed, interest is now placed on the use of forage or dual purpose legumes as supplementary feed. Utilization of grasses and crop residues with the aid of nitrogen supplied by leguminous forages could receive more response from subsistence farmers since the intervention is compatible with the long term productivity of grasses and cereal crops. This is due to the improvement in soil fertility resulting from the ability of legumes to fix nitrogen in the soil. The leaf fall at maturity not only adds to organic matter in the soil but also provides additional nitrogen. Kumar-Roa *et al.* (1981) reported residual nitrogen of approximately 40kg/ha. Since nitrogen is also the most limiting nutrient in the soils of Nigeria, the production of dual legumes could result in an increase in cereal grain yield which is accompanied with a rise in residue yield. Forage legumes could, therefore, serve as a key link for effective integration of animals into the strong crop oriented production system in Nigeria.

Forage legumes can also serve as a source of sulphur which is usually lacking in low protein roughage diets (Miller, 1982). Supplementation of roughage diet with sulphur (an essential element for ruminant microbes) showed increases in the digestion of cellulose (Tripathi *et al*., 2007). Although ammonia is the major source of nitrogen for microbial growth, some species in the rumen are unable to utilize it and so require peptides and/or amino acids for growth (Pisulewski et al., 1981). These cannot be supplied when Non-protein nitrogen (NPN) supplements are used.

Due to variations in degradation rate, many protein nitrogen sources release ammonia at lower rate than urea-nitrogen, more closely coinciding with release of energy from the cellulose component thus enhancing microbial production. This in turn stimulates increased rate of cellulose digestion and voluntary intake.

The synchronization of rate of degradation of nitrogen and balance of carbohydrate components in the rumen is important for the synthesis of microbial protein (Roffler *et al*. 1976). Microbial protein in the rumen is the major source of nitrogen to the host animal, accounting for 60-85 percent of the total amino acid entering the small intestine (Orskov, 1982). The pattern of degradation, therefore, influences the choice of nitrogen source for efficient utilization of roughages.

The presence of nitrogen in forage legumes however, does not always guarantee its availability to the target microbes in the rumen. Research by the International Livestock Centre for Africa (ILCA, 1988) showed that the content of insoluble proanthocyanides and soluble phenolics in legumes are related to nitrogen digestibility. Browses with moderate levels of phenolic compounds such as leaves of *Acacia brevispics, Acacia seyal* and *Acacia nilotica* and fruits of *Acacia albids* and *Acacia tortilis* are promising protein supplements, although the phenolics in these

species also reduce nitrogen availability. The negative effect is partially offset by lower urinary loss of nitrogen, allowing adequate animal performance (Kumar and Singh, 1984).

Forage rich in condensed tannin such as *Acacia aneura* may have a negative impact on animal performance even if these species represent a small proportion of the diet (Pritchard *et al*. 1988). A primary manifestation of an adverse effect is the depressed intake of metabolizable energy. This occurs principally due to a reduced voluntary dry matter intake as a consequence of impaired rumen fermentation of cellulose and hemicelluloses (Barry and Duncan, 1984), while occasionally, animals were found to lose weight or died (Kaitho *et al*., 1998).

2.4.2 Effect of legume supplementation of crop residue on animal performance

2.4.2.1 Maintenance of body weight

Alawa (1999) observed that while ruminants may survive by grazing low quality forage during the dry season in tropical countries where little or no supplementary feeding is practiced, losses in body weight, difficult to quantify are likely to occur. It was suggested that animals may maintain their weights by increasing the intake of native grass and crop residue and other low quality by-products if protein with moderate degradation within the rumen is supplied. Richard *et al.* (1994) also stated that protein supplementation of crop residue containing low nitrogen levels has increased forage intake and animal performance. However, protein degradation characteristics of feed ingredients, as well as interactions between nutrients in feed ingredients are important determinants of response to supplementation (Brown and Pitman, 1991). In some cases a low level of 10-20% supplementation of tropical grasses with tree legumes has increased animal efficiency without significant increase in dry matter intake.

2.4.2.2 Increase in dry matter intake

Moran *et al*., (1983) reported that dry matter intake increased when poor roughage was supplemented with *Leuceana leucocephala*. Manyuchi *et al*., (1997), reported that forage supplementation increased total feed intake but as the level of supplementation increased beyond 20-40 percent, the intake of the basal diet fell below the level achieved with the unsupplemented basal diet. This agrees with the result of Mosi and Butterworth (1984) in which increasing the inclusion of *Trifolium tembense* hay above 34.7 percent of the basal maize stover diet decreased the intake of maize stover from 15.1 to 12.2g/kg/day.

However, there appears to be differences in the level of response depending on the type and level of forage supplementation. Sujatha *et al*., (1998), fed three types of forages: *Leucenea leucocephala, Gliricidia and Trifolium tembense* hay and obtained variable responses of 35.4, 36.1 and 36.6g/kgW0.75/day for *Leucenea, Gliricidia* and *Trifolium* forage supplement respectively as against rice straw basal intake of 31.5 g/kgW0.75/day. The work of Dutta *et al*. (1999) also showed similar results. Dry matter intake of rice straw was highest with *Leuceana* supplement followed by *Prosopis* and least for oat straw. The dry matter intake was approximately 40.51 percent and 20.65 percent in the *Leuceana* and *prosopis* supplemented groups respectively. These workers attributed these differences not only to the effect of increased dietary crude protein, but to their readily fermentable fibre content. Mehrez and Orskov (1977), reported that animals fed on poor roughages as their sole diet show low dry matter intakes with decline in body weight. The nature of the basal diet is also known to affect response to supplementation.

2.4.2.3 Increase in rumen degradable protein

Alawa (1999) stated that, to evaluate various protein supplements in terms of the extent to which they meet the needs of the rumen microbes depends on the ruminal degradability of the protein. He further explained that the proportion of protein broken down in the rumen (RDP) varies with protein sources and depends on a variety of factors. Some of the factors stated are: structural characteristics of the protein, processing method, rumen retention time, nature of the basal diet and rumen ammonia concentration. The degradation of dietary nitrogen which determines rumen ammonia-nitrogen evolution has been implicated in the intake of feed. Newbold (1985) as cited by Alawa (1999) obtained a highly significant linear relationship between feed intake and dietary rumen degraded protein concentration. Alawa and Humingway (1986) also reported an increase in feed intake when rumen-ammonia nitrogen increased from 4.6g RDP to 14.4g RDP. A decrease in protein degradability implying reduced rumen ammonia nitrogen has been associated with reduced ruminal microbial population and fermentation thus, leading to reduced feed intake.

It is well documented that the utilization of the energy component of crop residues by ruminant animals is highly dependent on the efficiency of the fermentative activity of the microbes in the rumen. For optimum fermentation on a given diet, a certain level of ammonia concentration in the rumen is required. Otherwise, feed intake may be reduced if ammonia concentration limits the rate of fermentation.

2.4.2.4 Improvement in digestibility

Results of legume supplementation of low quality forage on digestibility have been variable. Cann *et al*., (1993), reported significant increase in the digestibility of maize stover and oat straw when supplemented with *Trifolium tembense* hay but no increase in digestibility when *Trifolium tembense* hay was used to supplement Tef straw and

wheat straw. They attributed these differences in digestibility to the content of lignin and silica in the cereal straws. According to their study, wheat straw had the highest level of lignin and silica and had the lowest digestibility. Their result also showed that improvement in the digestibility of the diets occurred at different levels of supplementation. Successive increment of *Trifolium tembense* hay caused an increase in digestibility with the exception of the highest level in animals fed on oat straw and Tef straw. This implies that digestibility increases with increase in the level of crude protein in the diet up to a point. Once the nitrogen deficiency of crop residues has been overcome, there may be little advantage in additional forage legume. Given a satisfactory level of nitrogen in the diet, the amount of protein synthesized by the rumen microbes and the rate at which they ferment roughages is limited primarily by the amount of readily available energy in the feed. Agricultural Research Council (1984) stated that with a readily available energy source, microbial protein yield is related to the amount of organic matter digested and vice versa.

2.5 Tree Leaves and Shrubs as Dietary Supplements for Ruminants

Trees and shrubs have provided valuable forage to man's herbivorous animals probably since the time of their domestication (Robinson, 1985). At least 75% of the shrubs and trees of Africa serve as browse plants and many of these are leguminous (Skerman, 1977). The overall importance of browse was summarized in the Commonwealth Agricultural Bureaux statement (1947) which indicated that more animals feed on shrubs and trees or on associations in which shrubs and trees play an important role than on true grasslands. Forage from trees and shrubs include not only leaves and young shoots but also pods, seeds and fallen flowers. The pod yield can vary greatly from year to year. In favourable years, a mature tree of Acacia (*Faidherbia albida*) in an area with 400-600mm rainfall can produce more than

100kgDM of pods with 70g digestible crude protein per kg DM. if there are 20 mature trees per ha, the yield can be as high as 2500kgDM of pods/ha. This is more than the yield of herbaceous plants in the same zone in dry years (Von Maydell, 1986).

Tree fodders maintain higher protein and mineral content during growth than grasses, which decline rapidly in quality as they progress towards maturity (Aganga and Tshwenyane, 2003). Wickenns (1980) estimated that at least 75 percent of the 7000-10,000 species of trees and shrubs in tropical Africa are used as forage. In some parts of central Nigeria, pastoralists could identify about 40 woody species that are browsed by cattle (Wickens, 1980).

Tree legumes, which persist during the seasons of pasture scarcity, have been shown to contribute protein-rich forage, digestible energy and minerals when used either as supplements or as sole feed (Abdulrazak *et al.*, 1997). McKell (1980) pointed out that shrubs and trees are the most visible plant forms in many landscapes, yet have been neglected in most scientific research. Trees legumes are increasingly important components of farming systems in the tropics (Prston and Murgueitio, 1987; Attahkrah, 1991). In Latin America,*Gliricidia sepium* (Gomez *et al.*, 1990) and *Erythrina poeppigiana* (Esnaola and Rios, 1990) have been used successfully to replace protein-rich oilseed meals in the diets of milking goats. The superiority of the legume leaf meal is in its high protein content of both fermentable, by-pass protein and additional benefit of supply of other nutrients that enhances rumen ecosystem (Preston, 1985).

2.5.1 The nutritive value of tree leaves and shrubs

The potential of leaf meals from tropical trees and shrubs to yield relatively higher levels of crude protein and minerals and lower crude fiber levels than tropical grasses has been recognized (Le Houerou, 1980; Mecha and Adegbola 1980; Onwuka *et al.*, 1989; D'Mello, 1992). Mecha and Adegbola (1980); Aletor and Omodara (1994), and more recently Orji and Isilebo (2000) and Okoli *et al.* (2001) among others, have characterized the nutrient composition of some Nigerian indigenous browse plants. These studies showed that crude protein and crude fiber contents of such plants range from 15.3% to 33.3% and 2.7% to 15.6%, respectively.

The value of forages from trees and shrubs is associated with a number of advantages. With *Leucaena* for example, it provides a valuable source of protein, energy and sulphur for the rumen bacteria. It also has multipurpose uses in fence lines and as fuel (Devendra, 1990). With specific reference to their value in animal feeding, the advantages include: availability on the farm; accessibility; provision of variety in the diet; source of dietary nitrogen, energy, minerals and vitamins; laxative effect on the alimentary system; reduction in the requirements for purchased concentrates; and reduced cost of feeding (Devendra, 1988)

The most important aspect of fodder trees as a source of feed for farm animals is the high protein content, which ranges from 11 - 26%. Some studies have demonstrated higher protein content of up to 34% which, unlike in most grass species, does not seem to change with leaf maturity even when they dry and fall off to the ground (Leng, 1992).

Kabaija (1985) showed that many browses degrade fairly well and rapidly, supplying much needed soluble carbohydrates and fermentable nitrogen to the rumen, thus enhancing forage breakdown. Leaf meal of legume tree when used as supplement

offers a good source of easily digestible and extractable protein (Iyayi, 1991). Apart from the protein, they contain 2-8 per cent fatty acids, which play an important role in ruminant nutrition. Leaves and fruits of ligneous species have a much higher level of digestible protein (DCP) than other fodder sources; in Senegal, it is 180 to 200 g DCP/kg DM in browse compared to 100 to 130 for groundnut leaves and 50 to 70 for leaves and fruits of various herbaceous species (Kabaija, 1985).

Undoubtedly, for animal production purposes, the mineral composition of tree foliages is superior to that of tropical grasses. Norton (1994) has reviewed the mineral content of a range of tree forages and reported that tree forages has appreciable quantity of minerals that is enough for maintenance. There is little information on the range of trace elements but if the tree is healthy then an array of trace elements in the foliage can be expected.

Goodchild and McMeniman (1994) attributed increases in ruminant production to leaf foliage included in the diet as being due mainly to its mineral content and therefore the supply of minerals to the animal and the rumen microbiota. They concluded that the responses of sheep to supplements of browse are to the extra N and minerals in the rumen and the organic matter in the foliage, which enhances the overall fibre digestibility of the diet also, supplementation with any dry browse seems to have an additional effect because they may act in the same way as bypass protein.

2.5.2 Leguminous trees as supplements to low quality forage

There is an extensive and diverse literature on the effects of leguminous tree supplementation on the productivity of cattle, sheep and goats. Tree leaves, particularly *Leucaena* and *Gliricidia sepium* (gliricidia), have been used as supplements to a wide range of forages and agricultural by-products. They have been

incorporated into concentrate rations as substitutes for more expensive processed protein sources, used as supplements to sisal waste and as the major protein source for cattle fed molasses base diets.

Since basal feed intake usually increases with supplementation, practical recommendations for levels of supplement to be offered are better expressed in relation to live weight of the animal rather than as a percentage of a diet. The studies of Iyayi (1991) with goats and sheep given leucaena as a supplement to spear grass (*Heteropogon contortus*) illustrate the common response to supplementation. These authors observed an increase in hay intake and an overall improvement in diet digestibility with supplementation. Although weight changes were not measured in these experiments, the increase in digestible dry matter intake is predictive of improved weight gain. Leucaena supplementation increased rumen ammonia concentrations, stimulated microbial protein synthesis in the rumen (from 1.6 to 2.9 g/day) and increased the amount of plant protein available for absorption. The degradability of *Leucaena* protein in the rumen was estimated to be 66% for fresh *Leucaena* and 40% for dried *Leucaena* The increased protein absorption from the small intestine stimulated an increased voluntary consumption of the low quality straw. Supplementation of rice straw with leucaena generally did not increase basal intake but did increase digestible nutrient intake (Ahn, 1990).

Whilst there is considerable information on the supplementation value of *leucaena* and *gliricidia*, less is known about other forage tree legumes. Forage tree legumes are a costly resource to establish and their judicious use is required if maximum benefit is to be obtained from them. Knowledge of their comparative nutritive value and the levels of supplementation required for particular purposes is needed if these trees are to become an important part of the feed resources available to livestock producers.

2.6 Anti-nutritional Factors in Browse Plants

These are compounds that limit the wide use of many plants due to their ubiquitous occurrence as natural compounds capable of eliciting deleterious effect in man and animals (Kubmarawa *et a*l., (2008). The antinutrient content of *Ficus sycomorus* leaves reported by (Nkafamiya *et al*., 2006) are oxalate 2.88 ± 0.37 mg/100g, tannins 4.01 ± 0.22 mg/100g, saponin 1.78 ± O.11%, phytate 1.98 ± 0.78 mg/100g, alkaloids 5.64 ± 0.41 mg/100g and HCN 3.05 ± 0.51 mg/100g, for *Ficus asperifolia* are oxalate 3.78 ± 0.28 mg/100g, tannin 5.60 ± 0.10 mg/100g, saponin 2.67 ± 0.28%, phytate 2.01 ± 0.12 mg/100g, alkaloid 6.40 ± 0.11 mg/100g and HCN 0.45 ± 0.12 mg/100g.

2.6.1 Effect of antrinutritive factors (polyphenolics) in browse trees and shrubs

The utility of the leaves, pods and edible twigs of shrubs and trees as animal feed is limited by the presence of anti-nutritional factors (ANFs). Tropical browses have been shown to contain varying quantities of condensed tannin and other anti-nutritional substances in their biomass that affect their optional utilization by animals (Aletor and Omodara, 1994; Osagie, 1998). The ANFs which have been implicated in limiting the utilization of shrub and tree forages include non-protein amino acids, glycosides, phytohemagglutinins, polyphenolics, alkaloids, triterpenes and oxalic acid.

2.6.1.1 Effect of secondary plant factors

The presence of antinutritive factors in most trees and shrubs have shown variable effect on ruminant animals. The effects depend on the type and amount ingested. For example, condensed tannins intake can have no effect or reduce voluntary intake (Komolong *et al.*, 2001), or even increase ruminal degradation (Miller *et al.*, 1982; McSweeney *et al.*, 2001), improve or reduce diet digestibility (Barry *et al.*, 1986; Waghorn *et al.*, 1994; Komolong *et al.*, 2001).

2.6.2 Effect of secondary plant compounds on voluntary feed intake

At high levels tannins have adverse effect on intake and digestibility, Makaranga (2002) reported that there was reduction on the dry matter intake (DMI) and crude protein intake (CPI), Osagie, (1998) found a negative correlation between tannins levels *in vitro,* especially condense tannins (CTs) in 40 natural browse plants and their DM digestibility using kudu rumen fluid. High levels of tannins may slow down the digestion of DM in the rumen, react with the outer cellular layer of the gut, and thus diminish the permeability of the gut wall (Mitjavila *et al.,* 1987). High condensed tannin concentrations in *Lotus pedunculatus* (63 and 106 g/kg DM) substantially depressed voluntary feed intake (VFI) in sheep (−27 %). Smaller depressions in VFI (−12 %) were produced by 55gCT/kg DM in *Lotus pedunculatus* (Waghorn *et al.,* 1994).

However, medium condensed tannins concentrations in Sulla (45 g/ kg DM) and in *Lotus corniculatus* (34 and 44 g/kg DM) had no effect upon VFI (Waghorn and Shelton, 1997; Wang *et al*., 1996). Intake of feed containing large amounts of condensed tannins has been reported to be low (Barry and Duncan, 1984). High concentrations of CT in *Lotus pedunculatus* (75-100 g/ kg DM) have been reported to depressed voluntary feed intake and rumen carbohydrate digestion and depressed rates of body and wool growth in grazing sheep (Barry and McNabb, 1999). Krebs and Howard (2003) reported that condensed tannins content have inverse relationship with voluntary feed intake, digestibility and nitrogen (N) retention in ruminants. The depression in intake could also be due to unpalatability, since the tannins in plant tissues may precipitate salivary proteins causing an astringent taste (dry feeling) in the mouth (Kumar and Horigome, 1986; Bate-Smith, 1973; Goldstein and Swain,

1963). Browses with moderate levels of proanthocyanidins improved roughage intake comparable to those on standard supplements (ILCA, 1988).

2.6.3 Effects of secondary plant factor on rumen microbial activity

The toxicity of free phenolic acids has been demonstrated on a wide range of rumen bacteria (Chesson *et al.,* 1982). Bactericidal and bacteriostatic effects have been demonstrated in cellulolytic bacteria, such as *Ruminococcus albus, R. flavifaciens* and *Bacteroides succinogenes,* in the presence of 10 mM or less of p-coumaric acid and ferulic acid (Chesson *et al.,* 1982). Akin (1982) also observed that cellulolytic and xylanolytic bacteria were inhibited by p-coumaric acid and ferulic acid and that p-coumaric acid reduced motility in entodinomorph, but not holotrich, protozoa. Ferulic acid and sinapic acid had lesser effects on protozoa (Akin, 1982). Hemicellulolytic bacteria appear to be more tolerant of phenolic acids than cellulolytic bacteria (Jung, 1985), presumably because these phenolics are linked to the hemicellulose fraction of the cell walls and hemicellulolytic bacteria are adapted to these phenolics.

2.6.4 Effect of secondary plant factors on digestibility

The way tannins react with proteins to form complexes and the activity of enzymes on these complexes is not fully understood. Barry *et al.* (1985) reported that condensed tannins both stimulated and inhibited digestion of complexed proteins of trypsin. It has been suggested that phenolic compounds limit the digestion of carbohydrates (Jung, 1985). Goldstein and Swain (1963) observed low digestibility of cell walls from *Desmodium intortum* and suggested that this was probably caused by proanthocyanidins complexing with cellulose. Experiments with some forage have shown a negative correlation between the phenolic constituents of cell walls and

apparent digestibility (Krebs and Howard (2003); removal of phenolic acids from cell walls increases digestibility (Chesson *et al.,* 1982).

In another study, Schwartzopf-Gensein (2000) examined the digestion of dried sainfoin (high-condensed tannin) and lucerne (low condensed tannin) in mature sheep. Although the crops were harvested at similar stages of growth and had similar total N contents, cellulose digestibility was significantly higher on sainfoin (78 vs 67) and the extent of cellulose digestion in the rumen was unaffected. In contrast, apparent N digestibility was significantly lower in sainfoin (68 vs 51).

Tannins may reduce cell-wall digestibility by binding bacterial enzymes and/or forming indigestible complexes with cell-wall carbohydrates (Reed et *al*., 1986). The digestibility of organic matter and fibre fractions of sheep diets comprising *A. cyanophylla* were depressed, because of high contents of proanthocyanidins and soluble phenolics. Neutral-detergent fibre digestibility was also depressed in diets containing two other tanniferous browses, *A. sieberiana* fruits and *A. seyal* leaves. Higher levels of tannins may reduce cell wall digestibility by binding bacterial enzymes and/or forming indigestible complexes with cell wall carbohydrates (Reed *et al.,* 1990). High levels (5-9 %) of tannins become highly detrimental (Barry 1983) as they reduce digestibility of the fiber in the rumen (Reed *et al.,* 1985) by inhibiting the activity of bacteria and anaerobic fungi (Chesson *et al.,* 1982).

2.6.5 Effect of secondary plant factors on nitrogen retention

The N retention is considered as the most common index of the protein nutrition status of ruminants (Otsyina, R.M. and McKell, 1985). Lower urinary and feacal nitrogen excretion of lambs fed acacia leaf meal may be attributed to tannins. The result is comparable to the report of Krebs and Howard (2003) who indicated that

condensed tannin content have an inverse relationship with voluntary feed intake, digestibility and nitrogen (N) retention in ruminants.

However, lowered N retention in animals fed some tanniniferous forages suggest that much bound protein, is unavailable for digestion in the gut (Mangan, 1988; Kumar and Singh, 1984; Waghorn and Shelton, 1995). Many studies have reported a rise in fecal N excretion as response to increased dietary tannins concentration (Mehansho *et al.*, 1987; Komolong *et al.*, 2001; McSweeney *et al.*, 2001).

Higher total fecal nitrogen (which could be accounted for by higher fecal NDF-N) was observed for all diets containing tanniferous feeds (Rittner, 1987; ILCA, 1988). Tannins from *Lotus pedunculatus* appear to overprotect protein from ryegrass fed to sheep (Waghorn and Shelton, 1995) with subsequent increased fecal loss of protein.

Tannins have been shown to reduce the permeability of the gut wall by reacting with the outer layer so that passage of nutrients is reduced (Mitjavila *et al.*, 1977). Animals fed tannin-containing feedstuffs excrete more faecal NDF-N than control animals fed feeds containing little or no tannin (Rittner, 1987) hence low nitrogen retention

2.6.6 Effect of secondary plant factors on rumen metabolites

Rumen ammonia has been reported to be high (49 mg/l) in diets containing *S. sesban*, (having low tannins content) and low for diets with increasing amounts of *A. brevispica*, reflecting the rapid fermentation rate of *S. sesban* due to low phenolic and fibre contents. Diets with *S. sesban* also had higher concentration of rumen ammonia than diets with *A. nilotica* or *A. seyal* (Rittner, 1987), reflecting the rapid fermentation rate of *S. sesban* due to low phenolic and fibre contents.

The studies of Wallace *et al.* (1981), Whetstone *et al.* (1981) and Newbold *et al.* (1990) have concluded that the lower ammonia concentrations were mainly due to reduce proteolysis, degradation of peptides and deamination of amino acids in the rumen, due mainly to the binding effect of tannins. A reduction of volatile fatty acid production and microbial protein synthesis as a result of tannin levels has been reported (Kumar and Singh, 1984).

2.6.7 Effect of secondary plant factors on animal performance.

Barry *et al.* (1986) examined the effects of tannins on nutrient utilization in sheep fed high-condensed-tannins *Lotus.* They observed increased levels of growth hormone and their results suggested an increase in the ratio of lipolysis to lipogenesis. Similar trends were reported by Purchas and Keogh (1984), who found lower carcass fat in lambs grazing *Lotus* than in those grazing white clover. They attributed this to dilution of fat content by increased N retention, while increased lipolysis may have been mediated by increased secretion of growth hormone. Reid *et al.* (1974) attributed increase in performance of sheep fed low tannin containing diet to an increased supply of amino acids to the small intestines as a result of protection of the plant protein from proteolysis in the rumen.

2.6.8 Effects of secondary plant factors on milk production

In ewes rearing twin lambs, Wang *et al.* (1996) found that condensed tannins from L *comiculatus i*ncreased milk yield, protein and lactose percentage, reducing fat percentage. The higher protein percentage could be due to an increase of amino acid especially essential amino acids flow from the small intestine. Newbold *et al.* (1990) found that goats browsing a shrub land comprising lensik (*Pistacia lentiscus*) and *Quercus* spp, increased milk yield and milk urea with no difference in milk fat

and protein percentage, when supplemented with PEG. Similar results were reported by Waller (2006). These results indicate that condensed tannin from different plant species has different effects, depending on levels and activity.

2.6.9 Effects of secondary plant factors on Wool growth

Condensed tannin seems to have different effect on wool growth depending on the concentration. Wool growth has a direct correlation with protein utilization. At low concentration, condensed tannin seems to increase wool growth (Waghorn and Shelton, 1997). The reduced protein degradation in the rumen and the better amino acid absorption from the small intestine noted by Barry *et al.* (1986) and Waghorn *et al.* (1987) could be responsible for the increased wool growth when *Hedysarum coronarium* ((Waghorn and Shelton, 1997) and *Lotus comiculatus* (Wang *et al.*, 1996) were fed to sheep. Mangan, (1988) also found that PEG administration in sheep fed *L. pendunculatus* tend to increase wool growth. This was due to higher level and activity of tannin of *L. pendunculatus.* On addition of PEG, the adverse effects of these tannins were alleviated, leading to increased voluntary feed intake and to a possible increase of growth hormone titre.

2.6.10 Effect of secondary plant factors on animal health

Alternative parasite management strategies using forages containing condensed tannins have recently been suggested (Niezen *et al.,* 2002; Min *et al.,* 2002). Studies have shown that lambs grazing condensed tannin-containing forages (sulla and *Lotus pedunculatus*) are better able to tolerate parasite infections than lambs grazing non condensed tannin-containing forage (lucerne), and show both increased growth and lower gut-worm burdens (Niezen *et al.,* 2002), the condensed tannin may directly react with and inactivate parasite larvae during passage through the gut. Tannins are less

effective for nematodes such as *Trichinella spriralist* that burry into the digestive mucosa (Min *et al.*, 2002).

Forages containing condensed tannin (CT) may offer a nutritionally based system for controlling the effects of parasites; Tannins reduce dependence on synthetic anthelmintics in sheep (Niezen *et al.,* 2002) and farmed deer (Hoskin *et al.,* 2000).Which is ecologically sustainable, thus reducing the use of anthelmintic drugs.

Tannins have been shown to have a direct anthelmintic effect on resident worm populations in animals, tannins and/or metabolites in dung may have a direct effect on the viability of the free-living stages (Waller, 2006). Many experiments have shown that fecal egg counts (FEC), parasite numbers or migration are reduced by tannin containing feeds such as cassava leaves, *Acacia brevispia* or *Desmonium ovalifolium*. Foster, (2006), reported positive effects of CT on gastrointestinal tract (GI) nematode parasites to include lower fecal egg counts, decreased worm burdens, and inhibition of egg hatch and larval development. It was then concluded that CT has biological effects on the control of gastrointestinal parasites; possible direct effects could be mediated through CT–nematode interactions, which reduce nematode viability.

Bloat is caused by very high solubility of forage proteins leading to the development of stable foam in the rumen, and is very prevalent in cattle fed on legumes, especially in spring (Mangan, 1988). Because of their protein-precipitating properties, grazing condensed tannin-containing legumes has long been known to eliminate bloat (Jones *et al.*, 1973). Tamminga (1996) stated that there are two major nutritional advantages of the consumption of feeds high in tannins for ruminants. The first relates to the prevention of bloat when animals eat pastures that are rich in soluble proteins. The second advantage is the ability of tannins to form complexes with free protein in the

rumen and thus protect the protein from degradation in the rumen. However, the minimum plant condensed tannin concentration needed to make forage bloat-safe was not known; this has recently been proposed to be 5 g condensed tannin/kg DM or greater (Jones *et al.,* 1973).

2.6.11 Effect of secondary plant factors on Growth

Animal growth rates reflect total intake and the availability of nutrients in the diet. When there was a reduction in total intake due to the fibre or phenolic content of browse, growth rate was low compared with that obtained with non-tanniferous supplements. Low growth rates were observed in animals fed fruits of *A. sieberiana* and *A. nilotica* (Tanner, 1988) although total feed intake was not very low. The negative effect of tannins in *A. cyanophylla* on growth rate was caused by a reduction in nitrogen availability.

2.6.12 Effect of secondary plant factors on meat and carcass

McLeod (1974) reported that tannin added to the diet of fowl has produced deterioration of taste and odor of the meat. In the field of small ruminants, there are only few studies with specific regard to condensed tannin and meat quality. In a trial conducted to compare two sorghum strains with different content of condensed tannin, lambs fed with the strain containing the higher level of condensed tannin showed a carcass lighter in color (Farouk and Lovatt, 2000). The presence of condensed tannin has been associated with reduced carcass fat in lambs grazing *L pendunculatus* (Pruchas and Keogh, 1984) and *H coronarium* (Terrill *et al.,* 1992).

Similarly, Purchas and Keogh (1984) found lower carcass fat levels in lambs grazing *Lotus* than in those grazing white clover. This could be due to dilution of fat content by increased N retention, while increased lipolysis may have been mediated by

increased secretion of growth hormone. Priolo *et al.* (2002) found that feeding carob pulp in partial replacement of dietary barley to Comisana male lambs between weaning (50 d) and slaughter (100 d) significantly increased *longissimus* muscle. Also Priolo *et al.* (2001) hypothesised that tannins were responsible for the differences found in meat color. In a successive experiment designed to evaluate the specific effect of carob pulp condensed tannin on lamb growth and meat quality Priolo *et al.* (2002), showed that when the effects of condensed tannin from carob pulp are eliminated by PEG supply, Comisana lamb *longissimus* muscle was significantly darker.

Ben Salem *et al.,* (2002) and Priolo *et al.,(* 2002) evaluated the effects of condensed tannin from *Acacia cyanophylla* foliage on meat quality of Barbarine male lamb. The animals were slaughtered at 230 d of age after being offered acacia foliage with or without PEG for 80 days. The *longissimus* muscle of animal that did not receive the PEG was significantly lighter. This result, together with that of Priolo *et al.* (2000) indicates that tannins from different plant species have similar effect on lamb meat color.

Bowling *et al.* (1977) reported that feeding tea leaves to Japanese heifers reduced muscle iron content. A strongly negative correlation between muscle iron and meat lightness was also found, and it is concluded that feeding tealeaves would be effective in increasing the luminosity of the meat. Also in another trial conducted to compare two sorghum strains with different content in condensed tannins, lambs fed with the strain containing the higher level of condensed tannin had meat lighter in color (Farouk and Lovatt 2000). The reduction in meat color was attributed to reduced

blood haemoglobin concentration, following condensed tannin intake (Bowling *et al.,* 1992).

2.6.13 Effects of secondary plants factors on non-ruminants

Melton (1983) stated that high tannin levels are quite deleterious in the nutrition of monogastric animals since they reduce the absorption of protein from the small intestine. Pigs given diets containing *Leucaena* leaf meal at 100 g/kg grew significantly faster than control animals but live weight gain declined progressively with higher inclusions (Mottram, 1998). It was reported that while inclusion rates of 50 and 100g/kg diet elicited satisfactory laying performance, the diet containing 200g/kg precipitated severe reductions in food intake and egg production. In the case of *Sesbania*, there are signs of acute toxicity with inclusion rates as low as 100g/kg diet, with 100% mortality in chickens fed *Sesbania* at 300g/kg diet (Mottram, 1988).

Mottram (1988) found that the inclusion of *S. sesban* leaf meal in poultry diets (10% of diet) proved fetal to young chicks, and that the provision of either cholesterol or sitosterol with the diet significantly improved survival. Olvera *et al.* (1988) found poor growth and high mortality in *Tilapia fingerlings* at all levels of inclusion (10-35%) of *S. grandiflora* leaf meal in a fishmeal diet.

The factors affecting palatability of *Gliricidia* in ruminants are probably the same as those that depress digestibility and growth in rabbits and chickens given *Gliricidia* leaf meal diets (Bowling *et al*., 1977). However, research with non ruminants indicates that tannins decrease the absorption of essential amino acids (especially methionine) and deprease growth (Mottram, 1998).

2.6.14 Effect of other secondary plant factors.

Coumarins have been found in G*liricidia* leaf, these compounds are precursors of phyto-oestrogens, which have caused infertility and abortion in sheep grazing clover in Australia (Makkar, 1991). Triterpenic substances and glycosides of echinocystic acid (saponin) have been isolated from the bark of *A. chinensis*, and these bark extracts have been found to have molluscicidal, spermicidal and insecticidal (Van Soest and Robertson, 1988) properties. Rahman *et al.* (1986) also reported that alkaloids from the seeds of *A. lebbeck* are fungicidal and cytotoxic to selected lines of cancer cells growing *in vitro.*

2.7 Methods of Minimizing Content of Antinutritive Factors in Browse Trees and Shrubs

In order to minimize the detrimental effects of tannins and phenolic compounds in trees/shrubs fodder, several suggestions have been put forward, some of which can be applied under smallholder farming system. Among these are post-harvest processing techniques such as conservation of fodder into bags or ensiling them in silo pits with other feed resources has also proved beneficial in minimizing the detrimental effects of tree/shrub fodder (Atta-Krah, 1989 and Makkar and Sing, 1993), sun-drying and wilting of forages before they are fed to animals (Jackson *et. al.*, 1996), treatment with chemicals, storage of fresh leaves in polythene bags and bio-treatment using the fungus *Sprotrichum pulverulentum* (Makkar, 1991).

2.7.1 Drying and wilting

Ahn (1990) reported extractable tannin content of *Gliricidia* leaves to be zero after drying and when dried leaf meal was fed to sheep, straw intake increased Nitrogen digestibility and N balance also increased. Dalzell (1996) has reported that drying

reduces extractable condensed tannins to 25% of that obtained from freeze-dried samples.

D'Mello (1992) stated that drying procedures of the forages may modify the nutritional effects of the tannin. Waghorn and Shelton (1989) observed that field drying of *Lespedeza cuneata* (high tannin) decreased its assayable tannin concentration and this resulted in improved intake and increased N and fibre digestibility. Low tannin *L cuneata* did not show similar effects. Ahn *et al.* (1990) observed that oven-drying (50°C) *of A. aneura, A. angustissima, A. chinensis* and *C. calothyrsus* caused a reduction in 'active' tannin which improved N digestibility in the rumen by 35%. Powell and Grabber, (2009) reported a reduction in hydrocyanic acid content of cassava leaves following ensiling or wilting.

Drying *Acacia cyanophylla* foliage under shade or in the sun reduced the CT content, but sun drying was more efficient than drying in the shade (Ben Salem *et al.,2005*). The reason could be that drying probably resulted in a complex formation between tannins and protein and/or oxidation of tannins causing a decrease of extractable CT concentration in Acacia foliage (Goldstein and Swain, 1963). Ben Salem *et al.* (2005) found that DMI of sheep fed field dried *Acacia cyanophylla* foliage was higher than that of sheep fed fresh Acacia foliage, but digestibility and ruminal fermentation of sheep were similar between the two forms of Acacia foliage. However, according to Ben Salem *et al.* (2005) voluntary intake of dried *Acacia cyanophylla* foliage by growing or adult sheep did not differ from fresh Acacia foliage.

Makkar (2003) reported that fresh *C. calothyrsus* was more rapidly digested than wilted, dried or freeze-dried material and the authors recommended the use of fresh forages for their maximum utilization. Therefore, the efficacy of wilting

and drying treatments in reversing the deleterious effects of tannins warrants further investigation.

The improvement in palatability of the leaves of browse species after leaf shedding was explained by Powell and Grabber (2009), who stated that leaves that might be toxic or unpalatable in their living state could be less so after shedding, as adverse secondary metabolites might have translocated from the leaf

2.7.2 Use of polyethylene glycol (PEG)

The incorporation of PEG had beneficial effects for feedstuffs such as *Quercus calliprinos*, *Pistacia lentiscus*, *Ceratonia siliqua* (Silanikove *et al.,* 1997), *Zizyphus nummularia* (Kumar and Vaithiyanathan, 1990), *Hedysarum coronarium* (Stienezen *et al.,* 1996), *Acacia aneura* (Eady *et al,* 1990; Pritchard *et al.,* 1992), *Lotus pendunculatus* (Barry *et al.,* 1986; McNabb *et al.,* 1996) and *Desmodium ovalifolium* and *Flamingia macrophylla* (Barahona *et al.,* 1997) which are rich in tannins (condensed tannin content: 5–10%). Inactivation of tannins through PEG increased availability of nutrients and decreased microbial inhibition, which in turn increased degradability of nutrients leading to higher animal performance.

Tannins bind to PEG in preference to protein (Jones and Mangan, 1977), this property has been used for studying the nutritional effects of reducing tannins in temperate legumes (Pritchard et al., 1992). Results with tropical legumes indicate that increased intake and nitrogen retention may be achieved by reducing the concentration of extractable CT with PEG (Carulla, 1994). Kumar and D'Mello (1995) reviewed some of the experiments in which tannin-rich forage *(Lotus pedunculatus)* and browse (*Acacia aneura)* legumes were fed to sheep with polyethylene glycol- 4000 (PEG-4000) supplementation. Increases in live weight gain and wool growth were recorded.

The tannins bind PEG- 4000 in preference to protein, allowing dietary protein to be free for digestion. The use of tannin-complexing compounds like the polyethylene glycol has proved beneficial in some countries (Powell *et al.* 2009; Silanikove *et al.,* 1997; Makkar, 2003). Ferric sulphate and polyethylene glycol (PEG) have been used to complex with mimosine and tannins respectively, with marked improvements on the growth of chicks fed *Leucaena*-based diets (D'Mello , 1992), the author however, pointed out that using PEG- 4000 in practice may not be economic.

2.7.3 Use of Chemicals treatment

The use of alkalis and oxidising agents has the potential for detanninification of leaves. Makkar (2003) observed that extraction with aqueous organic solvents (30% acetone, 50% methanol, and 40% ethanol) removed about 70% tannins from oak leaves. The advantage of using these organic solvents is that these can be recovered for reuse and the tannins can be used for the tanning of leather.

The reduction in tannins in oak leaves using alkalies ranged between 70 and 90%. Extraction with organic solvents (acetone, methanol, ethanol) and treatment with oxidising agents (potassium dichromate, potassium permanganate and alkaline hydrogen peroxide) were very effective and removed/inactivated up to 90% of the tannins in oak leaves (Makkar and Singh, 1993) and up to 99% in agro-industrial and forestry by-products (Makkar and Becker, 1998). .

Ferrous sulphate is known also to form complex with tannins ((Makkar and Singh, 1993) and increase in the degree of polymerization in the treated material could be due to binding of phenolics through ferrous ions. The use of oxidizing agents holds

promise for a large-scale detoxification of tannin-rich feedstuffs because of their low cost. These approaches are very simple, do not require complex equipment and are likely to be adopted by the feed industry in the future both in developing and developed countries. In addition, potassium permanganate is easily available in villages in developing countries (generally used for cleaning water in wells), is non-corrosive and hence farmers can use this chemical at home for detanninification of tannin-rich feedstuffs.

2.7.4 Utility of management

It has been suggested that the deleterious effect of secondary compounds can be overcome by the simple approach of feeding the toxic plant in a mixture with other plants, thus diluting the effective level of each compound. Some studies of the effect of mixtures of temperate (Cassida *et al.*, 1994) and tropical (Brown and Pitman, 1991) grasses and legumes. showed that, in sheep fed freshly cut rye grass, the addition of a third of the diet as *Lotus pedunculatus* (which supplied 1.8% condensed tannin in the total diet) resulted in the digestibility of the protein being significantly decreased from 78% to 65%.

Singh, (1988), reported that the utility of management practices involving lopping/harvesting of tree leaves at times when the concentration of ANFs are lowest can be practiced. It has also been noted that, as leaves mature, both the ANF and nutrient contents decrease (Singh, 1982). Another approach for enhancing the use of fodder legumes is through mixing of fodder with other feed resources such as crop residues. This helps to dilute the overall concentration of tanniniferous compounds in

the diets thereby minimizing their effects. According to Topps (1992), the most practical alternative would be either to dilute the effect of tannins by feeding the legume at low levels in a suitable mixture or to feed two or more rather than one legume species. The other option way may be to harvest the legumes and feed to animals in the stall in a controlled manner.

The concentrations of soluble phenolics and insoluble Proanthocyanidins in browses vary with season, site (Le Houérou, 1980) and individual plant. *Acacia cyanophylla* show an example of regional variation. It has been fed to small ruminants with good results in West Africa (Kumar and Singh, 1984) but in East Africa, it has proved to be a poor feed. This can be exploited by careful selection of time, type and site, when harvesting (lopping/pruning) browse plants for feeding animals.

2.8 *Ficus sycomorus*

2.8.1 Origin and distribution of *F. Sycomorus*

Ficus sycomorus is commonly known as Ibbe in *Fulfulde*, *Baure* in Hausa and *Abvoap* in Bajju Zango Kataf Local Government Area of Kaduna State. *F. sycomorus* is a genus of about 800 species of woody trees, shrubs, vines, epiphytes and hemi-epiphytes in the family M*oracea.* It can be monocious or diecious (Berg and Corner, 2005). The plant grows to 20 m tall and 6m wide with a dense round crown of spreading branches. The leaves are heart-shaped with a round apex, 14 cm long by 10 cm wide. The flowering and fruiting occurs from July - December.

Ficus sycomorus, which has been known as the biblical sycamore fig (Dharani, 2002) is distributed from the African continent in the south (Berg and Corner, 2005) to the Arabian Peninsula (Watcho *et al*., 2009) in riverine forests of arid and semi-arid areas.

In East Africa, this species is distributed widely at altitudes from sea level to 1850 m (Dharani, 2002).

2.8.2 Utilization of *F. Sycomorus*

Ficus fruits are available all year round in Africa fruiting 3-5 times per year (Jokthan *et al.*, 2003). This suggests that *Ficus* could have been a keystone or staple food of early hominids living in semi arid land. It has been found that *F. sycomorus* is the most abundant fruit supplier for frugivorous animals. It is known that chimpanzees use *Ficus* spp. as a fallback and/or food during the period of fruit scarcity (Nkamfamiya *et al*., 2010).

Igbokwe *et al.,* (2009) reported that oral administration of aqueous extract of *Ficus sycomorus* stem bark improved pH of sperm microenvironment and sperm cell production. It was reported that the extract increased sperm cell production and pH of homogenates of testes and epididymes of albino rats. *Ficus sycomorus* stem bark has also been reported to treat infertility involving low sperm counts (Igbokwe *et al*., 2009).

Beside the fruits, nearly every organ of Ficus plant can be utilized. The leaves of most species can be used as fodder for livestock. Due to the high dry weight protein content, leaves are an important source of protein for animals (Ngwa *et al.*, 2000). Leaves of *F. sycomorus* are readily eaten by cattle, sheep, goats and camels. Analysis of the chemical composition on a dry weight bases indicated that the leaves contain 17.24% crude protein and 39.32% carbohydrate (Nkamfamiya *et al*., 2010). They also reported 2.88% oxalate, 4.01% tannin, 1.78% saponin, 1.98% phytate and 3.05% HCN.

Green leafy vegetables constitute an indispensable constituent of human diet in Africa and West Africa in particular. These non-conventional leaf vegetables play an important role in every day cooking especially in the rural areas. In addition, the vegetables supply calories and nutrient to communities where these leaves abound. The seeds and leaves of *ficus* species have been ascribed several medicinal and other desirable properties and young shoots are used as vegetables in soups (Kubmarawa *et al*., 2008; Watcho *et al*., 2009).

The roots are used in the treatment of coughs, gastritis, urinary disorders and haemorhoids. Also the back of the tree is used to treat pains and circumcision wound. The leaves are considered to be abortificient. Fresh new shoots, which are always growing during the dry season, are commonly used in preparing soup especially for women after delivery as it facilitate breast feeding (Nkamfamiya *et al*., 2010).

2.9 Origin and distribution of *Digitaria smutsii*

Digitaria smutsii (D. smutsii) belongs to the family Poaceae and is commonly referred to as digitaria grass or crab grass. It is said to be native to Southern Africa (Hacker *et. al*., 1993). *Digitaria smutsii* is indigenous to Africa and grows well in the dry part of tropical and subtropical climates. The grass was first introduced into Nigeria from South Africa in 1956. *Digitaria* performs well in areas with annual rainfall ranging from 600-1800mm, but best rainfall optimum is 900mm per annum. Well-drained sandy- 1oam soil is preferable for the successful establishment of *D. smutsii*, which is by means of stem cuttings or stolons because no viable seeds are produced. *D. smutsii* is tolerant to acidic or alkaline soils and withstands limited-water logging.

The genus *Digitaria* has world-wide distribution in tropical areas (Hanard 1950). It is found in area characterized by fertile soil, seasonal rainfall and generally high

temperature (Osbourn, 1969). It is easily established, and is vigorous and adaptable. It persists under intensive grazing and is palatable to livestock (Osbourn, 1969). Its stoloniferous habits make vegetative propagation relatively easy in that both stolons and mature stems will produce. The plants cover the ground within 6-8 weeks, even when only 3 plants take root per square yard (Ronney, 1961).

2.9.1 Chemical composition of *Digitaria smutsii*

Digitaria grass comprises of a number of different species (*D. eriantha, D. umfolozi, D. smutsii, D .setivalva, D. peitzii, D. polevansii, D. decumbers* etc.) and they differ in their chemical composition. Minson (1984) attributed such differences to the genetic make-up of the, plant which controls morphological characteristics such as proportion of leaf to stem, and also to different management practices during growth or harvest of the crop.

Minson (1990) reported the dry matter content of six species to range from 56.1 to 70.9 percent, neutral detergent fibre content to range 13 to 34%, hemicelluloses 26.5 to 38.2% DM basis. This is lower than values of hemicelluloses (59.6–66.4%), neutral detergent fibre (43.2 – 54.9%) and cellulose (59.0 – 65.9%) reported by Minson (1984).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the Study

The study was conducted at the Livestock Unit of Department of Animal Science, Ahmadu Bello University, Zaria, Kaduna State. Zaria is located within the Northern Guinea Savanna Zone between latitudes 11^0 12' N and longitudes 7^0 33' E; at an altitude of 610m above sea level (Wikipedia 2013).

3.2 Feed Collection and Processing

Twigs of *Ficus sycomorus* were collected at the Institute for Agricultural Research Farm, Ahmadu Bello University Zaria in the month of November, 2012. The twigs were shade dried for 5 days. Thereafter, the leaves were later separated from the twigs and crushed to allow for easy mixing with the other ingredients in the concentrate feed, which was then bagged in polythene bags (Jimbo® bags) and stored in a room until it was needed for the study. *Digitaria smutsii* hay was obtained from the forage and crop residue Research programme, National Animal Production Research Institute (NAPRI) Shika-Zaria and stored until commencement of the experiment.

3.3 Experiment I: Growth and Digestibility Study

3.3.1 Determination of the chemical composition and mineral content of *Ficus sycomorus* and *Digitaria smutsii*

Representative samples of *Ficus* and *Digitaria* were collected and analysed proximate constituents according to the procedure of AOAC (1990). Cellulose, hemicelluloses, acid detergent fibre and neutral detergent fibre were determined by the method of Van Soest and Robertson (1988). Flame Spectrometer was used to determine the content

of calcium, phosphorus, sodium, iron, magnesium and potassium. Tannin content was analyzed using the method described by Wheeler *et al*. (1994).

3.3.2 Experimental animals and management

Thirty six (36) Yankasa rams with an average live weight of 15.40 kg were used for a growth trial. The animals were purchased from Anchau Livestock market, Kaduna State and quarantined for three weeks. A week to the start of the experiment, the animals were dewormed against internal parasite using Albendazole® 10% suspension and external parasites by dipping in acaricide (Amitics®). They were also administered with Terramycine® long acting antibiotics. The experimental animals were housed individually in the experimental pens with concrete floor.

3.3.3 Experimental treatments, design and feeding of animals

Four iso-nitrogenous supplementary diets containing 0, 5, 10 and 15% *Ficus sycomorus* leaf meal were formulated (Table 3.1). Each inclusion level served as a treatment (T_1, T_2, T_3 and T_4, respectively).

Experimental animals were randomly allotted to the four dietary treatments with nine animals per treatment and three animals per feeding regime and treatment, in a 4x3 factorial arrangement in a completely randomized block design.

Animals were fed the concentrate containing varying levels of *Ficus sycomorus* leaf meal at 2.5 percent of their body weight. The daily feeding of the supplementary diet was offered in single meals (at 008h) in the morning and had consumed the entire supplement, then *Digitaria smutsii* hay and fresh waterwas offered *ad libitum.* The growth trial was carried out for a period of 90 days, daily feed intake (supplement and basal diet), daily water intake; daily faecal output and fortnightly

body weight of all the rams were recorded before feeding in the morning throughout the study.

Table 3.1: Ingredient composition of supplementary diets fed to Yankasa rams.

	Inclusion level of *Ficus sycomorus* leaf meal (%)			
Ingredients	0	5	10	15
Maize offal	64.00	60.10	56.10	51.90
F.sycomorus leaf meal	0	5.00	10.00	15.00
Cotton Seed Cake (CSC)	18.00	16.90	15.90	15.10
Rice bran	15.00	15.00	15.00	15.00
Bone meal	2.00	2.00	2.00	2.00
Salt	1.00	1.00	1.00	1.00
Total	100.00	100,00	100.00	100.00
Calculated analysis (%)				
CP	16.00	16.00	16.01	16.00
CF	21.23	21.73	22.26	22.83

3.3.4 Digestibility and nitrogen balance

The aim of this study was to determine the digestibility of nutrients and nitrogen balance of different diets containing varying levels of ficus, fed at different feeding regimes in the growth study. At the end of the growth study all the animals were transferred to individual metabolism cage measuring 49 x 20.5 m which allowed for separation of faeces from urine (Osuji *et al*., 1993). During the trial, animals were maintained on the same treatment diets and feeding regimes as indicated in the feeding trial.

An adjustment period of 10 days was allowed before a 7 day collection period, during which feed offered, refusals, urine and faeces collected were weighed and recorded at 08.00hours every day.

Urine was collected into plastic container, which contained 25mls of 10% v/v sulphuric acid. Urine collected was bulked and 10% of the total daily urine collected, sub-sampled and kept at -20^{o}C until required for laboratory analysis.Representative of the daily faecal samples were also collected, weighed, bulked and sub-sampled at the end of the collection period and milled and milled with a Christy and Norris mill to pass through 1-mm mesh and stored in air-tight containers for proximate analysis.

3.3.5 Laboratory analysis

Samples of feed offered and faecal output were analysed for dry matter, crude protein, crude fibre, ether extract, ash according to the procedure of (AOAC 1990). Neutral detergent fibre (NDF), acid detergent fibre (ADC) and hemicelluloses were determined by the method of Van Soest and Robertson, (1988). Urine samples were analysed for nitrogen. Tannin content and other antinutritional factors (ANFs) were analysed by the method of Wheeler *et al*. (1994).

3.3.6 Statistical analysis

Analysis of variance was carried out on the data collected on feed intake, weight changes, nutrients digestibility and nitrogen balance using the GLM Procedure of SAS (SAS, 2002). Means that were significant were compared, using Duncan's Multiple Range Test (Duncan, 1955).

The following model was used:

$Y_{ijk} = \mu + A_i + B_j + (AxB) + e_{ijk}$

Where:
μ = overall mean
A_i = effect of inclusion levels (i = 1- 4)
B_j = effect of feeding regimes (j = 1-3)
(AxB) = interaction between feeding regimes and inclusion levels.
e_{ijk} = uncontrollable error associated with feeding and other factors

3.4 Experiment II: Rumen fermentation metabolites

This study was carried out to determine rumen fermentation and blood characteristics of supplementary diets containing 0, 5, 10, and 15% inclusion level of *F. sycomorus* leaf meal; ascertain the influence of treatments and feeding regime on pH, total volatile fatty acids (TVFA) and rumen ammonia nitrogen (NH_3-N).

3.4.1 Experimental Animals and design

Thirty six yearling Yankasa rams were used for this study. The rams were kept in individual pens throughout the period of the study. The rams were randomly allotted to four inclusion levels of *F. sycomorus* leaf meal with nine animals per treatment and three animals per feeding regime per treatment, in a 4x3 factorial arrangement in

a completely randomized block design. The treatments consisted of 0, 5, 10 and 15% inclusion level of *F. sycomorus* leaf meal and *D.smutsii* hay were fed *ad libitum* as a basal diet. Nine rams per treatment were kept in individual pens. The same animals used in the growth trial were used in the rumen study.

3.4.2 Rumen Liquor sampling

At the end of the growth trial, samples of rumen fluid were taken from each of the animals used for the experiment to determine some rumen metabolites. Rumen fluid samples were collected using stomach suction tube at 6, 12, 18 and 24 hours after morning feeding. A digital pH meter was used to determine the rumen fluid pH immediately after collection at the farm. The rumen fluid was filtered through layers of cheese cloth. About 15ml of the rumen fluid were acidified with 10 ml of 10% v/v H_2SO_4 solution, and frozen at -4^{o}C until when required for determination of ammonia nitrogen (Roy Markham, 1942) and total volatile fatty acids (AOAC, 2000).

3.4.3 Statistical analysis

All data collected were subjected to analysis of variance procedure using GLM of SAS (SAS, 2002). Means that were significant were compared, using Duncan Multiple Range test (Duncan, 1955).

CHAPTER FOUR

4.0 RESULTS

4.1 EXPERIMENT I

4.1.1 Chemical composition of experimental feeds

The chemical composition of *Digitaria smutsii* hay and *Ficus sycomorus* leave meal with the supplementary diets are presented in Table 4.1

The crude protein content of *Digitaria smutsii* hay and *Ficus sycomorus* leaf meal was 5.36 and 12.56% respectively. NDF content increased as the level of Ficus inclusion increased from 0 to 15% (34.61 to 38.88%) while the content of ADF also increased from 18.0 to 21.42% in the concentrate supplements.

4.1.2 Antinutritional factors in feeds

The results of the antinutritional factors are presented in Table 4.2. The phytate level of Ficus was 22.54mg/100g, while HCN and Saponin were 43.20 mg/100g and 8.19% respectively. Phytate and oxalate levels increased as the level of ficus leaf meal inclusion in the diet increased from 0 to 15% (52.59 to 69.12mg/100g and 70.40 to 79.20mg/100g, respectively) while tannins level also increased from 0 to 15% ficus inclusion (0.85 to 1.35mg/100g) in the concentrate supplements. The content of condensed tannins in the ficus leaf meal alone was 14.61 mg/100g. The level of saponin increased from 8.26% in 0% inclusion level of ficus leaf meal to 8.96, 9.22, and 9.84%, respectively in supplementary diets of 5, 10 and 15% level of ficus inclusion.

Table 4.1. Chemical composition of supplementary diets, *Ficus sycomorus* leaf and *Digitaria smutsii* hay.

Parameters	Inclusion levels of *Ficus sycomorus* leaf meal (%)					
	0	5	10	15	Ficus leaf	Digitaria hay
DM	92.67	93.13	94.88	93.50	89.56	90.04
CP	17.36	16.98	17.04	16.89	12.56	5.36
CF	14.21	12.80	13.11	12.11	18.19	30.05
EE	3.58	2.96	3.29	3.13	4.42	0.54
NFE	61.59	63.13	62.07	64.35	61.61	61.40
Ash	3.26	4.13	4.81	3.38	7.22	2.65
NDF	34.61	37.50	37.73	38.88	63.81	69.23
ADF	18.00	20.75	21.05	21.42	33.94	38.88
Lignin	7.84	8.69	7.01	8.47	17.02	20.40

Table 4.2. Levels of antinutritional factors of supplementary diets and *Ficus sycomorus* leaf

Parameters	Inclusion levels of *Ficus sycomorus* leaf meal (%)				
	0	5	10	15	Ficus leaf
Phytate (mg/100g)	52.59	55.59	60.10	69.12	22.54
Oxalate mg/100g)	70.40	72.60	74.80	79.20	21.20
HCN (mg/100g)	28.60	37.80	37.85	45.90	43.20
Tannin (mg/100g)	0.85	1.00	1.35	1.35	14.61
Saponin (%)	8.26	8.96	9.22	9.84	8.19

4.1.3 Effect of inclusion levels of *F. sycomorus* leaf meal in supplement diets on intake and weight gain of Yankasa rams fed *D. smutsii* hay as basal diet.

The results of feed intake and weight gain are presented in Table 4.3. The result showed a significant ($P<0.05$) decline in the voluntary intake of *D. smutsii* hay (140.40-131.21g/day) as the supplementation level of ficus leaf meal was increased from 0 to 15% inclusion level. In terms of total feed intake, there is a decrease in feed intake as a result of ficus leaf meal supplementation. The results showed a highly significantly ($P<0.05$) total intake at 0% inclusion level. Total feed intake at 5%, 10% and 15% inclusion levels of ficus leaf meal were however, similar.

The results showed an increase in weight of rams fed the experimental diets. Animals fed supplementary diets with 10% level of ficus leaf meal inclusion had significantly higher ($P<0.05$) total body weight gain compared to rams given diets with 0, 5 and 15% ficus leaf meal inclusion. Total body weight gain at 0, 5, and 15% inclusion levels of ficus leaf meal were however, similar. Similarly, animals fed supplementary diet with 10% level of ficus leaf meal inclusion had significantly ($P<0.05$) higher ADG, followed by animals on 15% ficus leaf meal inclusion diet.

Table 4.3. Effect of levels of *F. sycomorus* supplementation on feed intake and weight gain of growing Yankasa rams fed *D. smutsii* hay.

Parameters	*F. sycomorus* inclusion levels (%)				SEM	LOS
	0	5	10	15		
Dry matter intake (g/d)						
Supplement	382.68	380.43	380.09	382.82	2.01	NS
D. smutsii	440.40^{a}	435.27^{b}	433.41^{bc}	431.21^{c}	1.20	*
Total intake	823.08^{a}	815.70^{b}	813.50^{b}	813.03^{b}	2.98	*
Initial weight(kg)	15.39	15.33	15.40	15.44	0.21	NS
Final weight(kg)	17.56^{b}	17.49^{b}	18.94^{a}	18.01^{b}	0.44	*
Total weight gain(kg)	2.17^{b}	2.16^{b}	3.54^{a}	2.57^{b}	0.35	*
ADG(g)	24.38^{c}	24.27^{c}	39.78^{a}	28.88^{b}	2.01	*

^{abc} Mean values with different superscripts within a row differ significantly *significant at 0.05; ADG: average daily gain;

LOS= level of significant; NS= Not significant

4.1.4 Effect of feeding regime on feed intake and weight gain of Yankasa rams fed supplement containing *F. sycomorus* leaf meal

Table 4.4 shows the effect of feeding regime on feed intake and weight gain of Yankasa rams fed *D. smutsii* hay supplemented with concentrate containing *F. sycomorus.* The result showed a significant decline ($P<0.05$) in supplement intake as the feeding regime was changed from daily feeding (385.27 g/day) to skip-2-days feeding (367.08 g/day). The voluntary intake of Digitaria hay however, significantly ($P<0.05$) increased from 420.88 to 494.40 g/day as the feeding of the supplement was reduced from daily to skip-2-days.

Total feed intake also increased as a result of the feeding regime, skip-2-days (861.48 g/day) was significantly higher ($P<0.05$) than skip-a-day feeding (835.16 g/day) while daily feeding recorded the least total feed intake (806.15 g/day). Feeding the animals daily, skip-a-day and skip-2-days resulted in weight gain. Animals on skip-a- day supplementation significantly ($P<0.05$) gained 2.82kg, than those on daily and skip-2-days feeding (2.11 and 1.98kg respectively) at the end of the study. The result of the average daily gain (ADG) followed the same pattern with that of total weight gain.

Table 4.4. Effect of feeding regimes on feed intake and weight gain of Yankasa rams fed *D. smutsii* hay supplemented with concentrate containing *F. sycomorus* leaf meal.

Parameters	Feeding regime			SEM	LOS
	Daily feeding	Skip-a-day	Skip-2-days		
Dry matter intake g/d					
Supplement	385.27[a]	379.01[b]	367.08[c]	3.12	*
D. smutsii	420.88[c]	456.15[b]	494.40[a]	10.04	*
Total intake	806.15[c]	835.16[b]	861.48[a]	12.07	*
Initial weight (kg)	15.67	15.25	15.33	0.43	NS
Final weight (kg)	17.78[b]	18.07[a]	17.31[c]	0.11	*
Total weight gain(kg)	2.11[b]	2.82[a]	1.98[b]	0.29	*
ADG (g)	20.01[b]	30.10[a]	20.0[b]	3.42	*

[abc] Mean values with different superscripts within a row differ significantly($P<0.05$). *Significant at 0.05; ADG: average daily gain;

LOS= Level of Significant; NS= Not Significant

4.1.5 The overall effect of inclusion levels of *F. sycomorus* leaf meal in supplement diets and feeding regimes on feed intake and weight gain of Yankasa rams fed a basal diet of *D. smutsii* hay.

The overall effect of feeding regime on feed intake and weight gain of Yankasa rams fed *D. smutsii* hay supplemented with concentrate containing *F. sycomorus* is shown in Table 4.5. The supplement intakes in g/day by the experimented rams were not significantly (P<0.05) influenced by the interaction between the levels of ficus inclusion and feeding regime. Daily feeding of supplement containing 5% inclusion level recorded the highest intake of 400.77 g/day while the least intake of 374.70 g/day from the supplement containing 10% inclusion level was recorded at skip-2-days feeding. Digitaria intake was significantly (P<0.05) affected by the interaction between inclusion level and feeding regime. The interaction at every inclusion level significantly (P<0.05) influenced the intake of Digitaria hay at Skip-2-days feeding regime compared to other feeding regimes. The same pattern of interaction recorded in the intake of Digitaria hay was also observed in the total intake of feed consumed. The final weight, total weight gain and average daily gain (ADG) were significantly (P<0.05) influenced by the interaction between the inclusion levels and feeding regime. The interaction significantly (P<0.05) increased the final weight and total weight gain during skip-a-day feeding in all levels of inclusion.

Table 4.5: Effect of inclusion levels and feeding regimes of *F. sycomorus* leaf meal supplement on feed intake and weight gain of Yankasa rams fed a basal diet of *D. smutsii* hay.

Parameters	*F. sycomorus* inclusion levels/Feeding Regime												SEM
	0%			5%			10%			15%			
	Daily	Skip-a-day	Skip-2-days	Daily	Skip-a-day	Skip-2-days	Daily	Skip-a-day	Skip-2-days	Daily	Skip-a-day	Skip-2-days	
DM intake(g/day)													
Supplement	377.25	382.52	381.75	381.27	382.17	382.67	400.77	378.93	374.70	382.83	375.67	381.97	18.07
Digitaria hay	436.59^{b}	442.42^{b}	473.74^{a}	428.46^{b}	439.56^{b}	483.30^{a}	426.04^{b}	438.02^{b}	478.27^{a}	423.19^{b}	435.82^{b}	464.95^{a}	9.32 *
Total intake	813.84^{b}	824.94^{b}	855.49^{a}	809.73^{bc}	821.73^{b}	865.97^{a}	826.81^{b}	816.95^{b}	856.97^{a}	806.02^{c}	811.49^{b}	846.92^{a}	10.02*
Initial weight(kg)	15.17	15.33	15.67	15.33	15.33	15.33	15.73	15.16	15.00	15.83	15.17	15.33	0.43
Final weight(kg)	17.73^{bc}	18.29^{a}	17.30^{c}	16.70^{cd}	18.44^{a}	16.73^{cd}	18.37^{a}	18.67^{a}	17.97^{b}	17.73^{bc}	18.07^{ab}	16.63^{d}	0.29*
Total wt gain(kg)	2.56^{b}	2.96^{a}	1.63^{c}	1.37^{c}	3.11^{a}	1.40^{c}	2.64^{b}	3.51^{a}	2.97^{a}	1.90^{c}	2.90^{a}	1.30^{c}	0.32*
ADG(g)	28.13^{b}	32.53^{b}	17.91^{cd}	15.05^{d}	34.18^{ab}	15.38^{d}	29.01^{b}	38.57^{a}	32.64^{b}	20.88^{c}	31.87^{b}	14.29^{d}	2.70*

^{abc} Mean values with different superscripts within a row differ significantly (P<0.05) *Significant at 0.05 ADG =Average daily gain

4.1.6 Effect of levels of *F. sycomorus* in supplement diets on nutrient digestibility and nitrogen balance

4.1.6.1 Nutrients digestibility

The results of nutrient digestibility studies are presented in table 4.6. Dry matter digestibility (DMD), organic matter digestibility (OMD) and other nutrients digestibility were significantly ($p<0.05$) affected by inclusion levels of ficus leaf meal. DMD, OMD and crude protein digestibility were highest ($p<0.05$) for animals on 0% level of ficus, while lowest digestibility was observed in animals fed 15% inclusion level of ficus.

NDF digestibility was significantly ($p<0.05$) depressed as the level of ficus supplementation increased. Rams fed diets with 5% and 10% ficus inclusion had NDF digestibility values of 32.17 and 31.78% which were similar but higher ($p<0.05$) than rams offered supplementary diets with 15% level of ficus inclusion, which had NDF digestibility of 29.72%. Acid detergent fibre digestibility followed similar trend as NDF digestibility.

4.1.6.2 Nitrogen Balance

The results of nitrogen balance study are also presented in Table 4.6. Total nitrogen intake was similar among treatment groups. Rams offered supplementary diets with 10% and 15% ficus inclusion level had significantly higher ($p<0.05$) amounts of daily faecal N output (16.43 and 23.05 g/day respectively), than rams on 0% and 5% ficus diets (15.31 and 15.65 g/day respectively). The daily faecal output was however, not significantly ($P<0.05$) different between 0% and 5% inclusion level of ficus leaf meal.

Nitrogen retention was significantly ($P<0.05$) affected by ficus inclusion levels in the experimental diets. The values were significantly ($P<0.05$) higher in rams on 0% and 5% (26.09 and 25.71 g/day respectively) level of ficus supplementation, followed by rams on 10 and 15% inclusion. The nitrogen retention as percent of intake was significantly ($P<0.05$) lower in 15% inclusion levels when compared to 0, 5 and 10% inclusion levels.

Table 4.6. Effect of level of *F. sycomorus* supplementation on nutrient digestibility and nitrogen balance of Yankasa rams fed *D. smutsii* hay

Parameters	Inclusion Levels of *F. sycomorus* leaf meal (%)					
	0	5	10	15	SEM	LOS
Digestibility (%)						
Dry Matter	61.70[a]	57.83[b]	56.14[c]	55.43[c]	0.82	*
Organic	65.08[a]	55.53[b]	52.62[c]	50.80[c]	0.92	*
Crude protein	68.29[a]	60.40[b]	58.74[c]	56.59[d]	0.62	*
NDF	45.45[a]	32.17[b]	31.78[b]	29.72[c]	0.79	*
ADF	47.37[a]	30.03[b]	29.72[b]	27.63[c]	1.15	*
Nitrogen balance (g/day)						
Nitrogen intake	54.38	54.35	53.59	52.26	1.38	
Faecal N	15.31[c]	15.65[c]	16.43[b]	23.05[a]	0.09	*
Urinary N	12.98[a]	12.99[a]	12.12[b]	11.16[b]	0.23	*
N retained	26.09[a]	25.71[a]	25.04[b]	18.05[c]	0.30	*
N retained as % of intake	47.98[a]	47.30[a]	46.73[a]	34.54[b]	1.01	*

[abc] Mean values with different superscripts within a row differ significantly (P<0.05) *Significant at 0.05

NDF= Neutral detergent fibre; ADF= Acid detergent fibre; N= Nitrogen

4.1.7 Effect of feeding regime on nutrient digestibility and nitrogen balance

4.1.7.1 Nutrients digestibility

Table 4.7 shows the effect of feeding regime on nutrient digestibility of Yankasa rams fed *D. smutsii* hay supplemented with concentrate containing *F. sycomorus.* Percent DM, OM and CP digestibility significantly (P<0.05) decreased in the skip-a-day and skip-2-days feeding regime when compared to the daily feeding regime. A significant (P<0.05) higher percent ADF digestion was reported for skip-a-day and skip-2-days feeding regime (43.65 and 43.34% respectively) than for the lower value (42.90%) observed in daily feeding of the supplement.

4.1.7.2 Nitrogen balance

The result of nitrogen balance study is presented in Table 4.7. Total nitrogen intake was significantly (P<0.05) influenced by feeding regime. Animals on daily feeding of the supplement had the highest nitrogen intake of 55.76 g/day, while those on skip-2-days feeding of the supplement recorded the least nitrogen intake (50.25 g/day).

Daily urinary N output (g/day) was significantly (P<0.05) higher and similar in rams on daily feeding and skip-a-day feeding of the supplement (11.02 and 10.99 g/day respectively) compared to those on skip-2- days feeding (10.06 g/day) of the supplement containing ficus leaf meal.

Nitrogen retention declined (P<0.05) with decrease in feeding frequency. The retained N in daily feeding and skip-a-day feeding of supplement was similar (23.87 and 24.06 g/day respectively) but significantly higher than that in skip-2-days feeding regime (23.11 g/day). Nitrogen retention as % of intake was lower (P<0.05) in daily feeding of the supplement (42.81%) as compared to 44.97 and 45.99% in skip-a-day and skip-2-days feeding regime respectively.

Table 4.7. Effect of feeding regime on Nutrient digestibility and nitrogen balance of Yankasa rams fed concentrate containing *F. sycomorus* leaf meal

Parameters	Feeding regime			SEM	LOS
	Daily	Skip-a-day	Skip-2-days		
Digestibility (%)					
Dry Matter	67.80[a]	64.98[b]	63.26[b]	0.98	*
Organic matter	63.05[a]	60.76[b]	59.01[b]	1.02	*
Crude Protein	62.23[a]	61.31[b]	60.85[b]	0.44	*
NDF	46.68	46.50	45.32	1.43	NS
ADF	42.90[b]	43.65[a]	43.34[a]	0.19	*
Nitrogen balance (g/day)					
Nitrogen intake	55.76[a]	53.50[b]	50.25[c]	0.98	*
Faecal N	20.87[a]	18.45[b]	17.08[c]	0.46	*
Urinary N	11.02[a]	10.99[a]	10.06[b]	0.26	*
N retained	23.87[a]	24.06[a]	23.11[b]	0.24	*
N retained as % of intake	42.81[b]	44.97[a]	45.99[a]	0.49	*

[abc] Mean values with different superscripts within a row differ significantly P<,0.05) *Significant at 0.05

NDF= Neutral detergent fibre; ADF= Acid detergent fibre; N= Nitrogen; NS Not significant

4.1.8 The overall effect of inclusion level and feeding regime on nutrient digestibility and nitrogen balance

The overall effect of inclusion level and feeding regime on nutrient digestibility of Yankasa rams in the experimental diets is shown in Table 4.8. The DMD, OMD and CP digestibility were significantly ($P<0.05$) affected by level of inclusion and feeding regime. Daily feeding at 10 and 15% inclusion levels of *F. sycomorus* had significantly ($P< 0.05$) higher DMD (65.12 and 65.99%, respectively) compared to 0% and 5% (63.54 and 63.23% respectively). The interaction between supplement containing 10% inclusion levels with feeding regime recorded the highest CP digestibility of 57.33% while the least digestibility of 53.00% of supplement containing 15% inclusion level was recorded at skip-2-days feeding.

There was a significantly ($P<0.05$) interaction between inclusion level and feeding regime. The interaction significantly ($P<0.05$) influenced Nitrogen intake at all inclusion levels (0, 5, 10 and 15%), with daily feeding across treatment diets recording the highest values of N intake (55.78, 55.32, 55.18 and 55.00g/day respectively) while skip-2-days had the least (50.99, 50.44, 50.06 and 49.28 g/day respectively). This interaction ($P<0.05$) also influenced N retained and N retained as % of intake. The highest values were observed on skip-a-day feeding at 10% level of inclusion.

Table 4.8: Overall effect of inclusion level and feeding regime on nutrient digestibility and nitrogen balance of Yankasa rams fed concentrate containing *F. sycomorus* leaf meal and *D. smutsii* hay as basal diet

Parameters	*F. sycomorus* inclusion levels/Feeding Regime													
	0%			5%			10%			15%				
	Daily	Skip-a-day	Skip-2-days	Daily	Skip-a-day	Skip-2-days	Daily	Skip-a-day	Skip-2-days	Daily	Skip-a-day	Skip-2-days	SEM	LOS
Digestibility (%)														
Dry Matter	63.54^{b}	62.57^{b}	62.21^{b}	64.68^{ab}	63.23^{b}	62.45^{b}	65.12^{a}	63.30^{b}	64.11^{ab}	65.99^{a}	64.01^{ab}	64.98^{ab}	0.68	*
Organic Matter	62.00^{b}	64.23^{ab}	63.46^{b}	62.98^{b}	64.89^{ab}	63.32^{b}	63.01^{b}	65.43^{a}	63.29^{b}	63.47^{b}	64.99^{ab}	63.25^{b}	0.80	*
Crude Protein	56.23^{b}	55.67^{b}	53.55^{cd}	55.98^{b}	56.34^{b}	53.23^{cd}	54.21^{c}	57.33^{a}	53.33^{cd}	54.03^{c}	56.20^{b}	53.00^{d}	0.45	*
NDF	45.29	44.11	43.22	45.26	44.21	43.98	45.19	44.34	44.21	45.00	44.32	44.88	1.12	NS
ADF	42.43	43.87	44.02	42.08	43.66	43.32	41.88	43.41	42.67	41.37	43.18	41.87	1.42	NS
Nitrogen Balance (g/day)														
Nitrogen Intake	55.78^{a}	53.22^{b}	50.99^{c}	55.32^{a}	53.87^{b}	50.44^{c}	55.18^{a}	53.86^{b}	50.06^{c}	55.00^{a}	53.15^{b}	49.28^{c}	0.52	*
Faecal N	19.89^{a}	17.97^{b}	17.16^{b}	20.08^{a}	17.56^{b}	16.76^{bc}	20.57^{a}	17.25^{b}	16.49^{bc}	20.90^{a}	17.24^{b}	15.86^{c}	0.90	*
Urinary N	10.03	10.00	10.91	10.54	10.44	10.89	11.31	10.01	10.42	11.63	11.06	10.08	0.97	*
N retained	25.86^{b}	25.25^{bc}	22.92^{cd}	24.70^{c}	25.87^{b}	22.79^{cd}	23.30^{c}	26.60^{a}	23.15^{c}	22.47^{d}	24.85^{c}	23.34^{c}	0.31	*
N retained as % of intake	46.36^{b}	47.44^{b}	44.95^{c}	44.65^{c}	48.02^{b}	45.18^{bc}	42.23^{d}	49.39^{a}	46.24^{b}	40.85^{e}	46.75^{b}	47.36^{b}	0.62	*

^{abc} Mean values with different superscripts within a row differ significantly (P<0.05) *significant at 0.05 NDF= Neutral detergent fibre; ADF= Acid detergent fibre; N= Nitrogen; SEM =Standard Error of Mean; Level of Significant

4.1.9 Economic analysis of inclusion level of *F. sycomorus* in the supplement fed to Yankasa rams.

Table 4.9 shows the results of economic assessment of inclusion levels of *F. sycomorus* leaf meal in the diet of Yankasa rams. The result indicated that cost per kg of feed significantly (P<0.05) differ across inclusion levels with 0% inclusion recording the highest value (₦61.39/kg), while 15% inclusion was lowest (₦54.01/kg). Total feed consumed by rams during the feeding trial was higher in 0% inclusion (74.08kg) compared to other inclusion levels.

Cost of feeding the rams indicated a significant (P<0.05) decline as the inclusion level of *F. sycomorus* increased from 0% inclusion (₦505.31/ram) to 15% inclusion level (₦439.10/ram). Live weight gain was significantly (P<0.05) higher in rams fed 10% inclusion level of *F. sycomorus* (3.54kg) as compared to other inclusion levels. The result further indicated that the cost of feed per kg gain (₦/kg) was significantly (P<0.05) better in 10% inclusion level of *F. sycomorus* as compared to other inclusion levels. However, the cost of feed per kg gain was significantly (P<0.05) similar in 0% and 5% inclusion levels of *F. sycomorus* supplementation.

Table 4.9: Cost analysis of inclusion levels of *F. sycomorus* supplementation of Yankasa rams fed *D. Smutsii* hay as a basal diet

Parameter	Inclusion levels of *F. sycomorus* leaf meal (%)				SEM	LOS
	0	5	10	15		
Cost/kg feed(₦)	61.39[a]	58.84[b]	56.34[c]	54.01[d]	1.01	*
Total feed consumed (kg)	74.08[a]	73.41[b]	73.22[b]	73.17[b]	0.27	*
Cost of feeding(₦ /ram)	505.31[a]	479.94[b]	458.36[c]	439.10[d]	9.46	*
Live weight gain (kg)	2.17[b]	2.16[b]	3.54[a]	2.57[b]	0.35	*
Cost of feed/kg gain(₦/kg)	232.86[c]	222.19[c]	129.48[a]	170.86[b]	10.23	*

[abcd] Mean values with different superscripts within a row differ significantly, LOS = Level of Significance. NS = Not significant; SEM= Standard Error of Means, * = P<0.05. Cost/kg feed = a, Total feed consumed = b, Cost of feed = c = (a*b), Live weight gain = d, Cost of feed/kg gain = e = (c/d).

4.1.10 Cost analysis of inclusion levels of *F. sycomorus* in supplement diets on feeding frequency

The result of cost analysis on feeding regime of Yankasa rams fed supplement containing *F. sycomorus* leaf meal is shown in Table 4.10. The result shows a significant decline in cost per kg feed as the feeding regime changes from daily feeding (₦62.21/kg feed) to skip-2-days supplementation (₦52.11/kg feed). However, the total feed consumed significantly (P>0.05) increased from 72.55 to 77.53kg as the feeding of the supplement reduces from daily to skip-2-days.

Feeding frequency significantly (P<0.05) affected the cost of feeding the rams. The animals on daily supplementation had a higher cost of feed (₦376.11/ram) than those on skip-a-day (₦359.70/ram) and skip-2-days (₦336.67/ram). The feed cost tends to decrease with decreased in feeding frequency.

A significant difference (P<0.05) in cost of feed per kg gain across the feeding regime was observed in this study. Skip-a-day supplementation was better in cost of feed per kg gain (₦127.55/kg gain) as compared to other feeding regimes. Daily supplementation of *F. sycomorus* had the highest cost of feed per kg gain (₦178.25/kg gain).

Table 4.10: Cost analysis of supplementation of *F. sycomorus* on feeding frequency

Parameter	Feeding Regimes			SEM	LOS
	Daily	Skip-a-day	Skip-2-days		
Cost/kg feed(₦)	62.21[a]	57.43[b]	52.11[c]	1.98	*
Total feed consumed (kg)	72.55[c]	75.16[b]	77.53[a]	1.09	*
Cost of feeding(₦ /ram)	376.11[a]	359.70[b]	336.67[c]	5.67	*
Live weight gain (kg)	2.11[b]	2.82[a]	1.98[b]	0.29	*
Cost of feed/kg gain(₦/kg)	178.25[c]	127.55[a]	170.04[b]	3.02	*

[abcd] Mean values with different superscripts within a row differ significantly, LOS = Level of Significance.

SEM= Standard Error of Means, * = P<0.05. Cost/kg feed = a, Total feed consumed = b, Cost of feed = c = (a*b), Live weight gain = d, Cost of feed/kg gain = e = (c/d).

4.2 EXPERIMENT II

4.2.1. Effects of inclusion levels of *F. sycomorus* in supplement diets on mean rumen fluid variables in Yankasa rams fed *D. smutsii* hay

Results of the effect of level of *F. sycomorus* supplementation on mean rumen fluid variables in Yankasa rams fed *D. smutsii* hay is presented in Table 4.11. The pH significantly ($P<0.05$) differ among treatment diets with 0% inclusion level having the lowest (6.49) and 10% inclusion recording the highest pH value (6.88). The pH obtained in 5% and 15% inclusion level was similar but significantly higher than that of 0% inclusion level.

The mean values for TVFA across treatments showed that 0% inclusion had the least (11.42 mm/l) TVFA concentration, which was significantly ($P<0.05$) lower than other inclusion levels. Rams fed 10% and 15% diets had comparable TVFA (14.16 mm/l and 13.47 mm/l respectively) concentration, but were significantly ($P<0.05$) higher than 0% inclusion level (11.42 mm/l). The result showed increase in the TVFA concentration, as the inclusion level of *F. sycomorus* supplementation increased from 0% to 10% inclusion level.

The effect of inclusion level of *F. sycomorus* on mean NH_3-N is also presented on Table 4.11. Ammonia nitrogen concentration was least (30.95) in the 0% inclusion level. The result showed a non significant ($P>0.05$) increase in NH_3-N concentration with increased in inclusion level of *F. sycomorus*.

Table 4.11: Effect of level of inclusion of *F. sycomorus* supplementation on mean rumen fluid variables in Yankasa rams fed *D. smutsii* hay as a basal diet.

	F. sycomorus inclusion levels (%)					
Rumen Variables	0	5	10	15	SEM	LOS
pH	6.49[c]	6.61[b]	6.88[a]	6.65[b]	0.02	*
TVFA (mm/100ml)	11.42[c]	12.75[b]	14.16[a]	13.47[a]	0.35	*
NH3-N (mg/l)	30.95	31.79	35.75	36.64	2.90	NS

[a,b,c] Means within row with different superscript are significantly different; LOS = Level of Significance. NS = Not significant; SEM= Standard Error of Means * = P<0.05

4.2.2. Effect of feeding regime on mean rumen fluid variables in Yankasa rams fed concentrate containing *F. sycomorus* and a basal diet of *D. smutsii* hay

The effect of feeding regime on mean rumen fluid variables of Yankasa rams fed supplement containing *F. sycomorus* is shown in Table 4.12. The feeding regime had significant ($P< 0.05$) effect on rumen pH, TVFA and NH_3-N. Total VFA and NH_3-N significantly ($P<0.05$) increase with increased in feeding frequency up to skip-a-day feeding regime. Rumen pH, TVFA and NH_3-N values (6.82, 14.04mm/100ml and 32.60mg/l respectively) recorded on skip-a-day feeding of the supplement were significantly ($P<0.05$) higher than other feeding regimes. The skip-2-days feeding frequency resulted in less stable rumen metabolites.

Table 4.12: Effect of feeding regime on mean rumen fluid variables in Yankasa rams fed supplement containing *F. sycomorus*

	Feeding regime				
Parameters	Daily	Skip-a-day	Skip-2-days	SEM	LOS
pH	6.50[c]	6.82[a]	6.64[b]	0.06	*
TVFA mm/100ml	12.60[b]	14.04[a]	12.27[b]	0.51	*
NH_3-N mg/l	31.68[b]	32.60[a]	30.24[c]	0.21	*

[a,b,c] Means within row with different superscript are significantly different; LOS = Level of Significance. NS = Not significant; SEM= Standard Error of Means; * = P<0.05

4.2.3. Effect of sampling time on mean rumen fluid variables in Yankasa rams fed concentrate containing graded levels of *F. sycomorus.*

The result of the effect of sampling time on mean rumen fluid variables in Yankasa rams fed concentrate containing *F. sycomorus* is presented in Table 4.13. Sampling time significantly ($P<0.05$) influence rumen pH and NH_3-N concentration, but not total volatile fatty acids. The rumen pH at 18 and 24 hours post feeding (6.92 and 6.93 respectively) were significantly ($P<0.05$) higher than the values obtained at 6 and 12 hours post feeding (6.54 and 6.64 respectively), Rumen NH_3-N concentration at 6 and 24 hours (29.17 and 29.02 mg/l respectively) post feeding were significantly ($P<0.05$) lower compared to the result obtained at 12 and 18 hours (32.73 mg/l) post feeding. The effect of sampling time on total volatile fatty acids and NH_3-N concentration showed a similar pattern, where their concentrations increase from 6 hours post feeding to 18 hours post feeding and declined at 24 hours post feeding.

The effect of sampling time on total volatile fatty acids and NH_3-N concentration showed a similar pattern, it revealed an increase in the concentration of TVFA and NH_3-N as the sampling time increased from 6 hours post feeding up to 18 hours thereafter, there was a decline.

Table 4.13: Effect of sampling time on mean rumen fluid variables in Yankasa rams fed concentrate containing *F. sycomorus* and a basal diet of *D. smutsii*

	Sampling Time post feeding (Hours					
Rumen Variables	6	12	18	24	SEM	LOS
pH	6.54[b]	6.64[b]	6.92[a]	6.93[a]	0.18	*
TVFA (mm/100ml)	13.03	13.31	13.38	12.28	0.59	NS
NH3-N (mg/l)	29.17[c]	31.73[b]	32.94[a]	29.02[c]	0.32	*

[a,b,c] Means within row with different superscript are significantly different; LOS = Level of Significance. NS = Not significant; SEM= Standard Error of Means * = P<0.05

4.2.4. Overall effect of *F. sycomorus* inclusion levels in supplement diets and feeding regime on rumen metabolites in Yankasa rams supplemented with

The overall effect of inclusion level and feeding regime on rumen metabolites of Yankasa rams supplemented with concentrate containing *F. sycomorus* is shown in Table 4.14. The rumen fluid variables were not significantly (P>0.05) influenced by the interaction between the inclusion level and feeding regime. There was no significant interaction between levels of supplementation and feeding frequency on rumen pH, but there was a numerical rise in the pH at all feeding regimes as the level of inclusion increased up to 10% inclusion. The concentration of TVFA and NH_3-N was not significantly (P>0.05) influenced by the interaction between inclusion levels and feeding regime, although there was a similar pattern where the concentrations decrease as the feeding regime changed from daily to skip-2-days feeding across inclusion levels.

Table 4.14. Overall effect of inclusion level and feeding regime on rumen metabolites of Yankasa rams supplemented with *F. sycomorus* leaf meal

Rumen metabolites	*F. sycomorus* inclusion levels(%)/Feeding regime													
	0			5			10			15			SEM	LOS
	Daily	Skip-a-Day	Skip-2-days	Daily	Skip-a-Day	Skip-2-days	Daily	Skip-a-Day	Skip-2-days	Daily	Skip-a-Day	Skip-2-days		
pH	6.42	6.75	6.77	6.40	6.83	6.78	6.45	6.89	6.79	6.44	6.87	6.76	0.38	NS
TVFA(mm/100ml)	13.92	13.33	11.00	15.42	14.00	11.00	12.33	11.25	10.67	14.50	14.17	14.08	0.98	NS
NH_3-N (mg/l)	25.44	23.03	20.08	36.61	35.74	34.91	32.89	31.74	30.73	35.47	32.29	29.15	0.99	NS

LOS = Level of Significance. NS = Not significant SEM= Standard Error of Means * = P<0.05

4.2.5. Effect of inclusion level of *F. sycomorus* leaf meal in supplement diets and sampling time on rumen variables

4.2.5.1. Rumen pH

The result of the effect of inclusion levels of *F. sycomorus* supplementation and sampling time on rumen pH of rams is presented in Table 4.15. The rumen pH at 6 hours post feeding was significantly ($p<0.05$) higher in 10% inclusion (6.93) than in 5% inclusion level (6.46), while those in 0% (6.70) and 15% inclusion (6.66) were similar. At 12 hours post feeding *F. sycomorus* supplementation had a significant ($p<0.05$) effect on pH across inclusion levels with 10% and 15% inclusion (6.94 and 6.94 respectively) being the highest while 5% inclusion recorded the lowest values (6.41). There was a significant ($p<0.05$) rise in pH at 24 hours post feeding as the level of *F. sycomorus* in the diet increases to 15% inclusion level.

Table 4.15: Effect of level of *F. sycomorus* leaf meal in supplement diets and sampling time on rumen fluid pH of Yankasa rams fed a basal diet of *D. smutsii* hay

	F. sycomorus inclusion levels(%)/ Rumen pH					
Sampling time (hours)	0	5	10	15	SEM	LOS
6	6.70^{ab}	6.46^{b}	6.93^{a}	6.66^{ab}	0.28	*
12	6.47^{b}	6.41^{b}	6.94^{a}	6.94^{a}	0.21	*
18	6.98	6.35	6.99	6.95	0.47	NS
24	6.73^{b}	6.90^{ab}	6.93^{ab}	6.98^{a}	0.06	*

^{a,b} Means within row with different superscript are significantly different; LOS = Level of Significance. NS = Not significant; SEM= Standard Error of Means * = P<0.05

4.2.5.2 Total volatile fatty acid production

Table 4.16 shows the effect of *F. sycomorus* supplementation on total volatile fatty acids (TVFA) concentration in the rumen of rams. There was significant ($p<0.05$) difference in total volatile fatty acids across inclusion levels at 12 and18 hours post feeding. At 12 hours post feeding 5% (17.07 mm/100ml) and 10% inclusion (17.85 mm/100ml) were similar and significantly ($P<0.05$) higher in concentration of TVFA than 0% (13.89 mm/100ml) and 15% inclusion (15.22 mm/100ml). At 18 hours post feeding, 10% inclusion level (17.98 mm/100ml) was significantly ($P<0.05$) higher in concentration of TVFA than other inclusion levels which were significantly ($P<0.05$) similar. There was a general increase in TVFA production at 12 hours post feeding where TVFA production peaked at 10% inclusion level with a value of 17.85 mm/100ml and then decline. This is similar to the TVFA produced at 18 hours sampling time post feeding, 10% inclusion had the highest TVFA concentration.

Table 4.16: Effect of level of *F. sycomorus* supplementation and sampling time on total volatile fatty acids of Yankasa rams fed a basal diet of *D. smutsii* hay

	F. sycomorus inclusion levels(%)/TVFA (mm/100ml)					
Sampling time (hours)	0	5	10	15	SEM	LOS
6	13.14	14.00	14.43	14.56	0.92	NS
12	13.89[b]	17.07[a]	17.85[a]	15.22[b]	0.92	*
18	13.89[b]	14.47[b]	17.98[a]	14.00[b]	1.13	*
24	13.13	13.11	11.00	13.22	0.56	NS

[a,b] Means within row with different superscript are significantly different; LOS = Level of Significance. NS = Not significant; SEM= Standard Error of Means * = P<0.05

4.2.5.3. Ammonia nitrogen (NH_3-N)

Table 4.17 shows the effect of level of *F. sycomorus* supplementation and time of sampling on rumen ammonia nitrogen (NH_3-N) concentration in rumen fluid of rams fed *D. smutsii* hay. There was no significant (P>0.05) difference in ammonia nitrogen concentration across inclusion levels at 6 hours post feeding, but NH_3-N concentration increase numerically with increased in inclusion level of *F. sycomorus* from 16.50 mg/l in 0% inclusion to 36.28 mg/l in 15% inclusion level of *F. sycomorus*. There was a significant (p<0.05) variation in NH_3-N at 12, 18 and 24 hours post feeding. Ammonia nitrogen concentration values were significantly higher in 10% (36.74 mg/l) and 15% inclusion (35.15 mg/l) than 0% (16.80 mg/l) and 5% inclusion level (21.84 mg/l) at 12 hours post feeding time of sampling. At 18 hours post feeding, 10% and 15% inclusion levels (39.03 mg/l and 36.26 mg/l respectively) were significantly (P<0.05) higher in NH_3-N concentration than 0% (16.98 mg/l) and 5% inclusion levels (22.04 mg/l). Inclusion level of *F. sycomorus* significantly (P<0.05) affected NH_3-N concentration at 24 hours post feeding sampling time with 10% inclusion level recording the highest value of 34.12 mg/l and 0% inclusion the lowest value (23.88 mg/l). The highest concentration level of NH_3-N at 12, 18 and 24 hours post feeding was obtained in 10% inclusion level (36.74, 39.03 and 34.12 mg/l respectively). The result indicated a significantly (p<0.05) increase with increased at 12, 18 and 24 hours post feeding in inclusion level of *F. sycomorus* up to 10% inclusion level thereafter declines at 15% inclusion especially at 24hours sampling time.

Rumen ammonia nitrogen is a measure of the extent of rumen microbial protein degradation. The result indicated a significantly (p<0.05) increase with increased in inclusion level of *F. sycomorus* up to 10% inclusion level thereafter declines. The least values of NH_3-N were obtained in the control diet and at 6 hours sampling time post

feeding. In this study, the highest concentration of rumen NH_3-N observed at 18 hours post feeding indicated that there was high degradation of the experimental diet, which is an indication of high degradability of nitrogen in the rumen.

Table 4.17: Effect of level of *F. sycomorus* leaf meal in supplement diets and sampling time on rumen ammonia nitrogen of Yankasa rams fed a basal diet of *D. smutsii* hay

	F. sycomorus inclusion levels(%)/NH_3-N (mg/l)					
Sampling time hours)	0	5	10	15	SEM	LOS
6	16.50	23.30	34.20	36.28	4.66	NS
12	16.80[b]	21.84[b]	36.74[a]	35.15[a]	5.11	*
18	16.98[b]	22.04[b]	39.03[a]	36.26[a]	5.37	*
24	23.88[c]	33.01[a]	34.12[a]	28.37[b]	2.68	*

[a,b,c] Means within row with different superscript are significantly different; LOS = Level of Significance. NS = Not significant; SEM= Standard Error of Means * = P<0.05

4.2.6. Effect of feeding regime and sampling time on rumen variables

The effect of feeding regime and sampling time on rumen pH of Yankasa rams fed a basal diet of *D. smutsii* hay is shown in Table 4.18. The result showed a significant ($p<0.05$) difference in rumen pH at 6, 12 and 24 hours post feeding across the different feeding regime. At 6 hours post feeding, the rumen pH significantly ($p<0.05$) decrease as feeding regime changes from daily (6.93) to skip-2-days feeding (6.45). Daily feeding (6.70) and skip-2-days feeding (6.62) significantly ($P<0.05$) differ with skip-a-day feeding (6.41) in rumen pH at 12 hours post feeding sampling time. At 18 hours post feeding sampling time, feeding regime did not showed any significant ($P>0.05$) effect on the rumen pH, but there was a numerical decrease on the pH of the rumen from 7.04 in daily feeding to 6.54 in skip-2-days feeding regime. The rumen pH at 24 hours post feeding was significantly ($P<0.05$) higher at daily feeding (6.96) and skip-2-days feeding (6.95) than in skip-a-day feeding (6.75).

The rumen pH values observed in this study were significantly ($P<0.05$) affected by feeding regime. The daily feeding recorded the highest pH values while the skip-a-day feeding recorded the lowest pH at all sampling time. The rumen pH at 12 and 24 hours post feeding showed a similar pattern; where daily feeding and skip-2-days feeding regimes were significantly ($P<0.05$) higher than skip-a-day feeding.

The effect of feeding regime and sampling time on total volatile fatty acids concentration of Yankasa rams fed supplement containing levels of *F. sycomorus* and a basal diet of *D. smutsii* hay is shown on Table 4.19. Feeding regime had a significant ($P<0.05$) influence on TVFA concentration at 12 and 18 hours post feeding. Rams on skip-a-day feeding of supplement had higher values of 13.80, 19.43, 18.36 and 12.90 mg/100ml at 6, 12, 18 and 24 hours post feeding respectively. The lowest TVFA of 10.92 were observed at 18 hours post feeding. Feeding regime

significantly ($P<0.05$) affected the total volatile fatty acids concentration at 12 and 18 hours post feeding.

The Effect of feeding regime and sampling time on NH_3-N in Yankasa rams fed supplement containing *F. sycomorus* leaf meal is shown on Table 4.20. Feeding regime did not significantly ($p>0.05$) affect the concentration of NH_3-N at the various sampling time. However, NH_3-N concentration at 6, 18 and 24 hours post feeding increase from daily feeding to skip-a-day feeding and then decline at skip-2-days feeding regime.

Table 4.18: Effect of feeding regime of *F. sycomorus* supplementation and sampling time on rumen fluid pH of Yankasa rams fed a basal diet of *D. smutsii* hay

	Feeding regime/Rumen pH				
Sampling time hours)	Daily	Skip-a-day	Skip-2-days	SEM	LOS
6	6.93[a]	6.35[b]	6.45[b]	0.18	*
12	6.70[a]	6.41[b]	6.62[a]	0.07	*
18	7.04	6.61	6.54	0.27	NS
24	6.96[a]	6.75[b]	6.95[a]	0.06	*

[a,b] Means within row with different superscript are significantly different; LOS = Level of Significance. NS=Not significant; SEM= Standard Error of Means; * = P<0.05

Table 4.19: Effect of feeding regime of *F. sycomorus* supplementation and sampling time on total volatile fatty acids of Yankasa rams fed a basal diet of *D. smutsii* hay

	Feeding regime/TVFA(mm/100ml)				
Sampling time hours)	Daily	Skip-a-day	Skip-2-days	SEM	LOS
6	13.30	13.80	12.58	0.36	NS
12	16.25^{ab}	19.43^{a}	12.58^{b}	1.98	*
18	15.54^{ab}	18.36^{a}	10.92^{b}	2.17	*
24	12.30	12.90	13.00	0.22	NS

^{a,b} Means within row with different superscript are significantly different; LOS = Level of Significance. NS=Not significant; SEM= Standard Error of Means; * = P<0.05

Table 4.20: Effect of feeding regime of *F. sycomorus* supplementation sampling time on rumen fluid ammonia nitrogen Yankasa rams fed a basal diet of *D. smutsii* hay

	Feeding regime/NH_3-N(mg/l)				
Sampling time hours)	Daily	Skip-a-day	Skip-2-days	SEM	LOS
6	26.50	27.75	25.70	0.60	NS
12	27.24	27.59	30.17	0.92	NS
18	29.29	30.29	29.43	0.31	NS
24	28.08	29.37	28.75	0.99	NS

LOS = Level of Significance. NS=Not significant; SEM= Standard Error of Means

CHAPTER FIVE

5.0 DISCUSSION

5.1 Experiment 1

5.1.1 Chemical composition

The chemical composition of *Digitaria smutsii* offered as basal diet was comparable to values earlier reported (Meissner and Paulsmeier, 1995). The nutrient levels of *F. sycomorus* in this study were comparable to those reported by Abdu *et al.,* (2012). However, CP content of 12.56% obtained in this study is lower than the 14.90% reported by Njidda (2010) and 11.38% reported by Abdu *et al,* (2012). The difference observed from the present study may be due to stage of plant growth and/or season of collection (Ben Salem *et al*., 2005), site of sampling (Makkar and Becker, 1998), and/or proportions of foliage materials sampled (Ben Salem, 2005).

The concentration of NDF and ADF increased with increasing levels of ficus in the diets. This could be attributed to the high cell wall constituents usually present in leaf meals (Anbarasu *et al.,* 2004).

5.1.2 Voluntary feed intake

5.1.2.1 Effect of inclusion level on voluntary intake

DM intake decrease as the level of ficus increased in the diets. This is in contrast to the work of Richard *et al.* (1994) who reported an increase in feed intake when crop residues with poor nitrogen levels were supplemented with legume forages. Brown and Pitman (1991) however, stated that in some cases the use of legume supplement at between 10-20% increased animal performance without significant increase in

intake. The significantly lower total DM intake observed in this study could be as a result of the increased content of some of the anti nutritional factors with increased level of *F. sycomorus* in the experimental diets. These anti nutritional factors have been reported to depress voluntary feed intake (D'mello, 1992, Meissner and Paulsmeier, 1995) as a result of their astringent reaction in the mouth, which reduces palatability (Sodeinde *et al*., 2007).

5.1.2.2 Effect of feeding regime on voluntary intake

Feeding frequency significantly affected voluntary intake of dry matter. Both the supplement and Digitaria hay consumed were affected by feeding regime. The significant effect of feeding frequency on DM intake in the present study was in accordance with the expected changes in ruminal fermentation, where differences in total VFA concentration were observed. This result agree with results presented by Soto-Navarro *et al.,* (2000), who reported that reducing the frequency of feeding cause alteration in ruminal VFA concentration compared to daily feeding, hence affecting DM intake. The result of this study did not agree with Robbles *et al.,* (2007) who reported that reducing feeding frequency in cattle fed barley straw supplemented with concentrate did not affect DM intake positively.

5.1.2.3 The overall effect of inclusion level and feeding regime interaction on voluntary intake

There was a significant interaction between inclusion level and feeding regime on total intake. The increase in total feed intake as influenced by feeding frequency observed in the present study agrees with the findings of Robbles *et al.*, (2007), who

also reported an increase in DM intake of steers as a result of the interaction between inclusion level and feeding frequency.

5.1.3 Weight gain

5.1.3.1 Effect of inclusion level on weight gain of animals

Generally, the result showed low weight gains of the rams supplemented with concentrate containing varying levels of ficus. Similar results have been reported by several authors on different forage legume supplementations (Sultan *et al*., 2009; Tripathi and Karim, 2010; Njidda and Nasiru, 2010). The authors attributed this to low digestibility due to low mineral and energy content. The lower result observed though significant could be due to possible binding effect of tannins to dietary proteins to inhibit utilization of endogenous protein (Ngwa *et al.,* 2002).

5.1.3.2 Effect of feeding regime on weight gain

Feeding frequency had a major impact on animal performance. The result of the average daily gain (ADG) followed a similar pattern with that of total weight gain. The result obtained in the present study is in agreement with the findings of Schrutz *et al.,* (2007), who reported a greater weight gain and/or average daily gain at skip-a-day feeding of steers fed supplement at three different feeding frequency. In contrast, Goonewardene *et al.,* (1995) reported no differences in average daily weight or feed efficiency of feedlot steers. However, this contrast with a summary of findings compiled by Gibson (1981), where feed efficiency was observed with increased feeding frequency.

5.1.3.3 The overall effect of inclusion level and feeding regime on weight gain

The interaction between inclusion level and feeding regime resulting in improvement in weight of the animals has been observed by Rotger *et al.* (2006). They explained that a change in feed composition and feeding pattern alters the amount of organic matter, nitrogen and their fermentation rate in the rumen, thereby bringing an improvement in weight gain.

5.1.4 Nutrient digestibility

5.1.4.1 Effect of inclusion level on nutrient digestibility

A significant difference in percentage digestibility of DM, OM, NDF and ADF across the inclusion levels was observed in this study. The significant reduction in organic matter digestibility observed in the present study is in accordance with the report of Rotger *et al.* (2006) who stated that a change in feed ingredients alters the amount of OM and N and their fermentation rate in the rumen. With increasing inclusion of ficus, the organic matter, crude protein decreased across treatments. Puppo *et al* (2002) had indicated that increasing contribution of roughage in a ration could lead to a decline in cellulose digestion. The observed decreased in NDF digestibility affirm the assertion that the escape of potentially degradable fibre substrate from the rumen, possibly resulted in a depression in NDF digestibility (Robbles *et al.,* 2007). However, Pereira *et al.* (2007) found no effect of concentrate supplementation on ruminal apparent digestibility of nutrients.

It is well accepted that forage degradation in the rumen is mainly affected by the cell wall content and its degree of lignification. Lignin is indigestible and acts as a barrier limiting the access of microbial enzymes to the structural polysaccharide of the cell wall.

5.1.4.2 Effect of feeding regime on nutrient digestibility

Diet DM digestibility was influenced by feeding regime in this study. This agrees with earlier findings that increased feeding frequency has a positive impact on digestibility of DM, OM and CP, as greater feeding frequencies have been shown to result in increased numbers of protozoa (Weimer, 1998; Atkinson *et al.*, 2010). Abouheif *et al.*, (2010) attributed the positive effects of increased meal frequency to a more stable rumen environment and thereby a more efficient digestion. In contrast, Bunting *et al.* (1987) observed that CP digestibility decreased with increasing meal frequency. Also, restricted feed intake has been reported to increased nutrient digestibility and decreased methane loss in goats (Tovar-Luna *et al.*, 2007).

5.1.4.3 The overall effect of inclusion level and feeding regime on nutrient digestibility

There was a significant interaction between inclusion level and feeding regime in dry matter, organic matter and crude protein digestibility (DMD, OMD and CPD respectively). The improvement in DMD, OMD and CPD as influenced by feeding frequency observed in this study agrees with the report of Rotger *et al*. (2006). They reported that a change in feed composition and frequency of feeding influenced digestibility of nutrients in feeds.

5.1.5 Nitrogen Balance

5.1.5.1 Effect of inclusion level on nitrogen balance

The results of nitrogen balance showed increased faecal and reduced urinary losses with increasing levels of ficus in the diets. The observed result on faecal and urinary nitrogen does agree with the findings of Al-Asfoor, (2010) who reported that the nitrogen concentration of faeces strongly depends on the N concentration of the diet. The reduced N retention in animals fed the supplement containing ficus may suggest

that probably much of the protein is unavailable for digestion owing to formation of tannin-protein complexes. Elseed *et al.,* (2005) however observed that supplementation of protein sources improved microbial N yield and N retention.

5.1.5.2 Effect of feeding regime on Nitrogen balance

Nitrogen retention declined (P<0.05) with decrease in feeding frequency. The observed decrease in nitrogen intake, faecal nitrogen and urinary nitrogen with decrease in feeding frequency is in line with the report of Borsting *et al.,* (2003) who stated that the faecal N concentration can be influenced by dietary manipulation. Excess supply of N is avoided through the manipulation of feeding frequency and the N efficiency is maximized. It has also been observed that N and starch in faeces are positively and moderately related to N and starch in the feed (Al-Asfoor, 2010).

5.1.4.3 The effect of inclusion level x feeding regime on Nitrogen balance

The increase in nitrogen intake as inclusion level and feeding regime reduces from daily feeding to skip-2-dayst is similar to the findings of Soto-Novarro *et al.,* (2000), who reported an increased in nitrogen intake of feed offered to steers as treatment x feeding frequency interacted.

5.1.6 Cost analysis

5.1.6.1 Cost-benefit analysis of inclusion levels of *F. sycomorus* leaf meal in supplement diets fed to Yankasa rams

The reduction in the cost of supplementation (Table 4.10) with increase in the levels of inclusion is due to lower cost of *F. sycomorus* (N/kg) compared to the cost of cotton seed cake, which was expensive. It has been reported that replacement of conventional feed ingredients with unconventional feed ingredients reduced cost of feed (Adegbola and Okonkwo, 2000). Salvadogo (2000) reported that industrial by-

products (oil seed cakes) are not readily available or where available, they are so expensive.

The feed cost per kg gain showed that inclusion of 10% *F. sycomorus* in the supplement was more cost effective than other inclusion levels. The high feed cost per kg weight gain observed on animals fed 0% inclusion level of *F. sycomorus* in the supplement could be attributed to the fact that it contained high quantity of cotton seed cake, which is more expensive when compared to *F. sycomorus.* It is clear from this study that incorporating *F. sycomorus* leaf meal in the diet of Yankasa diet at 10% resulted to increase in live weight gain and decreased cost of feed per kg gain.

5.1.6.2 Cost-benefit analysis on Feeding regime of Yankasa rams fed supplement containing *F. sycomorus* leaf meal

Cost of feeding and cost of feed per kg gain was influenced by feeding regime in this study. This agrees with earlier findings that increased feeding frequency has a negative impact on cost of feeding, as greater feeding frequencies have been shown to result in increased cost of feeding ruminants (Komwihangilo and Mlela. 2012). Also, restricted feed intake has been reported to increase nutrient digestibility and decreased methane loss resulting to better weight gain (Tovar-Luna *et al*. 2007).

The feed cost per kg gain indicated that skip-a-day feeding regime was more cost effective than other feeding regimes, as least cost per kg gain was observed. The higher feed cost per kg weight gain observed on animals on daily supplementation could be attributed to the rate of conversion of nutrients into body tissue as a result of inadequate utilization of nutrients due to rapid passage of the ingesta.

5.2 EXPERIMENT II

5.2.1 Effect of level of *F.sycomorus* in supplement diets on mean rumen fluid variables in Yankasa rams fed *D. smutsii* hay

The pH values of 6.49-6.88 in this study were slightly above 6.98-7.13 reported by Alawa, (1991), when Friesian x Bunaji heifers were fed groundnut haulms. Jokthan (2006) obtained a pH value of 7.1-7.31 when pigeon pea forage to rice straw based diet was fed to sheep. Reddy and Reddy (1998) have reported a normal pH range of 6.2-6.9. The linear increase in the TVFA concentration may probably due to increased in the concentration of ammonia in the rumen. The observed NH_3N concentration values (30.95-36.64) are higher than 3.74-7.29 reported by Abdu (2011) when Zizyphus leaf meal to maize stover diet was fed to sheep and 15.95-18.34 reported by Finangwai (2013), when Friesian x Bunaji heifers were fed groundnut haulms to Gamba hay base diet. Manipulation of feeding frequency and/or feed intake can modulate the responses of ruminal metabolism to forage legumes diets (Sun *et al.* 2012). Perdok and Leng (1989) showed that a higher level of rumen NH_3-N (15-30 mg/dl) improved intake and digestibility. Kanjanapruthipong and Leng, (1998) also revealed that increasing the rumen NH_3-N level to more than 30 mg/dl significantly increased microbial protein synthesis (17-47%). In an experiment with swamp buffaloes fed on untreated rice straw, Wanapat and Pimpa (1999) also found similar results in that rumen NH_3-N levels of 13.6-34.4 mg/dl improved rumen fermentation by increasing digestibility and intake of straw. However, the literature is inconsistent regarding the effects of supplementation of grass with concentrates on rumen fermentation patterns in ruminants (Weimer, 1998; Wanapat, 2005; Hersom, 2008)

5.2.2 Effect of feeding regime on mean rumen fluid variables in Yankasa rams fed concentrate containing *F. sycomorus* and a basal diet of *D. smutsii* hay

The effect of feeding regime on rumen fluid variables indicated that skip-2-days feeding frequency resulted in less stable rumen metabolites. Pritchard, (2003) observed that rumen NH_3-N and TVFA were highest on cattle fed diets containing legumes on a skip-a-day feeding basis, indicating greater production efficiencies. On the other hand several studies reported that frequency of feeding had no effect on the concentration of the VFA in the ruminal ingesta (Cecava *et al*., 1990; Robbles *et al.*, 2007). However, Sun *et al.* (2012) indicated that manipulation of feeding frequency and/or feed intake can positively influence the responses of ruminal microbes to forage legumes diets.

5.2.3 Effect of sampling time on mean rumen fluid variables in Yankasa rams fed concentrate containing *F.sycomorus.*

The effect of sampling time on total volatile fatty acids and NH_3-N concentration showed a similar pattern, it revealed an increase in the concentration of TVFA and NH_3-N as the sampling time increased from 6 hours post feeding up to 18 hours thereafter, there was a decline. This indicates that there was efficient utilization of the ingested feed material leading to a favourable rumen environment and subsequent yield of rumen metabolites. Abouheif *et al*. (2010) reported that TVFA concentration in the rumen liquor of lambs fed concentrate was affected by sampling hours post feeding. They added that the concentration of TVFA increased gradually to attain its peak value before subsequently decreasing to the original concentration at 24 hours post feeding.

5.2.4 Overall effect of inclusion level and feeding regime on rumen metabolites of Yankasa rams supplemented with *F.sycomorus*

There was no significant interaction between levels of supplementation and feeding frequency on rumen pH, but there was a numerical rise in the pH at all feeding regimes as the level of inclusion increased up to 10% inclusion. The concentration of TVFA and NH_3-N was not significantly ($P>0.05$) influenced by the interaction between inclusion levels and feeding regime, although there was a similar pattern where the concentrations decrease as the feeding regime changed from daily to skip-2-days feeding across inclusion levels. The interaction between inclusion level and feeding regime resulting in a decline in the concentration of TVFA and NH_3-N has been observed by Rotger *et al.* (2006). They explained that a change in feed composition and feeding pattern alters the amount of organic matter, nitrogen and their fermentation rate in the rumen, thereby bringing an optimum absorption and utilization of TVFA and NH_3-N in the rumen.

5.2.5 Effect of inclusion level of *F.sycomorus* supplement and sampling time of rumen variables

5.2.5.1 Rumen pH

Supplementation with *Ficus sycomorus* had a significant effect on rumen pH. The values of rumen pH observed could be as a result of the progressive increase in levels of *F. sycomorus* fed to the rams, the result is in agreement with the report of Khampa and Wanapat (2007) who reported that forages could improve rumen efficiency by maintaining higher pH. It had also been reported that higher rumen fluid pH is conducive for cellulose digestion (Grants and Mertens, 1992) and increases rumen activity (Nangia and sharma (1994).

5.2.5.2 Total volatile fatty acid production

The TVFA values obtained in this study were higher than normal values (10.5-12.8mm/l) reported by Kandil *et al.* (1996). The result showed increase in the level of total volatile fatty acids as the inclusion level of *F. sycomorus* increased up to 18 hours post feeding. The increased in volatile fatty acids at 6 hours post feeding to 18 hours post feeding could be associated with the digestibility of the feed material (Orskov and Ryle 1990; Khampa and Wanapat 2007), since the volatile fatty acids are products of degradation of feed in the rumen. The slight non significant decline in TVFA values at 24 hours post feeding across inclusion levels agrees with the work of Orskov (1982), who reported that the concentration of rumen volatile fatty acids decline with time, since volatile fatty acids are the major source of energy and are always absorbed through the walls of the rumen. This gave a positive indication of the energy value of the experimental diets and signifies better utilization by the animals.

5.2.5.3 Ammonia nitrogen (NH_3-N)

Rumen ammonia nitrogen is a measure of the extent of rumen microbial protein degradation. There was an increase with increased in inclusion level of *F. sycomorus* up to 10% inclusion level thereafter declines. In this study, the highest concentration of rumen NH_3-N observed at 18 hours post feeding indicated that there was high degradation of the experimental diet, which is an indication of high degradability of nitrogen in the rumen. The rumen NH_3-N observed in this study was higher than the value of 2-8 mg/100ml reported for high producing ruminant livestock (Drewnoski and Poore, 2012). The differences observed in the present study may be due to stage of plant growth and the animals involved.

5.2.5.4 Effect of feeding regime and sampling time on rumen variables

The rumen pH values observed in this study were affected by feeding regime. This is in agreement with earlier findings of Sun *et al.* (2012) who reported that feeding regime significantly affected rumen pH with either increasing the pH or reducing it.

Feeding regime affected the total volatile fatty acids concentration at 12 and 18 hours post feeding sampling time. The observed general increase in the total volatile fatty acid concentration from daily feeding to skip-a-day feeding regime is related to the report of Drennan *et al.* (2006), who reported that total volatile fatty acids concentration in the rumen tend to increase with decrease in the frequency of feeding depending on feeding programme.

Feeding regime did not influence the concentration of NH_3-N at the various sampling time. However, there was a pattern for NH_3-N concentration at 6, 18 and 24 hours post feeding where the concentration increase from daily feeding to skip-a-day feeding and then decline at skip-2-days feeding regime.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

The study was conducted to investigate the effect of inclusion levels of Fig (*Ficus sycomorus*) leaf meal in concentrate diets on the performance of Yankasa rams fed *Digitaria smutsii* hay and also to explore the potentials of feeding the concentrate at different frequencies on the performance and rumen metabolites profile of Yankasa rams. Leaves of *Ficus sycomorus* are readily eaten by cattle, sheep, goats and camels due to the high dry weight of protein content.

Thirty six (36) Yankasa rams with average live weight of 15.39 kg were used for the study. Four iso-nitrogenous supplementary diets containing 0, 5, 10 and 15% *Ficus sycomorus* leaf meal were formulated (Table 3.1). Each inclusion level served as a treatment (T_1, T_2, T_3 and T_4, respectively). Experimental animals were randomly allotted to the four dietary treatments with nine animals per treatment and three animals per feeding regime and treatment, in a 4x3 factorial arrangement in a completely randomized block design.

The growth performance, digestibility of nutrients, nitrogen balance and rumen metabolites profile was determined.

6.2. Conclusion

The study showed that rams fed supplement containing 10% *F. sycomorus* inclusion had higher weight gain 3.54kg compared to other inclusion levels. Increasing *F. sycomorus* inclusion level to 15% did not result in additional weight gain.

Feeding regime significantly improved total dry matter intake as the feeding frequency changes from daily (806.15 g/day), skip-a-day (835.16 g/day) and then to skip-2-days (861.48 g/day) feeding regimes. Body weight gain was highest on rams fed supplement on skip-a-day feeding frequency (2.82kg) compared to other feeding frequencies.

Digestibility of DM, OM, CP, ADF and NDF was significantly reduced with inclusion of *F. sycomorus* in the supplement. However digestibility of DM, OM and CP was significantly higher in Daily feeding (67.80, 63.05 and 62.23% respectively) as compared to skip-a-day and skip-2-days which were similar.

Results obtained from rumen fluid metabolites as a result of supplementing with *F. sycomorus* inclusion showed that pH levels remained within acceptable range for optimum rumen fermentation (6.49-6.88). Total volatile fatty acids concentration was higher in rams fed supplement with 10% *F.sycomorus* inclusion.

Feeding regime had a positive influence on rumen metabolites with skip-a-day having the highest concentration in TVFA (14.04 mm/100ml) and NH_3-N (32.60 mg/l). For the rams to maintain a high concentration of TVFA and NH_3-N, the supplement should be given at skip-a-day frequency.

pH levels were influenced by *F. sycomorus* supplementation and sampling time, however pH remained within the acceptable range for rumen fermentation (6.35-6.98). Total volatile fatty acids (TVFA) concentration was higher at 10% *F. sycomorus* inclusion and at 12 and 18 hours post feeding sampling time (17.85 and 17.98 mm/100ml respectively). Also higher concentration of NH_3-N was observed at 10 and 15% inclusion level when sampling at 12 hours (36.74 and 35.15 mg/l respectively) and 18 hours (39.03 and 36.26 mg/l respectively) post feeding.

Supplementation of *D. smutsii* with *F. sycomorus* leaf meal lower cost of feed per kg body weight gain and was better in rams fed 10% (₦129.48/kg) inclusion level of *F. sycomorus*.

Cost of feed per kg body weight gain was lower and better on skip-a-day (₦127.55/kg gain) feeding regime.

6.2 Reccommendation

From the results of this study, the following recommendations were made:

1. *Ficus sycomorus* leaf meal should be used by farmers as a good source of feed supplement during the peak of the dry season to maintain live weights of ruminant animals.
2. Strategic feeding regimes for ruminants should be encouraged so as to improve the quality and quantity of animal product as this has no detrimental effect on performance and rumen fluid profile of the animals.
3. Optimum performance was obtained at 10% level of inclusion of *Ficus* sycomorus and on skip-a-day feeding regime. Therefore, *F. sycomorus* should be included in concentrate supplements of Yankasa rams at 10% level and fed at skip-a- day frequency.
4. Smallholder producers are advised to feed their rams concentrate supplement containing 10% *Ficus sycomorus* to enhance income and better standard of living.
5. Further studies should be conducted to investigate the potential of *Ficus sycomorus* in smallholder fattening operations.

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