

PERFORMANCE OF SMALL RUMINANTS FED CROP RESIDUE
SUPPLEMENTED WITH TREE LEAVES AND SHRUBS.

BY



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01576

A thesis submitted in partial fulfillment of the
requirements for the
Degree of Master of Philosophy.



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April, 1997

G. 352703
SF 99-C 73 S07





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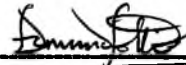
DEDICATION

This work is dedicated to my parents, Mr. & Mrs. S. N. Sottie, my brothers and sisters, Eric, Chris, Gifty and Faustie for their love, help and prayer support shown throughout my career and to all loved ones especially Akorfa.



DECLARATION

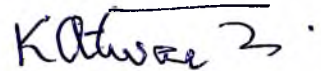
This study is the result of my own research and it has not been presented in whole or part by any other person in this university or elsewhere. All the references cited have been duly acknowledged.



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ACKNOWLEDGEMENT

I wish to thank my supervisor, Dr. J. E. Fleischer and co-supervisor, Rev. Dr. K. Amaning-Kwarteng for their guidance, support and constructive criticisms during this study.

My special thanks also go to Mr. Abubakari Yakubu and Mr. Amoah of the Animal Science Department, Mr. Theophilus Afunyah of the Soil Science Department for their excellent technical assistance. Mr. Daniels, Mr. A. Otibu and Mr. R. Ntreh of A.R.S. (Legon) were very helpful during the feeding and maintenance of the experimental animals. I wish to also thank all the staff of the Animal Traction Unit (A.R.S.) for assisting me with equipment and valuable services.

I am grateful to Miss Regina Bonaparte for helping with the typing of part of this script.

I am indebted to a number of loved ones who God brought my way to help play vital roles in my education. They are my parents, brothers, sisters, in-laws, nephews and nieces, and friends like Eric Nartey, Samuel Afram, Cephas Otwete, Mr. & Mrs. L. Boakye-Yiadom, Rosemary Adoe, Sylvia Tetteh, Ivy Acquaye, Kafui Ametefe, Bertrand Vanderpuije, Nana Serwaa Appiah, Eric Kra, Eleanor Peters, K. Agyei-Henaku, Cynthia Ametefe, Alberta Indoome, Linka Dadzie, Becky Ghanney, Edith Kotei, John Abbeo, Pat Kennah and G. Meyer

My final thanks go to the Almighty God for all His help, grace and mercy throughout my life.

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ABSTRACT

Three experiments were conducted to determine the performance of small ruminants fed crop residue supplemented with tree leaves and shrubs.

Experiment 1 was undertaken to determine the chemical composition of eight browse species harvested during the dry and wet seasons of Ghana. Also, the chemical compositions of untreated rice straw (RS), sodium hydroxide treated rice straw (STS) and urea ammoniated rice straw (UTS) were determined. Samples were analyzed for Dry matter, Crude protein, Neutral detergent fibre, Cellulose, Lignin, Ash and *in vitro* dry matter digestibility.

The mean DM value of the dry season browse species (38.9%) was significantly higher ($p < 0.05$) than that of the wet season species (33.0%). The mean CP value for the dry season species (17.9%) was however not significantly different ($p > 0.05$) from that of the wet season species (15.0%). Similarly, there were no differences ($p > 0.05$) between the other parameters. Crude protein ranged from 12.9% in *Khaya* to 21.9% in *Milletia* for the dry season samples and 11.8% in *Khaya* to 17.1% in *Ritchiea* for the wet season samples. The IVDMD (75.1 and 80%) was highest in *Securinega virosa* for dry and wet season samples respectively and lowest in *Milletia* (40.7 and 41.1%) for dry and wet season samples respectively.

Experiment 2 compared the effects of ammoniation and browse supplementation on rumen metabolites and rumen degradation in sheep. With the exception of *Delonix* and *Milletia*, all the browse species had dry matter degradability (DMD) values above 60%



while UTS had a value of 55%. The N degradation characteristics gave a range of 50 to 83.5% for the browse species, 47.3 and 60.9% for STS and UTS respectively.

There were no difference between the mean pH levels and peak ammonia nitrogen levels for animals on STS supplemented with browse and those on UTS.

The feeding value of STS supplemented with browse was compared with that of UTS in Experiment 3. Parameters investigated included dry matter intake, liveweight changes and nutrient digestibility.

Although the DMI of UTS (433.8g/d) was higher than that for STS with browse, which ranged between 339 to 392.5g/d, the liveweight changes and nutrient digestibilities showed no significant differences ($p > 0.05$).

Straw treated with NaOH and supplemented with browse can help maintain the weights and provide some amount of growth in small ruminants during the dry season.

CHAPTER ONE

1.0

INTRODUCTION

The most urgent task facing agricultural scientists all over the world and in particular sub-Saharan Africa is that of providing food of adequate quality for the rapidly increasing human population. The problem is likely to become more critical in the years to come if much is not done to arrest the situation.

Ruminants have a very important role to play in converting plant energy and protein into food for man. The main feed resource for ruminants in Ghana is the natural grassland. In the coastal savanna grassland the protein content of the natural grassland may range between 8% and 12% of DM at the start of the rainy season (Amaning-Kwarteng, 1991) but in the dry months, it may fall to around 3% (Rose-Innes and Mabey, 1964). Digestible crude protein values are low and generally inadequate for animal maintenance during the dry period (Crowder and Chheda, 1982). Animals on a low protein herbage tend to suffer not only from protein deficiency but also from lack of energy (Zemmelink, 1974). Changes also occur in the mineral or ash constituents. The total ash content decreases as the plant matures (McDonald *et al*, 1981).

Whereas crop residues can make a significant contribution to the feed resources for ruminants in the West African sub-region, they are currently not used much but largely left to rot or burned (Fleischer, 1986). Maize, millet and sorghum stovers,

groundnuts, cowpea and rice straw are the main crop residues available for ruminants in the West African sub-region.

Except for the leguminous crop residues which have reasonable amounts of proteins, other crop residues, especially cereal crops, are deficient in nitrogen and have a high cell-wall content. Both factors reduce the intake and digestibility. Supplementation with non-protein nitrogen or high protein feedstuffs may improve intake and digestibility of crop residues. Among the protein sources to be used in combination with crop residues are leaves from trees and shrubs.

The major value of browse trees and shrubs is that they provide proteins, vitamins, and frequently mineral elements which are lacking in crop residues and grassland pastures during the dry season. Because of its high content of protein, browse has been suggested as a solution to feeding tropical animals (Woodward and Reed, 1989). They also enable standing feed reserves to be built up, so that herds are able to survive critical periods of shortfalls or prolonged drought without losses. Trees and shrubs survive harsh climatic conditions and are an important source of browse feed in drier parts of Africa. Moreover, browse species are an effective means of utilizing marginal land on which normal crop production is ineffectual owing to climatic, topographic or edaphic constraints. Woody species are more drought-tolerant than grasses and may be a more reliable feed resource. Browse trees benefit soils by protecting them from erosion and may increase soil fertility. They also benefit animals

with shade and people with fuels, medicines and building materials. Browse species are used for agroforestry.

The use of browse may improve animal feeding systems but it has been suggested by Woodward and Reed(1989) that individual browse species must be evaluated according to their effects on the metabolism of individual animals because of the different levels of phenolic compounds in different browse species. In Ghana, even though some tree leaves and shrubs are coppiced and offered to animals in the traditional system, no systematic study has been carried out in their combination with crop residues. Such a study may lead to a better understanding of the use of crop residues and/or tree leaves by the farmer.

Thus, the objectives of this study therefore are to study:

1. The chemical composition and *in vitro* digestibility of some tree leaves and shrubs.
2. The level of inclusion of the tree leaves and shrubs that would allow for optimum utilization.
3. Effects of ammoniation and browse supplementation on rumen dynamics and metabolites e.g. Rumen NH_3 and rumen pool size.
4. The relative preference, intakes and growth responses of sheep fed these tree leaves and shrubs in combination with rice straw.

CHAPTER TWO

2.0

LITERATURE REVIEW

2.1 CLIMATIC CONDITIONS OF GHANA

Ghana lies between 4°N and 11.5°N and is situated in the belt of tropical and equatorial climates. The winds that influence the climate are the “Harmattan”(the hot, dry and dust-laden north-easterly winds which reach Ghana from the Sahara area), and the cool moisture-laden south-west trade winds blowing on-shore called the Monsoon. The rainfall distribution follows more or less the same pattern throughout the year. The wet season is between April and July and the dry season from October to February. Along the coastal and sub-coastal zones of Ghana and Togo is a semi-arid and sub-humid equatorial enclave with rainfall of 500 - 800 mm (Accra and Lome) and a 4 - 6 month dry season. The forest zone has annual averages of between 1270 - 2160 mm separated by a short dry season, while in the interior and northern savannas, the annual average is 1125 - 1270 mm occurring in one main rainy season followed by a long dry season. The rainfall is lower still in the coastal plains, where it averages only between 760 and 1125mm, except that it occurs in two seasons separated by two relatively short dry seasons (Ampadu-Agyei *et al.*, 1994).

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Relative humidities are highest in the morning. In the coastal areas they reach 95 - 100 per cent in the morning and decrease to a minimum of 65-75 per cent in the afternoon. Corresponding values in the north are almost as high as in the coastal areas during the raining season. However in the rest of the year, the average night values are below 80 per cent and may fall as low as 25 per cent in the extreme north.

Temperatures throughout the country are typically high with average figures ranging between 24 and 30°C, although values as low as 18 and as high as 40°C or more are known in the southern and northern parts respectively, as a result of seasonal and diurnal changes.



2.2 GRASSLAND VEGETATION IN GHANA

According to Rose-Innes (1964), the two main grassland regions, the northern or interior savanna and the coastal savanna are separated by a broad belt of closed tropical forest.

In the interior savanna, the vegetation is composed of trees of varying size and density dispersed in grassland consisting largely of tall species of *Andropogon* and *Hyparrhenia*. Short annual species like, *Aristida*, *Eragrostis*, *Digitaria*, *Diectomis* and *Heteropogon* are also common. The coastal savanna is dominated by medium to short grass species - varying in composition according to soils.

Rose-Innes and Mabey (1964) reported that the predominant browse species in Ghana included, *Antiaris africana* (Moraceae), *Baphia nitida* (Fabaceae), *Capparis*

erythrocarpos (Capparidaceae), *Capparis thoningii* (Capparidaceae), *Dichapetalum guiniense* (Chailletiaceae), *Fagara xanthoxyloides* (Rutaceae), *Grewia carpinifolia* (Tiliaceae), *Griffonia simplicifolia* (Caesalpineaceae), *Milletia thoningii* (Fabaceae), *Ritchiea reflexa* (Capparidaceae), and *Tiliacora warneckii* (Menispermaceae).

2.3 THE RUMINANT.

2.3.1 Classification of ruminants

Ruminants are classified in the subclass Ungulata (i.e. the hooved mammals): they belong to the order Artiodactyla and the suborder Ruminantia: these are the cud-chewing animals. Ruminants are characterized by possession of large complex compartmental stomachs (Rumen, Reticulum, Omasum and Abomasum) and by the process of rumination (Hungate, 1966). The main domesticated ruminant species (sheep, goat and cattle) belong to the family Bovidae (Church, 1976). The ruminants digestive system has been a very successful evolutionary development (Moir, 1965). Dietary habits consequently vary widely because of the diversity due to the location and climatic environment.

2.3.2 Gastro-intestinal tract of the Ruminant.

Ruminants are adapted physiologically and anatomically to low quality roughage utilization because ruminants foster in their rumen a microbial symbiotic relationship (Church, 1976). Even though mammals including herbivores do not

synthesize enzymes capable of degrading β -linked polymeric carbohydrates like cellulose and zylans micro-organisms are present in the gut of all animals and their contributions to the digestive system depend on the diet and the construction of the gut (Hobson, 1969).

For herbivorous animals, the micro-organisms present are of central importance to the digestive processes, particularly in the utilization of the plant cell wall materials such as cellulose. Cellulose digestion by micro-organisms is a comparatively slow process, hence the passage of ingesta needs to be slowed down for maximal digestion. It is in the reticulo-rumen that most of the bacterial activity takes place. (McDonald *et al.*, 1981).

2.3.3 Microbial Population and Fermentation.

Microbial digestion in the rumen is relatively unrelated to the host animal's digestive processes in the gut, whereby hydrolytic enzymes break down more complex compounds to nutrient molecules that can be absorbed as such. Microbial fermentation in the rumen of feed constituents such as cellulose, hemicellulose, starches, sugars, proteins and amino acids and organic acids results principally in the production of the volatile fatty acids (VFAs) - acetic, propionic and butyric acids; gases - methane and CO₂ and NH₃ from nitrogenous compounds; and the microbial cells (McDonald *et al.*, 1981, Nolan and Leng, 1972)

The gastro-intestinal tract of the ruminant is arranged in such a way that the products of microbial digestion can be absorbed by the host as well as acted upon by the normal digestive processes as the digesta pass into the abomasum and the small intestine. In the rumen, the microbes utilize these nutrients for their own metabolic needs and in so doing leave the end products of fermentation and themselves for the host. The VFAs and the microbial cells constitute a major fraction of the animal's real food. Conditions for normal fermentation are maintained in the ruminal fluid by continual adjustment of pH chiefly by saliva inflow and absorption of VFAs into the blood across the rumen wall (Marston, 1948). Under normal conditions of feeding, the rumen contents of adult animals contain about 10^{10} bacteria ml^{-1} (Hobson, 1969). The concentration of protozoa varies markedly, but something like 200,000 of the smaller species and 4,000 of the larger species ml^{-1} might be present (Hobson, 1969). The microbial populations are maintained reasonably constant in number by being swept out of the rumen with the movement of fluid digesta, and also by breakdown within the rumen (Jarvis, 1968; Nolan and Leng, 1972). The digestion of rumen micro-organisms occurs in the abomasum and small intestine thus contributing amino acids and other nutrients (Smith, 1975; Armstrong and Smithard, 1979).

It would be advantageous to the host animal if proteins, starch or sugar were to escape microbial fermentation in the rumen, as these nutrients can be directly digested and the products absorbed are more efficiently metabolized by the animal than their fermentation products. However, the main advantage of the rumen system lies in the

ability of the animal, with the help of microbes, to utilize carbohydrates which are otherwise not susceptible to the normal digestive process and in the utilization of non-protein nitrogen (NPN) via microbial synthesis of amino acids and proteins (Ørskov, 1982)

2.4 FEED RESOURCES AVAILABLE TO RUMINANTS

2.4.1 Crop Residues

Crop residues are materials left after harvesting crops (maize stover, cassava tops, maize cobs, rice straw). These materials are usually high in fibre, low in nitrogen and are poorly digested such that they barely meet the maintenance requirements of livestock (Sundstøl, Coxworth and Mowat, 1978). They are widely distributed in the farming communities of Ghana.

In 1981, an estimated 236 million tonnes of cereal crop residues were produced in Africa (Kossila, 1984). Nearly 70% of the residues were derived from cereals with maize, millet and sorghum providing the largest portion in sub-Saharan Africa. Throughout the continent, the amount of crop residues produced averaged 1.5t of feed per livestock unit per year (Kossila, 1984). Fleischer (1991) estimated that in the West African sub-region a total of some 136 million metric tons of crop residue was produced. This ranged from 0.07 to 70.57 million tons depending on the country and it may constitute about 1% to 82% of the available national feed resource. In Ghana, it is estimated that the annual production of crop residues is about 9.38 million metric tons

(Ampadu-Agyei *et al.*, 1994) and this may form about 30% of the available feed resource (Fleischer, 1991).

2.4.2 Nutritive Value Of Crop Residues

Crop residues are deficient in nitrogen and have a high cell-wall content. Both factors reduce their intake and digestibility. When fed unprocessed to livestock, crop residues are poorly consumed and ultimately result in poor performance or response.

Five different varieties of rice straw were fed *ad libitum* to adult wethers weighing about 30 kg to estimate voluntary intake and digestibility (Cheva-Isarakul and Cheva-Isarakul, 1985). The sheep consumed on the average about 2.2 per cent of their body weight of the straw. Dry matter digestibility of 49.8% was reported by Cheva Isarakul and Cheva Isarakul (1985). Suriyajantratong and Senetas (1985), on the other hand, fed sheep with groundnut haulms whose digestibility was 52% and reported a higher dry matter intake (DMI) of 2.9% of body weight. According to Doyle (1982) and Pearce (1984), materials with low dry matter digestibilities coupled with low intakes may not satisfy maintenance needs of the animals, hence the need to upgrade the residues to improve their nutritive value.

Supplementation with non-protein nitrogen (NPN) or high-protein feedstuffs may improve both intake and digestibility, but cannot always compensate for other anti-nutritional factors, such as high fibre content and presence of phenolic compounds (Donefer *et al.*, 1969; Ørskov and Grubb 1978; Chesson and Ørskov, 1984).

Cell wall polysaccharides (cellulose and hemicellulose) account for more than 70% of the dry matter in crop residues and are a major source of energy and volatile fatty acids (VFAs) for the microbial production of protein in the rumen.

However, cell-wall content is negatively correlated with intake. High cell-wall content increase rumination time and is associated with decreased efficiency of conversion of metabolizable energy to net energy. The ability of the rumen micro-organisms to digest cell-wall polysaccharides is limited by the presence of phenolic and other aromatic compounds (Hartley, 1981).

2.4.3 Digestibility Of Crop Residues

Large variations in digestibility occur among different varieties of crop residues and also among the various morphological fractions (Fleischer and Tackie, 1994). According to Nicholson (1984), several researchers have reported large variations in IVOMD of cereal crop residues grown in various parts of the world. The *in vitro* organic matter digestibility (IVOMD) of 26 improved varieties of sorghum grown in Ethiopia was found to range from 38.3 to 55.2% (Reed *et al.*, 1986). Similarly Fleischer and Tackie (1994) reported variations in the *in vitro* dry matter digestibility (IVDMD) values for the different plant fractions of 6 sorghum varieties. They obtained a range of 26.8 - 52.9% for the different fractions. Also cereal crop residues (mainly barley and wheat straw) fed to working oxen in the Ethiopian highlands had IVOMD values of 45 to 60% (Goe, 1987).

Thus rations based on cereal crop residues with moderate to high digestibility (i.e. above 50%) can provide draught animals and other livestock supplemented with low levels of non-protein nitrogen with the energy required for maintenance and work (Soller *et al.*, 1986). When, however, digestibility is below 50%, intake will be inadequate for maintenance and work (Reed and Goe, 1989) even with NPN supplementation .

2.5 MANAGEMENT AND IMPROVEMENT OF FEED VALUE OF CROP RESIDUES

2.5.1 Potential Use Of Crop Residues

The nutritive quality of crop residues declines the longer they remain in the field. The most nutritive parts - leaves, and the upper part of the stalk are lost due to drying, wind damage and shattering. McIntire *et al.*, (1989) have found that grazing *in situ* is the dominant form of use of cereal crop residues on smallholder farms in sub-Saharan African, except in the densely populated highlands. Turning animals onto harvested fields allows for selective grazing of plant parts but there is also substantial wastage of the residue by trampling, in some cases between 40 and 50% (Chandler, 1984, Tessema, 1984) or as high as 70 to 75% in 80 to 100 days of grazing (Ward, 1978). Even when stovers are stored and fed as whole stalk and leaves without chopping, wastage is high and intake low (Said and Wanyoike, 1987). Thus, cereal



crop residues represent a feed resource with a potential that is not fully exploited on many smallholder farms.

2.5.2 Problems Associated With The Use Of Crop Residues

While certain management methods can increase both the quality and intake of crop residues, farmers' acceptance of even simpler techniques, such as stripping of leaves, topping after maturity, chopping, and storage to preserve quality material, has been minimal because of the additional labour required and the low visibility of return (McDowell, 1988). In some instances, the management of crop residues by farmers may be adequate but limited production of feed supplements, and the high cost of their transportation and handling, ultimately result in less efficient use of crop residues (Scarr, 1987).

2.5.3 Improving The Feed Value Of Crop Residues

Improved methods of storing can help maintain the initial quality of crop residues longer but this will depend on the physical form of the crop residue. Transporting cereal crop residues to the place of storage involves additional labour. Because of their bulkiness, maize, millet and sorghum stovers are often stacked or bundled and left in the field to be either transported to the homestead later or fed

directly from the stack. In contrast, barley and wheat residues are threshed into small pieces, which makes handling and storage easier.

The utilization of crop residues by ruminants can be improved in several ways. These methods may include physical, chemical and biological methods to help break down the cellulose-lignin complex and thus make structural carbohydrates more accessible for breakdown by rumen microbes. The diet can be supplemented with brans and millings, oilseed cakes, legumes, urea and fodder from multipurpose trees (Dzowela, 1987). A number of considerations are made on the feasibility of processing roughage. These include: whether the digestibility, and therefore, the metabolisable energy (ME) content of the material is improved by the process, and also whether the intake of the product is increased.

2.5.4 Methods of Processing Crop Residues

2.5.4.1 Physical Treatment.

This includes processes like soaking; chopping; grinding and pelleting, boiling, gamma irradiation, and high pressure steaming. Physical treatment has been found to increase intake of crop residues (Chaturvedi *et al.*, 1973; Adu and Lakpini, 1983)

Chopping and grinding of straw has been found to help increase the daily intake of straws by animals (Smith, 1987). This is partly due to the reduction of the chewing time required to reduce ingested feed material to a particle size suitable for digestion

by rumen micro-organisms. Pelleting has been found to improve intake, probably because it reduces dustiness due to grinding (Chaturvedi *et al.*, 1973).

After soaking straw in water, Chaturvedi, Singh and Ranghan (1973) reported an increase in digestible organic matter and intake of straw. Nitrogen retention was however variable. Soaking also increased DM intake of the treated material.

2.5.4.2 Chemical Treatment

Alkalis, acids or oxidizing agents capable of weakening cell wall component complexes, solubilizing the components and increasing the swelling capacity of the cell wall thus facilitating microbial enzyme entry can be used (Smith, 1987).

Sodium hydroxide is an alkali generally used for its effective improvement of the digestibility of crop residues. Amaning-Kwarteng (1991) reported that NaOH increased the *in vitro* digestibility of treated straw (up to 38% units) as well as *in vivo* digestibility (24-30% units) and also increased intake of about 30%.

Urea is another alkali generally used to treat crop residues. Response parameters used to assess the effect of urea ammoniation on animal performance include intake, live-weight gain and digestibility. Mosi and Lambourne (1982) found that the intake and digestibility of teff straw, oat straw and mixed legume haulms were approximately doubled when the straws were ensiled with 4% (wt/vol.) fertilizer-grade urea for 3 - 6 weeks. Sheep fed on the ensiled product gained 80 g/day during the 21 day feeding period as compared to a gain of 20 g/day in animals fed untreated straw.

Studies by other workers (Dolberg *et al.*, 1982; and Wanapat *et al.*, 1982, Quashie, 1993 and Egyir, 1994) have indicated that ensiling straw with urea (3 - 5%) increased the digestibility by 10 - 12% units.

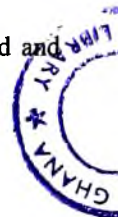
Chemical treatment of residues at present has not caught up with the small holder in Africa because of the problems of availability, cost and handling (Reed and Goe, 1989).

2.6 NITROGEN METABOLISM IN THE RUMEN

The primary source of nitrogen for rumen microbes is either protein or non-protein nitrogen from feed. Most of the NPN is converted to ammonia and then incorporated into microbial cells (Ørskov, 1982). The ability of rumen organisms to use ammonia depends on an adequate supply of energy. The energy must be available at the same time as the ammonia, otherwise the ammonia will not be effectively utilized. Excess ammonia in the rumen is absorbed into the blood and converted to urea by the liver.

A secondary source of nitrogen for the rumen microbes is urea recycled from the blood directly through the rumen wall or in saliva (Kennedy and Milligan, 1980). The amount of urea recycled is fairly constant and independent of dietary nitrogen (Van Soest, 1982).

The conversion of feed nitrogen into microbial cell is obviously an advantage to the animal in the case of NPN. However, it is detrimental if the nitrogen source is high-quality protein because most nitrogen in bacterial cell walls is indigestible due to



the high levels of purine (Ørskov, 1982), resulting in a net loss of N available to the host.

Some protein escapes ruminal digestion to undergo peptic digestion in the abomasum. The rate of protein escape is increased by high rates of passage, low protein solubility, small particle size and high level of intake (Van Soest, 1982). Efforts have been made to encourage protein to escape the rumen by chemical or physical treatment which alters protein solubility or degradability. The escape protein is protected from rumen fermentation and may be digested and absorbed by the host. Many African browse species however contain high levels of polyphenolic compounds (including tannins) which have a large effect on protein digestibility and nitrogen metabolism in ruminants.

Research by Driedger and Hatfield (1972) suggests that when protein is treated with tannins, it may increase rumen protein escape. Some tannins may bind protein in the neutral pH of the rumen and release them in the acidic abomasum (Barry and Forss, 1983). This seems to occur with feeds treated with hydrolysable tannins (Driedger and Hatfield, 1972) because they contain ester linkages (Haslam, 1966) which hydrolyze in gastric acid, thus releasing the protein. However, it is unlikely that proanthocyanidins will have the same effect (Zelter *et al.*, 1970) because they have an acid-resistant biphenyl structure (Haslam, 1966). Most naturally occurring forage tannins are proanthocyanidins (McLeod, 1974).

Microbial and escape protein from the rumen may be digested in the lower tract and absorbed by the host. Protein bound in plant cell walls or in chemical complexes is not absorbed. The unabsorbed protein, as well as endogenous nitrogen from the digestive tract and recycled urea may be available to micro-organisms in the large intestine (Visek, 1968; Beever *et al.*, 1974; Nolan, 1975). The incorporation of nitrogen into micro-organisms in the lower tract depends on the energy source which escapes absorption (Beever *et al.*, 1974; Van Soest, 1982).

Recommendations on protein requirements for ruminants (ARC, 1980) are thus based on the concepts of rumen-degradable protein (RDP) to satisfy the requirements of microflora, and undegradable dietary protein (UDP) to be utilized by the host animal.

2.6.1 Utilization of Nitrogen

2.6.1.1 Rumen Ammonia, Plasma Urea Nitrogen And Urinary Nitrogen

These are the most accessible pools with which to describe nitrogen available to and incorporated into animal tissues. Proteolytic activity in the rumen is indicated by ammonia concentration. Results obtained for both sheep and goats fed *ad libitum* diets made up of combinations of either *Acacia brevispica* or *Sesbania sesban* plus teff straws (Woodward, 1988) and also for sheep given diets composed of *S sesban*, *Acacia nilotica* or *A seyal* (Rittner, 1987) showed that rumen ammonia was highest for diets including *S sesban* in both trials and lowest for diets with increasing amounts of *A*

brevispica. This reflects the rapid fermentation rate of *S sesban* due to its lowest phenolic and fibre content (Rittner, 1987).

Rumen ammonia enters the plasma urea pool after it has been absorbed into the blood and converted to urea by the liver. Excess plasma urea nitrogen is excreted in urine, preventing toxicity in the animal. High values of plasma urea nitrogen indicate an inability of the animal to utilize nitrogen made available by digestion. (Woodward, 1988).

2.6.1.2 Faecal Nitrogen

This is composed of indigestible feed nitrogen, microbial nitrogen from the rumen, and lower-tract and endogenous (metabolic) nitrogen secreted into the digestive tract but not incorporated into microbial nitrogen (Mason, 1969; Van Soest, 1982). Faecal NDF-N may also include indigestible tannin-protein complexes (Reed, 1986).

Higher total faecal nitrogen, which could be accounted for by higher faecal NDF-N, was observed for all diets containing tanniferous feeds (Rittner, 1987; ILCA, 1988; Tanner, 1988, Woodward, 1988). The higher faecal NDF-N values can be attributed to indigestible tannin-protein complexes, and may result from a higher production of rumen microbes as a consequence of greater recycling of urea from blood to rumen. (Reed and Soller, 1987; ILCA, 1988).

2.6.1.3 Digestibility Of Nitrogen

In non-tanniferous feeds, the true digestibility of nitrogen is approximately 93% (Van Soest, 1982). In experiments performed by ILCA (1988), the true digestibility of nitrogen for browses ranged between 52 and 94%. Browses with high contents of proanthocyanidins typically had low nitrogen digestibilities, reflecting the ability of these chemicals to bind protein, thereby reducing its availability to the animal.

2.7 THE USE OF BROWSE IN ANIMAL FEEDING

The flora of tropical Africa is estimated at about 30 000 species (Brenan, 1979) of which probably slightly more than 7 000, but certainly less than 10 000, are trees or shrubs. Of these at least 75% are browsed to a greater extent (Whyte, 1947) and probably about 50% have been recorded as being useful to man. The utilization of browse and fodder plants by man is very much dependent upon availability. The main uses are for food, human and veterinary medicine, agricultural fuel, timber and domestic economy.

Toutain (1980) suggested that browse is one of the most important and cheap feed supplements available to tropical farmers especially during the dry season. Because of its high content of protein, browse has been suggested as a solution to feeding tropical animals. From a silvo-pastoral point of view, and with no

supplementation being given, browse should represent at least 20% of livestock diets during the dry season in the Sahelian and northern Sudanian zones (Le-Houèrou, 1980).

Certain factors should be considered in evaluating browse for use in silvo-pastoral systems. These factors include, the chemistry of the browse, the effects of the browse on the ruminant's productivity, as well as the possibility of the animal becoming adapted to the browse. Research has shown that polyphenolics in browse, especially proanthocyanidins, affect the availability of protein to, and the nitrogen metabolism of ruminants. The complexity of tannin chemistry has made it difficult to define clearly the chemical fractions that have predictable effects. Hence it is necessary to look at the effects of individual compounds.

2.7.1 Chemical Composition And Nutritive Value of Browse Species

In evaluating forage species, it is important to obtain information on crude protein content, digestibility and forage intake. These values usually determine the amount of energy that can be obtained by animals (Wilson and Harrington, 1980). According to Leigh *et al.* (1978), seasonal variation plays a minor role in determining browse quality. Compared with tropical grasses, browse are richer in protein and minerals except for the young grasses when the protein content may be comparable (Rose-Innes, 1964; Le Houèrou, 1965, 1978). Le Houèrou (1980) reviewing work done on browse in the West African sub-region observed that the mean crude protein

(CP) content was 125g/kg DM but ranged between 87 and 340g/kg. The proportion of silica is two to three times lower in browse as compared to grasses (Le Houèrou, 1980). In terms of energy, browse contains double the amount in dry grass owing to its lower content of crude fibre, as compared to grass. The mineral content of browse is on the whole, adequate in terms of phosphorus and magnesium, but it is a little high in calcium and potassium. However the calcium/phosphorus ratio is usually much too high.

Rose-Innes and Mabey (1964) gave the CP values of 18.0, 19.0, 15.0 and 18.0 per cent for *Griffonia simplicifolia*, *Milletia thomingii*, *Khaya senegalensis* and *Grewia carpinifolia* respectively. Le-Houèrou (1980) gave the nutrient of some browse species and their family averages (see Table 2.1). In contrast to herbaceous species and chenopod shrubs, where the true digestibility of protein is 97-100%, the protein of browse has a true digestibility (or availability) of only 70-80% (Wilson, 1977). This arises from the protection of protein from digestion by tannins (Gartner and Hurwood, 1976).

Tannins may reduce cell-wall digestibility by binding bacterial enzymes and/or forming indigestible complexes with cell-wall carbohydrates (Barry and Manly, 1984; Barry *et al.*, 1986; Reed, 1986). The digestibilities of organic matter and the fibre fractions of sheep diets comprising *Acacia 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 (Woodward and Reed, 1989).

TABLE 2.1 Nutrient composition of browse (%DM)

FAMILY			
Species	CP	CF	ASH
CAPPARIDACEAE	20.7	17.4	13.9
<i>Ritchiea reflexa</i>	9.6	34.2	8.5
EUPHORBIACEAE	14.0	19.3	8.1
<i>Securinega virosa</i>	16.6	11.7	10.4
CESALPINOIDEAE	13.6	22.8	6.9
<i>Griffonia simplicifolia</i>	15.7	29.3	8.5
MELIACEAE	14.9	22.5	6.7
<i>Khaya senegalensis</i>	14.9	22.5	6.7
PAPILIONOIDEAE	19.1	24.3	8.0
<i>Milletia thonningii</i>	19.0	29.5	8.8
MORACEAE	10.1	15.1	17.1
<i>Antiaris africana</i>	11.4	15.2	18.2
TILIACEAE	14.3	18.2	10.6
<i>Grewia carpinifolia</i>	17.7	17.8	9.6

Figures for families represent averages of different species in the family.

Source: Le Houèrou (1980).

2.7.2 Palatability Of Browse Species

Palatability could be defined simply as the overall acceptance and relish with which an animal consumes any given feedstuff or diet. Palatability is, essentially, the result of a summation of many different factors sensed by the animal in the process of locating and consuming food and it depends upon appearance, odour, taste, texture, temperature of the food, and in some cases, auditory properties of the animal. These various factors are, in turn, affected by the physical and chemical nature of the food, the effect on individual animal may be modified by physiological or psychological differences. The factors affecting palatability vary in both time and space and are also linked as much as to the animal as to the plant (Dicko-Toure, 1980)

Animals have feed preferences which lead them to make greater or less use of a particular stratum of vegetation. The physiological or nutritional condition of the animal makes it more or less selective.

On the animal side, the palatability of a taxon varies according to its stage of development, its chemical composition and its organoleptic qualities. Some plants are consumed when young and ignored on reaching older stages while others are palatable when scorched and withered than when green (Le-Houèrou, 1980).

The palatability of certain browse species may also be site specific. Reports from Israel (National Academy of Science, 1975) that *Cassia nemophila* var. *coriacea* (syn. *Cassia sturtii*) is a palatable and desirable browse shrub in Israel is not

supported by field observation in Australia (National Academy of Science, 1975). This could indicate a varietal difference as well as animal behavioural differences.



2.7.3 Intake Of Browse Species

Tannins may reduce intake and palatability of feeds by causing an astringent (Bate-Smith, 1973) or dry feeling in the mouth (Goldstein and Swain, 1963), or by negatively affecting digestion.

Reed *et al.* (1990) comparing three browses high in polyphenolics (Leaves of *Acacia cyanophylla* and *Acacia seyal*, and fruits of *Acacia sieberiana*) with that low in polyphenolics (*Sesbania sesban*) and three standard protein supplements (*Vicia dasycarpa* and noug or urea), all of which were fed in combination with teff straw (*Eragrostis abyssinica*) observed that tannins appeared to reduce total feed intake.

Sheep consumed almost all of the *S sesban* offered but only about half of the *A cyanophylla*. Compared with the other two acacias, intake of *A cyanophylla* was lowest, due to its very high content of insoluble anthocyanidins. Intake of *A seyal* was initially also very low, but it increased after the animals got used to the browse.

The effect of browse on the intake of roughage fed concurrently is an important consideration. When *S sesban* was fed with teff straw, the high content of nitrogen and low content of fibre and proanthocyanidins in *S sesban* caused an increase in teff intake over diets including vetch (Reed *et al.* 1990; Woodward and Reed, 1990).

Compared with roughage intake obtained with standard supplements, such as (*Vicia*

dasycarpa and noug or urea), browse with high contents of proanthocyanidins caused a reduction in roughage intake (Tanner, 1988; Reed *et al.* 1990). Browse with moderate levels of proanthocyanidins led to either improved roughage intake (Woodward and Reed, 1989) or intake comparable to that with standard supplements (ILCA, 1988).

2.7.4 Growth Response

Animal growth rates reflect total intake and availability of nutrient 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 (See Table 2.2).

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. Reed *et al.* (1990) found that animals fed *A. sieberiana* fruits and *A. seyal* leaves had low total intake and low growth rates, while feeding *A. cyanophylla* resulted in a negative growth rate. The growth rates of animals fed diets with *A. seyal* improved after a period of adaptation to the browse. The negative effect of tannins in *A. cyanophylla* on growth rate was caused by a reduction in nitrogen availability.

Table 2.2 Browse And Roughage Intakes And Growth Rate Recorded In Three Experiments With Sheep

Browse	Intake (g/d)			Growth	Source
	Browse	Roughage	Total		
<i>Acacia cyanophylla</i> (l)	170	318*	488*	-11*	Reed <i>et al</i> (1990)
<i>Acacia sieberiana</i> (f)	195	269*	464*	20*	Reed <i>et al</i> (1990)
<i>Acacia seyal</i> (l)	193	285*	478*	21*	Reed <i>et al</i> (1990)
<i>Sesbania sesban</i> (l)	157	473	630	48	Reed <i>et al</i> (1990)
<i>Acacia tortilis</i> (f)	336	423	759	53	ILCA (1988)
<i>Acacia brevispica</i> (l)	237	510	747	53	ILCA (1988)
<i>Acacia tortilis</i> (f)	206	430*	636	32	Tanner (1988)
<i>Acacia albida</i> (f)	194	401*	595	22	Tanner (1988)
<i>Acacia nilotica</i> (f)	204	347*	551	16*	Tanner (1988)
<i>Acacia sieberiana</i> (f)	212	320*	532	0*	Tanner (1988)

Notes: Animal performance with browse was compared to performance obtained with a standard supplement. Browse offered varied with experiment but was calculated to provide the same amount of nitrogen in each experiment. The roughage used were grass hay (ILCA, 1988), maize stover (Tanner, 1988) and teff straw (Reed et al, 1990). Standard supplements were cowpea hay and lucerne (ILCA, 1988) noug cake (Tanner, 1988; Reed et al, 1990) and vetch hay (Reed et al, 1990). The browse parts were leaves (l) and fruits (f).

** – Significantly ($P < 0.05$) lower than the value obtained in the same trial for the standard supplement.*

Source: Woodward and Reed, 1989.

2.8 EFFECTS OF BROWSE ON RUMINANTS

One of the most important factors limiting the use of legume shrubs and trees as sources of animal fodders is the presence of antinutritional factors. D'Mello and

Acamovic (1989) list eight antinutritional factors found in *L. leucocephala*. They are mimosine (3-hydroxy -4(1H)-pyridine, DHP), tannins, trypsin inhibitors, galactomannan gums, saponins, flavonols and haemagglutinins. Most of the toxic nature of leucaena arise principally from mimosine and its degradation product, DHP.

The formation of tannin-protein complexes has been found to be the major effect of polyphenolics in browse species, leading to reduced digestibility of nitrogen. The consequences for the animal were an increased faecal nitrogen excretion and a lower rumen fermentation rate.

When an extreme amount of nitrogen was bound, the animal could not achieve positive nitrogen balance and would eventually starve. When the phenolic content was very low, fermentation was so rapid that excess ammonia had to be excreted as urea in urine. This represented loss of nitrogen as well as energy required for detoxification (Woodward and Reed, 1989)

Most species however have moderate levels of proanthocyanidins, which reduce nitrogen availability enough to slow rumen fermentation, thereby resulting in little excess ammonia. More efficient recycling of plasma urea nitrogen to the rumen may also have contributed to a lower loss of nitrogen in urine (Woodward and Reed, 1989). Thus in animals eating feeds with moderate levels of proanthocyanidins, higher faecal nitrogen loss was offset by lower urinary loss. Another advantage of such browses is that the lower fermentation rate of their nitrogen helps improve the

utilization of fibrous crop residues, which also ferment slowly (Woodward and Reed, 1989).

2.9 CONSIDERATION FOR EVALUATION AND MANAGEMENT OF BROWSES

The concentrations of soluble phenolics and insoluble proanthocyanidins in browses vary with season (Woodward, 1988), site (Le Houèrou, 1980) and individual plants. *Acacia cyanophylla* is an example of regional variation. It was fed to small ruminants with good results in West Africa (Dumancic and Le-Houèrou, 1980) but in East Africa, it proved to be a poor feed (Reed *et al.*, 1990).

The variation in phenolic concentration within species and among collections for an experiment may have to do with plant strategy for defense against herbivores (Janzen, 1979) or with response to soil and climate (Le-Houèrou, 1980). In some management systems, browse may be harvested and stored for feeding during the dry season. Rittner (1987) has shown that the effect of storage on phenolic concentration varies with species.



CHAPTER THREE

EXPERIMENT 1

3.0 TITLE : Chemical composition and *in vitro* digestibility of some tree leaves and shrubs, urea ammoniated rice straw, sodium hydroxide treated straw and untreated straw.

3.1 INTRODUCTION

For any browse species to be used effectively as feed supplement, it is important that its chemical composition be known. As a priority, the browse species should have a high protein content to supply both fermentable and by-pass protein. In addition, the browse must contain other critical nutrients (e.g. lipids, minerals, vitamins and other plant compounds) which will enhance the rumen ecosystem so as to increase microbial growth, rate of fibre digestion, propionate production and escape of dietary protein e.g. contains tannins (Preston, 1986). The nutritive value of tropical browse species has been found to be very variable in quality at different seasons. The young growth is frequently more nutritious and/or palatable than mature growth (Wilson and Harrington, 1980).

The objective of this study was therefore to determine the nutritive value of eight different browse species during the two major seasons (wet and dry) of Ghana. Also the nutritive value of untreated rice straw and rice straw treated with urea or sodium hydroxide was determined.

3.2 MATERIALS AND METHODS

3.2.1 Location of Experiment:

The experiment was carried out in the Nutrition Laboratory of the Department of Animal Science, University of Ghana, Legon.

3.2.2 Plant Species

Eight browse species observed to be browsed by livestock in Ghana and fairly spread in some parts of Ghana were selected. These species retain most of their green leaves during most part of the dry season. The tree species were: *Antiaris africana* (Moraceae), *Delonix regia* (Leguminosae), *Khaya senegalensis* (Meliaceae), and *Milletia thonningii* (Papilionaceae), and the shrubs were *Grewia carpinifolia* (Tiliaceae), *Griffonia simplicifolia* (Caesalpiniaceae), *Ritchiea reflexa* (Capparidaceae) and *Securinega virosa* (Euphorbiaceae).

Fresh samples of each species were collected in June, 1993 and January, 1994 to represent wet and dry season samples respectively. Only the leaves were collected regardless of location on the plant. They were bagged and dried at 55°C in an oven to a constant weight.

3.2.3 Untreated and treated rice straw

Rice straw (local variety from Kpong Farms) was coarsely chopped (2-4cm pieces) and used.

3.2.3.1 Ammoniated Straw (UTS)

Chopped straw was spread in a concrete culvert (2 1/2cm x 50cm x 100cm) lined with polythene sheets and each layer of 16kg straw sprayed with urea solution

(75.5g urea in 434.3ml water/kg straw) and rammed down. Filled pits of 64kg were covered with polythene sheets, followed by heaps of soil and left for 21days before removal as done by Quashie (1993) and Egyir (1994). Treated straw was aired for 24 hours before being used.

3.2.3.2 Sodium Hydroxide Treated Straw (STS)

Chopped straw was sprayed with NaOH solution (44.2g NaOH in 118g water per kg straw). The treated straw was kept in jute sacs for at least 7 days before being used.

3.2.4 Chemical Analysis

Some of the chopped straw (treated and untreated) was ground to pass through a 1.00 mm sieve and used for chemical analysis and *in vitro* digestibility.

Dry matter (DM), organic matter (OM) and crude protein (CP) were determined using the methods of A.O.A.C. (1984). Neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose and lignin were analyzed using methods described by Goering and Van Soest (1970).

3.2.5 In vitro digestibility

In vitro digestibility was carried out by the Minson and McLeod (1970) method.

3.2.6 Statistical Analysis

The data were subjected to analyses of variance and treatment means, where necessary, compared on the basis of the least significant difference test.

3.3 RESULTS

Chemical composition and *in vitro* dry matter digestibility of browse species for the two seasons are shown in Table 3.1.

3.3.1 Dry-matter (DM)

Milletia had the highest value of 36.9% for the wet season and Securinega had the lowest value of 25.2%. On the other hand, Ritchiea had the highest DM value of 44.8% for the dry season species with Milletia having the lowest value of 31.5%.

3.3.2 Crude Protein (CP)

Milletia had the highest CP for both the wet and dry seasons (17.1 and 21.9% DM respectively) while Khaya had the lowest values of 11.8 and 12.9%DM respectively for wet and dry seasons.

3.3.3 Neutral Detergent Fibre (NDF)

For both seasons, Milletia had the highest value and Securinega the lowest value. Milletia had NDF values of 63.7 and 63.2% DM while Securinega had values of 28.0 and 26.5% DM for wet and dry seasons respectively.

3.3.4 Acid Detergent Fibre (ADF)

Grewia had the highest values of 41.2 and 45.5% for both wet and dry seasons and Securinega had the lowest values of 13.5 and 14.2% respectively.

3.3.5 Cellulose

Milletia had the highest value of 22.1% during the wet season while Grewia had the highest value of 31.0% during the dry season. Securinega had the lowest cellulose values of 9.7 and 10.6% for wet and dry seasons respectively.

3.3.6 **Lignin**

Delonix had the highest values for both seasons while Securinega had the lowest values. The lignin values for Delonix were 24.0 and 22.0% for the wet and dry season species respectively while Securinega had 3.5 and 3.3% respectively.

3.3.7 **Ash**

For both seasons, Antiaris had the highest values while Delonix had the lowest. Antiaris had values of 10.8 and 10.9% for wet and dry seasons respectively and Delonix had 3.8 and 3.9% respectively.

3.3.8 **In vitro Dry matter digestibility (IVDMD)**

The IVDMD values range between 40.7-75.1% for the dry season with a mean of 57.69% and the wet season had values ranging between 41.12 and 80.00% with a mean of 60.19%.



Table 3.1 Chemical composition (% DM) and per cent *in vitro* Dry matter digestibility (IVDMD) of 8 browse species collected during the dry and wet seasons

Species	Season	DM	CP	NDF	ADF	Cellulose	Lignin	Ash	IVDMD
<i>A. africana</i>	Dry	44.26	14.66	43.91	29.57	16.06	7.87	10.90	70.35
	Wet	34.90	14.66	47.98	30.65	19.27	7.70	10.80	72.02
	Mean	39.58	14.66	45.94	30.11	17.66	7.78	10.87	71.19
	SE	±2.34	+0.24	+1.02	+0.33	+0.84	+0.09	+0.03	±0.42
<i>D. regia</i>	Dry	34.27	19.91	56.45	34.63	12.10	22.02	3.88	52.86
	Wet	34.38	16.85	53.78	35.66	10.96	24.02	3.79	56.97
	Mean	34.33	18.38	55.12	35.14	11.53	23.02	3.85	54.92
	SE	±0.03	±0.77	±0.68	±0.49	±0.31	±0.59	±0.02	±1.03
<i>G. carpinifolia</i>	Dry	37.69	18.16	62.33	45.53	31.04	23.14	9.76	58.41
	Wet	29.99	16.19	55.78	41.17	17.37	14.78	9.70	59.07
	Mean	33.84	17.17	59.05	43.35	24.20	19.96	9.74	58.74
	SE	±1.93	±0.70	±1.64	±1.12	±3.42	±2.09	±0.03	±0.17
<i>G. simplicifolia</i>	Dry	40.60	16.85	55.59	37.43	18.23	19.05	8.45	53.10
	Wet	33.95	13.13	50.29	31.42	14.93	16.00	8.44	54.60
	Mean	37.28	14.99	52.94	34.42	16.58	17.52	8.44	53.85
	SE	±1.66	±0.70	±1.33	±1.55	±0.84	±0.79	0.00	±0.38
<i>K. senegalensis</i>	Dry	34.85	12.91	55.37	35.38	20.50	14.60	5.92	50.94
	Wet	32.74	11.81	48.55	36.45	20.15	15.18	6.09	53.74
	Mean	33.80	12.36	52.96	35.91	20.33	14.89	5.98	52.34
	SE	±0.53	±0.36	±2.21	±0.31	±0.16	±0.32	±0.09	±0.07
<i>M. thonningii</i>	Dry	31.54	21.88	63.23	37.99	25.61	11.85	9.30	40.70
	Wet	36.91	17.07	63.65	40.14	22.09	16.95	9.04	41.12
	Mean	34.23	19.47	63.46	39.07	23.85	13.73	9.21	40.91
	SE	±1.34	±1.25	±0.13	±0.61	±0.89	±0.95	±0.08	±0.11
<i>R. reflexa</i>	Dry	44.85	19.69	52.97	32.05	22.75	8.87	7.21	60.11
	Wet	35.67	17.06	49.41	27.10	17.63	9.30	7.00	64.01
	Mean	40.26	18.38	51.19	29.58	20.19	8.72	7.14	62.06
	SE	±2.30	±0.66	±0.89	±1.24	±1.28	±0.17	±0.06	±0.98
<i>S. virosa</i>	Dry	44.33	18.82	26.52	14.15	10.15	3.32	9.45	75.05
	Wet	25.22	13.56	27.95	13.52	9.74	3.53	9.46	80.00
	Mean	34.78	16.19	27.34	13.84	10.15	3.43	9.45	77.53
	SE	±4.74	±1.35	±0.40	±0.21	±0.24	±0.12	±0.01	±1.24

Mean values of the chemical composition and IVDMD for the two seasons are shown in Table 3.2. Except for DM content which showed a significant difference ($P < 0.05$) between the two seasons, there was no difference between the other parameters.

Chemical composition and IVDMD of treated and untreated straw is shown in Table 3.3. Urea treatment increased ($P < 0.05$) CP, ADF and IVDMD but decreased Ash content. On the contrary sodium hydroxide treatment did not increase ($P > 0.05$) CP but increased ($P < 0.05$) ADF, Ash content and IVDMD.

Table 3.2 Mean chemical composition (% DM) and per cent *in vitro* Dry matter digestibility (IVDMD) of browse species for dry and wet seasons

Season	DM	CP	NDF	ADF	Cellulose	Lignin	Ash	IVDMD
Dry	38.92 ^B	17.86 ^A	52.05 ^A	33.34 ^A	19.61 ^A	12.80 ^A	8.11 ^A	60.19 ^A
Wet	32.97 ^A	15.04 ^A	49.67 ^A	32.01 ^A	16.01 ^A	14.48 ^A	8.04 ^A	57.69 ^A

Means in the same column with uncommon superscripts are significantly different ($P < 0.05$).

Table 3.3 Chemical composition (% DM) and *in vitro* digestibility (IVDMD) of untreated (RS), NaOH treated (STS) and urea ammoniated (UTS) rice straws.

	RS	UTS	STS	SE
DM	86.06 ^B	84.70 ^B	79.17 ^A	3.24
CP	5.74 ^A	10.45 ^B	6.08 ^A	0.61
NDF	80.20 ^C	62.40 ^A	73.05 ^B	2.22
ADF	50.35 ^A	56.80 ^C	54.55 ^B	1.46
Cellulose	32.00 ^A	34.12 ^A	33.40 ^A	1.40
Lignin	9.55 ^A	8.98 ^A	9.02 ^A	0.33
Ash	15.98 ^B	14.30 ^A	16.92 ^C	0.45
IVDMD	40.86 ^A	52.05 ^B	50.98 ^B	0.73

Means in the same row with different superscripts are significantly different ($P < 0.05$).

3.4 DISCUSSION

The dry matter (DM) values obtained for the browse species agree with values obtained by some authors. Rose-Innes and Mabey (1964) had DM values for tropical browse species ranging between 30.8 and 47.1% in Ghana. DM values compiled by Topps (1992) for different tropical legume shrubs and trees from different countries ranged between 19.9 - 36.7%. This shows that even during the dry season, the moisture content of these species is high enough to benefit the livestock. During the wet season because of the high moisture in the soil and high humidity, the leaves have more moisture than the dry season since evapotranspiration is lower during the rainy season. Some of the tree leaves encountered during harvesting in the dry season were succulent because they were the young growths.

All the species had a moderate to high CP content (11.81 - 17.07% DM, in the wet season and 12.91 - 21.88%DM, in the dry season). These values agree with the range of values obtained by Agyei-Henaku (1993), Rose-Innes (1964) and Topps

(1992) for tropical shrubs and tree leaves. When these values are compared with the values of the untreated and treated rice straws (Table 3.3), the browse species have higher CP values. This could make the browse species a valuable source of protein for livestock in the tropics. The CP values of the browse studied show that they could be used as nitrogen supplement to improve the protein content of the diet especially during the dry season. This will help improve the digestibility of the diet hence enhance intake. Though there were differences in the CP contents within most species, these differences were not significant ($P>0.05$).

The range of values of the Neutral detergent fibre (NDF) among the species was quite wide, however, the very low values for *Securinega* compared to the others was due to the fact that most of the *Securinega* plants encountered during harvesting were very succulent. According to Crowder and Chheda, (1982), grasses usually have higher cell wall content than tree leaves and shrubs during the dry season; grasses usually have higher dry matter and this causes an increment in cell wall contents hence reduction in cell contents. This might have caused the rice straws (untreated and treated) to have higher ADF and NDF values as compared to the browse species (Tables 3.2 and 3.3). Characteristically, rice straws also have high silica content which contributes to their high cell wall content.

The total ash content of the species range between 3.79 - 10.90% DM. This falls within the range of values for most tropical species (Topps, 1992). The silica content of the rice straws also contributes to their high ash content.

The IVDMD values indicate that the browse species have medium to high digestibility figures. The mean IVDMD values of the browse species are higher than those for the rice straws. Treatment of the rice straw with urea and sodium hydroxide improved its digestibility (Table 3.3). This supports the findings of Quashie (1993), Egyir (1994) and Amaning-Kwarteng (1991).

CHAPTER FOUR

EXPERIMENT 2

4.0 TITLE: Comparative effects of ammoniation and browse supplementation on rumen metabolites and rumen degradation in sheep fed sodium hydroxide treated rice straw (local variety).

4.1 INTRODUCTION

The nylon bag technique has been used as an appropriate tool for providing information on:

- a) the nutritive value of a feed for ruminants and
- b) the efficacy of the rumen ecosystem.

It generates useful information on the protein status of a feed; and the degree to which both protein and dry matter will be digested in the rumen or escape to the intestines (Preston, 1986).

Though the method has been criticized by some authors (Meyer and Mackie, 1986; Nocek, 1988) it has the advantage of giving very rapid estimates without necessitating any procedure more complicated than simple weighing. It is also a useful tool for improving tropical animal production systems because it is reliable, cheap and easy to perform (Abate and Kiflewahid, 1991). For many feedstuffs in developing countries, there are no data available on the extent of protein degradation, thus limiting the widespread application of feed formulation based on rumen degraded protein (RDP) and undegraded protein (UDP).

The objective of this experiment was to study the degradation characteristics of the eight browse species, urea ammoniated and sodium hydroxide treated rice straw used in Experiment 1 and thus obtain information relating to their nutritive values.

4.2 MATERIALS AND METHODS

4.2.1 Rumen Degradation

4.2.1.1 Location of Experiment

This experiment was carried out at the University of Ghana, Agricultural Research Station (ARS), Legon.

4.2.1.2 Animals

Four rumen-cannulated sheep were used. The diameter of the rumen cannulae was 6.4cm. They were assigned to the experimental diets in a two-4 x 4 Latin square design for fourteen days after fourteen days feed adjustment period. The diets fed were urea ammoniated rice straw, sodium hydroxide treated rice straw supplemented with *Milletia thonningii*, *Delonix regia* and *Securinega virosa*.

4.2.1.3 Sample

Two grams each of the oven-dried (at 55°C) browse species (*Antiaris africana*, *Delonix regia*, *Grewia carpinifolia*, *Griffonia simplicifolia*, *Khaya senegalensis*, *Milletia thonningii*, *Ritchiea reflexa* and *Securinega virosa*), air-dried urea ammoniated rice straw, NaOH-treated rice straw and untreated rice straw, ground to pass through a 2.00 mm sieve, were weighed into nylon bags (with dimensions of 8 cm x 12 cm and pore size of 25 μ .) which had been oven dried and weighed. Dry matter (DM) and Nitrogen (N) analyses were performed on the samples prior to incubation and on the residue following incubation.

4.2.1.4 Incubation and removal of bags

The nylon bags containing samples were soaked in water to displace air before inserting into the rumen. Samples were incubated in duplicates per animal and

replicated. Six bags were tied to a drop line consisting of nylon cord (200 mm x 2 mm) and weighted with a 20g steel bolt at one end.

Incubated bags were withdrawn after 0, 3, 6, 12, 24, 48 and 72 hours. The unopened bags were immediately dipped into absolute alcohol to arrest fermentation. The bags were washed under running water until the solution became clear and then dried at 50°C to a constant weight.

4.2.1.5 Chemical Analysis and Calculation

The dried residues were analyzed for DM and N. The degraded portions for each sample were determined as the difference between the values on the original sample and the incubated and dried residue.

For each sample, percent DM and N disappeared was plotted against incubation time. The values of percent solubility 'a' (the intercept of the graph on the y-axis) and the potentially degradable fraction 'b' (the highest point on the graph) were determined. The steepest section of the curves indicating maximum rate of degradation were identified and the percentage degradation (p) and the incubation time (t) corresponding to the mid-point of this section were read off. This enabled the degradation rate constant 'c' to be calculated from the following exponential equation (Ørskov *et al.*, 1980):

$$P = a + b(1 - e^{-ct})$$

where

P = Potential degradability at time 't'

a = Readily fermentable fraction

b = Potentially degradable fraction (%)

t = Time

c = The rate constant for the degradation of 'b'



4.2.2 Rumen Ammonia and pH

4.2.2.1 Rumen Sample

Rumen liquor was collected after the nylon bag studies. The samples were obtained through the cannula by inserting a short tube connected to a suction pump into different locations in the rumen. About 20–30 ml was collected at every four hour interval starting from time of feeding till 24 hours after feeding and then strained through cheese cloth into a beaker. Immediately pH was taken with a pH meter, after which two drops of concentrated sulphuric acid were added and frozen to await ammonia analysis. This was done over three consecutive days during which the respective trial feeds were given.

4.2.2.2 Chemical Analysis and Calculation

The frozen samples were thawed and centrifuged for 10 mins at 3000 revolution per minute (r.p.m.) and a 5ml aliquot distilled for 5 mins. Using Makhan's steam distillation with 2ml 40% sodium hydroxide. The distillate was collected in 5ml of 2% boric acid solution and then titrated against 0.0142 N H_2SO_4 .

Ammonia - N concentration per 100ml rumen liquor was calculated by the following equation.

$$\text{NH}_3\text{-N} = \frac{T \times 0.2 \times 100}{5}$$

5

where T = Titre value in mls.

4.3 RESULTS

4.3.1 Degradability

Degradation characteristics of the browse species are shown in Table 4.1. The soluble fractions in DM ('a') showed that Khaya had the highest value with Antiaris having the lowest value. Grewia had the highest potential degradable fraction with Milletia having the least. Antiaris had the highest rate of DM degradation ('c') while Grewia had the least.

The DMD values of the browse species ranged between 36.8 to 80.5%. With the exception of *D regia* and *M. thonningii* which had values below 40%, all the species had values above 60%.

Ritchiea had the highest soluble fraction ('a') in N, with Delonix having the least. Securinega and Ritchiea had significantly higher potentially degradable fractions ('b') as compared to the others. Antiaris had the highest rate of nutrient degradation ('c') with Khaya having the least.

The N degradation characteristics range between 50 to 83.5% with Ritchiea having the highest and Delonix the least.

The DM degradation characteristics of untreated rice straw (RS), urea ammoniated rice straw (UTS) and NaOH-treated rice straw (STS) showed that UTS had the highest soluble fraction with RS having the least. Sodium hydroxide treated rice straw had the highest potential degradation fraction ('b') with RS having the least. The rate of nutrient degradation ('c') followed a similar trend as that of the potential degradable fraction.

4.3.2 Rumen pH and Ammonia Nitrogen

Figs 4.1 and 4.2 show ruminal pH changes with time. There was no significant difference ($P > 0.05$) in the pH changes and the peak for the different browse species. The rumen pH showed a decline after feeding with browse and the straw. A steady

increase was however observed after some time. The minimum rumen pH values were 6.3, 6.3, 6.2, 6.3, 6.2, 6.3 and 6.4 for *Delonix*, *Milletia*, *Securinega*, *Grewia*, *Griffonia*, *Khaya* and urea ammoniated rice straw respectively and these occurred at 12, 20, 20, 18, 18, 16 and 12 hours after feeding.

Figs 4.3 and 4.4 show the $\text{NH}_3\text{-N}$ changes with time. There were no significant changes in the peak $\text{NH}_3\text{-N}$ levels for the various browse species. For all the browse species, it was observed that immediately after feeding the rumen ammonia concentration rose till 8 hours after feeding then there was a decline.

Table 4.3 gives the mean pH and peak rumen ammonia levels for all the species.

Table 4.1 Rumen degradation characteristics of tree leaves and shrubs used in feeding trial

SPECIES	DM			N		
	a	b	c	a	b	c
<i>Antiaris africana</i>	8.95 ^A	54.94 ^C	0.052 ^E	15.70 ^C	56.00 ^F	0.043 ^E
<i>Delonix regia</i>	10.50 ^B	27.75 ^A	0.041 ^D	11.00 ^A	39.60 ^A	0.039 ^E
<i>Grewia carpinifolia</i>	9.67 ^A	58.83 ^D	0.025 ^A	18.40 ^D	52.01 ^E	0.023 ^C
<i>Griffonia simplicifolia</i>	16.00 ^C	49.00 ^B	0.032 ^B	23.00 ^F	51.00 ^D	0.023 ^C
<i>Khaya senegalensis</i>	24.00 ^F	48.90 ^B	0.037 ^C	22.70 ^E	46.10 ^C	0.011 ^A
<i>Milletia thonningii</i>	11.00 ^B	25.90 ^A	0.051 ^E	13.00 ^B	40.20 ^B	0.031 ^D
<i>Ritchiea reflexa</i>	20.00 ^D	47.10 ^B	0.036 ^C	25.10 ^G	58.40 ^G	0.034 ^D
<i>Securinega virosa</i>	23.00 ^E	57.50 ^{CD}	0.039 ^{CD}	22.90 ^{EF}	59.80 ^{HI}	0.017 ^B
SE	0.54	1.12	0.01	0.73	0.98	0.01

a = water soluble component (%)

b = potentially degradable fraction (%)

c = rate constant (per hour) at which 'b' is degraded

Means within columns with different superscripts are significantly different ($P < 0.05$)

Table 4.2 Rumen degradation characteristics of treated and untreated rice straws

	DM			N		
	a	b	c	a	b	c
Rice straw (RS)	0.70 ^A	45.88 ^A	0.021 ^A	6.10 ^A	37.70 ^A	0.023 ^A
NaOH-treated rice straw (STS)	5.00 ^B	53.00 ^B	0.046 ^A	7.20 ^A	40.10 ^A	0.020 ^A
Ammoniated rice straw (UTS)	5.80 ^C	49.32 ^{AB}	0.023 ^A	10.50 ^B	50.40 ^B	0.041 ^B
SE	0.34	1.94	0.02	0.51	1.05	0.01

a = water soluble component (%)

b = potentially degradable fraction (%)

c = rate constant (per hour) at which 'b' is degraded

Means within columns with different superscripts are significantly different ($P < 0.05$)

Table 4.3 Mean pH level and Peak NH₃-N of sheep offered browse species with NaOH treated rice straw; and ammoniated rice straw.

	pH level	Peak NH ₃ -N level (mg/100ml.)
<i>M. thonningii</i>	6.7	15.0
<i>D. regia</i>	6.7	14.0
<i>S. virosa</i>	6.5	17.0
<i>G. carpinifolia</i>	6.4	19.0
<i>G. simplicifolia</i>	6.6	18.0
<i>K. senegalensis</i>	6.7	16.0
UTS	6.7	15.0

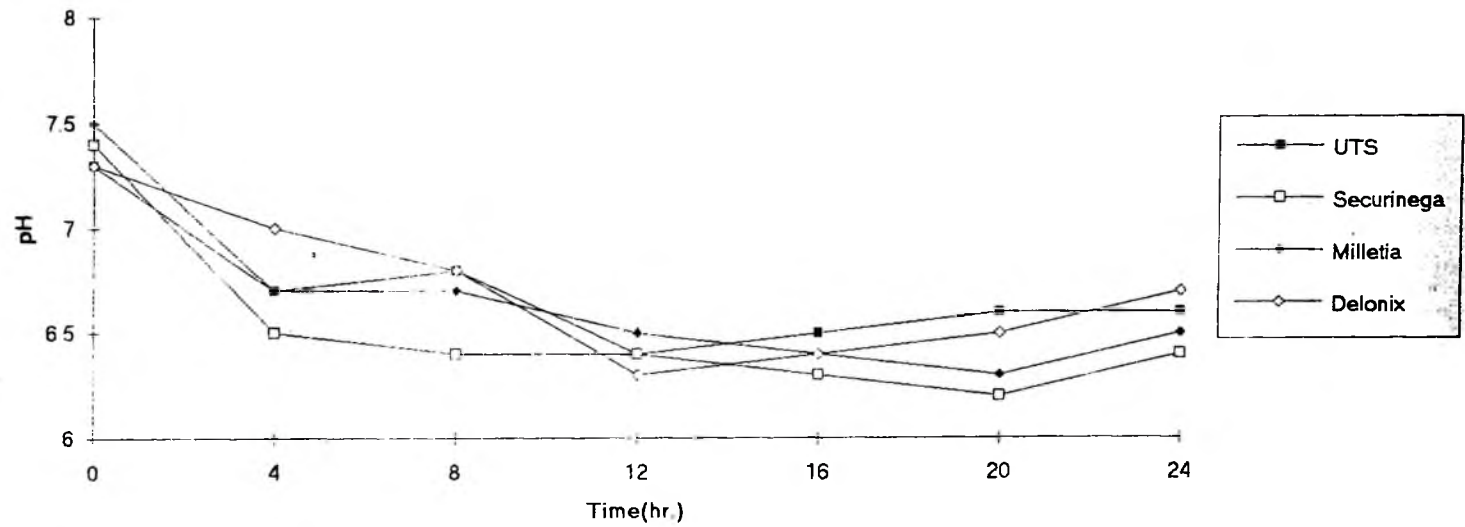


Fig 4.1 Rumen pH levels for urea treated straw (UTS), Securinega, Milletia and Delonix during 24hr feeding period.

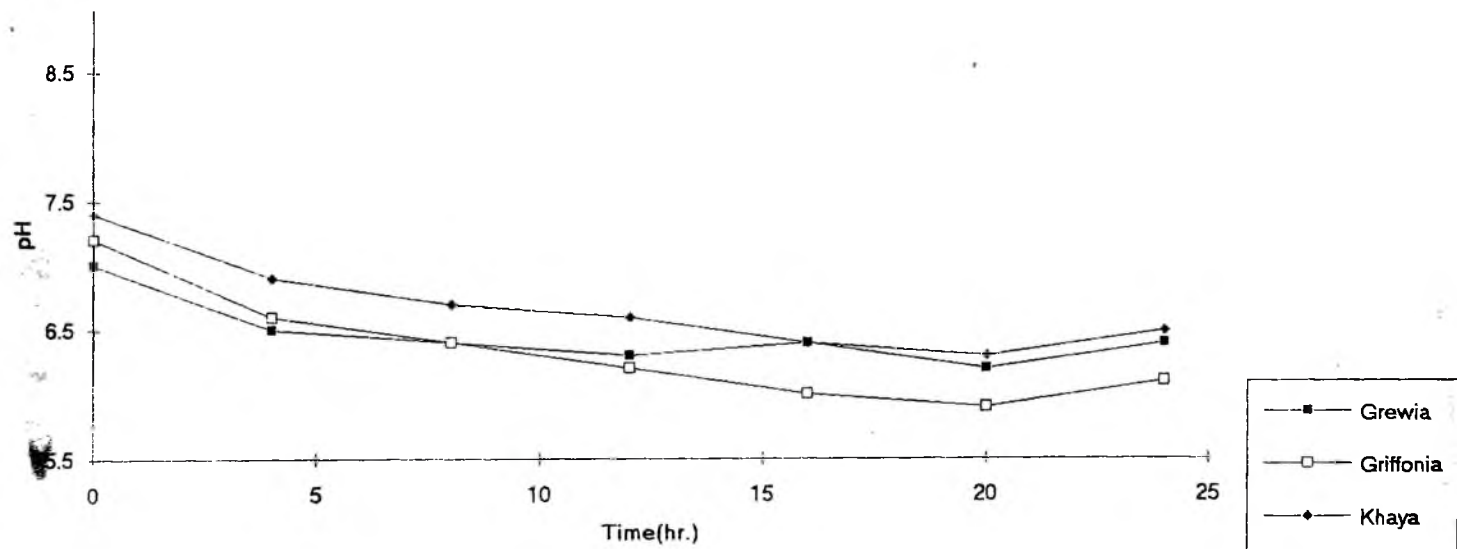


Fig 4.2 Rumen pH levels for Grewia, Griffonia and Khaya during 24hr feeding period.

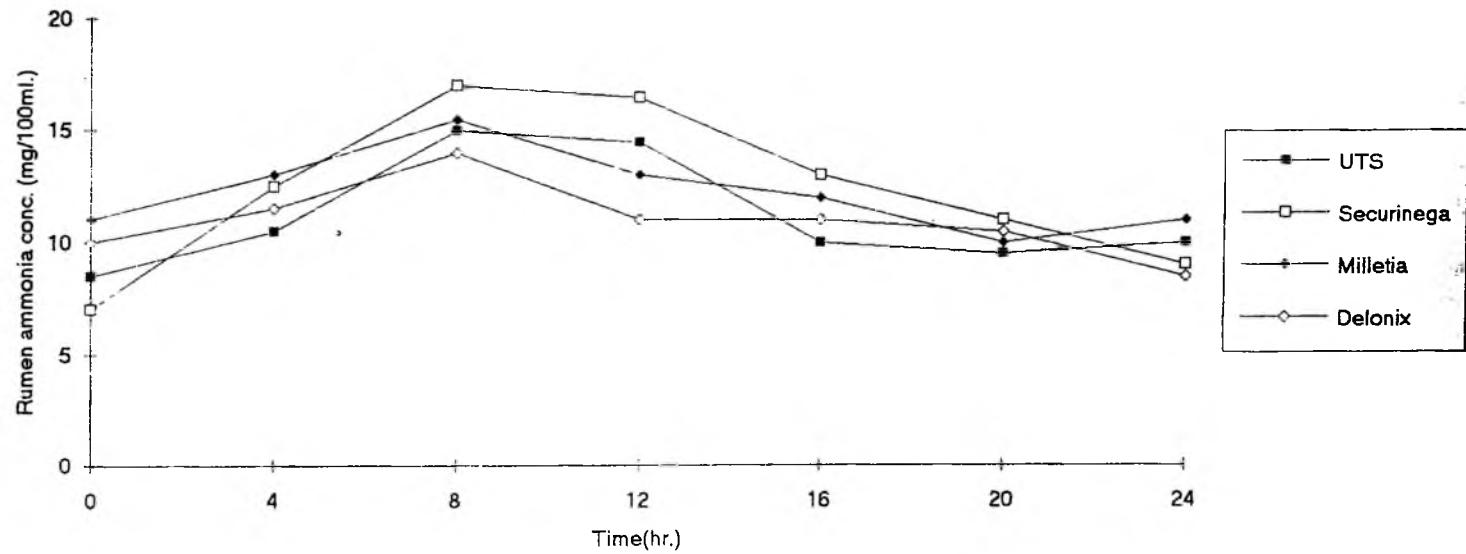


Fig 4.3 Rumen ammonia concentration during 24hr feeding period on urea treated rice straw (UTS), Securinega, Milletia and Delonix.

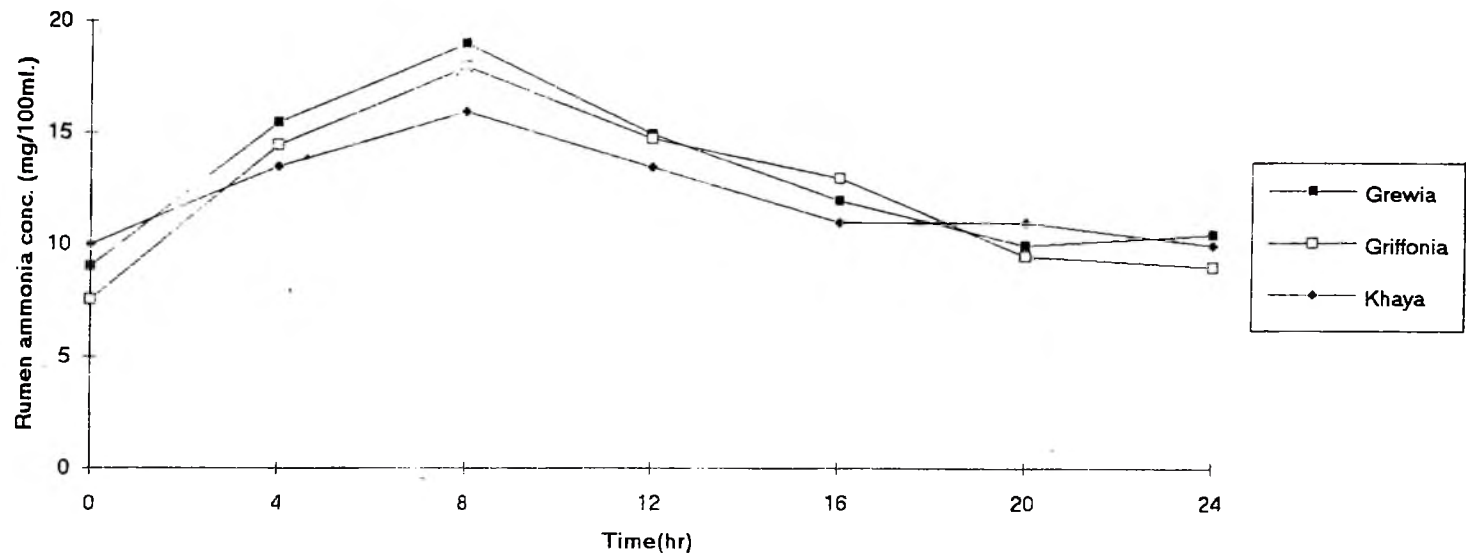


Fig 4.4 Rumen ammonia concentration during 24hr feeding period on Grewia, Griffonia and Khaya.

4.4 DISCUSSION

4.4.1 Degradability

The range of degradability values obtained for the browse species falls within the range of values of 37 to 84% observed by Smith *et al.* (1989). Treatment of crop residues with NaOH or urea improved dry matter digestibility (DMD) of the material as has been reported by Quashie (1993), Egyir (1994) and Amaning-Kwarteng (1991).

According to Preston (1986), if the extent of degradation of roughage after 48 hours in the rumen is less than 40%, then it is not worth feeding. The range of 45 to 56% (DMD) for the untreated and treated crop residues in this study suggest that during the dry season, a balanced selection of browse and crop residues may be able to increase the productivity of ruminants.

Milletia and Delonix showed appreciably lower potential degradable fraction values. They could be sources of undegradable protein. Delonix had the highest amount of lignin. This is likely to affect its degradation in the rumen. According to Van Soest (1982), degree of lignification has a negative effect on cell wall digestion in forages. Fibrous materials are less soluble because of the dominance of structural over soluble carbohydrates in the cell wall. The low and slow degradability of Delonix and Milletia can limit their intake. Low degradability increases retention time of the feed residue in the rumen and this is associated with decreased voluntary intake. The speed at which the digested components are removed from feedstuffs and thus the time which the feed occupies space in the rumen as well as the space taken up by the material during digestion are influenced by both the rate of degradation and the extent of digestion of the feedstuff.

For most of the species in this study the potential degraded fraction is low to medium giving an indication that they could have medium to high protein value. The potential degradable fractions of N for the browse species show that even though most

of them will be highly degraded in rumen, quite a proportion will escape rumen microbial degradation, especially those of *Milletia* and *Delonix*.

A high protein value of a feed is obtained when the degradation of protein in the rumen is low and the rumen undegraded protein (UDP) passing the small intestine has high digestibility (Mgheni, 1994).

4.4.2 Rumen pH and Ammonia Nitrogen

Ruminal pH of 6 - 7 tend to favour fibre digestion (Preston and Leng, 1986), this makes solubility of protein to increase and absorption of NH_3 to become rapid. Solubility of protein is reduced at lower pH (less than 5.5) and protein in solution is more accessible to microbial attack than insoluble protein.

There is production of volatile fatty acid (VFA) after feeding which results in decline in the pH value. The decline in pH values did not affect cellulolytic microbes hence did not affect degradability. The rumen pH for all the diets showed that the values were adequate for rumen micro-organisms to function. (Preston and Leng, 1986).

Generally there was a fall in the ammonia content after 8 hours of feeding due to the utilization of ammonia by the rumen microbes and absorption into the blood. The level of rumen ammonia is critical for efficient microbial fermentation of feed. Rumen ammonia concentration can therefore be used to diagnose a deficiency of fermentable nitrogen in the diet. Mehrez *et al.*(1977) reported that the optimum level of rumen ammonia for maximum rate of fermentation on fibrous substrate was around 20mg/100ml. However Preston (1986) has indicated that it is advantageous to have a level lower than optimum level (20mg/100ml.) on such diets to slow down the rate of fermentation.

The production of low ammonia nitrogen during the feeding of fibrous material could hamper the activities of rumen microbes. When low quality roughage materials are consumed, rumen ammonia levels should not be less than 5mg/100ml (Preston,

1986) since less than 5mg/100ml results in negative nitrogen balance, reduced rate and dry matter digestion, reduced fibre digestion and reduced dry matter intake. The critical ammonia level in the rumen for efficient microbial growth on different substrates is likely to vary according to the fermentability of the substrate. Preston (1986) has however suggested that that figure (5mg/100ml.) appears too low and that the first supplement to be considered should be a source of fermentable nitrogen to ensure the level of rumen ammonia is above 15mg/100ml. of rumen fluid and this must be for prolonged periods for effective use of fibrous diets.

In the current study most of the rumen ammonia concentration were raised above 15mg/100ml. for some time and kept above 5mg/100ml. throughout the sampling period. This was true for the rice straw supplemented with browse or treated with urea. The low ammonia concentrations occurred during the night because of the long hours without any supplementation.



CHAPTER FIVE

EXPERIMENT 3

5.0 TITLE Performance of sheep fed sodium hydroxide treated rice straw supplemented with browse compared with those fed urea treated rice straw.

5.1 INTRODUCTION

The use of multipurpose trees to provide forage in a cut-and-carry system has been advocated for small-holder farmers in most parts of Africa (Atta-Krah *et al.*, 1987). Supplementation of poor quality diets with tree foliage has been shown to improve growth rates in animals (van Eys *et al.* 1986). The chemical composition and the degradabilities of the tree leaves and shrubs in the previous experiments (Experiments 1 and 2 respectively) suggest they could be very valuable in animal feeding.

The objective of the present study was to find out the relative intakes of crop residues and browse as well as the growth rates of sheep fed crop-residue supplemented with the tree leaves (*Milletia thonningii*, *Delonix regia* and *Khaya senegalensis*) and shrubs (*Griffonia carpinifolia*, *Grewia simplicifolia* and *Securinega virosa*) compared with urea treated rice straw.

5.2 MATERIALS AND METHODS

5.2.1 Metabolism Studies

This was done in two phases. Eight wethers of average liveweight of 22kg. were used for the first part. Four of the animals were fitted with permanent rumen cannulae (6.4cm diameter) and the other four were 'intact' The intact animals were

each paired with the fistulated ones. All the animals were housed in individual metabolism cages. The animals were assigned to the experimental diets in a two-4 X 4 Latin square design. In phase I, the diets were urea ammoniated rice straw; NaOH treated rice straw supplemented with *Securinega virosa*, *Delonix regia* or *Milletia thonningii*. The urea ammoniated rice straw were prepared as described in Experiment 1. The feeding period was 28 days made up of fourteen days for sample collection. Salt block and water was made available to the animals at all times.

The phase II, involving 6 animals (3 fistulated and 3 intact), the animals were assigned to the experimental diets in a two-3 X 3 Latin square design. The diets were NaOH treated rice straw supplemented with *Grewia carpinifolia*, *Griffonia simplicifolia* or *Khaya senegalensis*.

Feed intakes were measured daily and refusals were collected daily and bulked. Daily faecal output was weighed and bulked. Subsamples were taken and dried at 55° C. The animals were weighed before the experiment and on the last day of the experiment.

5.2.2..Chemical Analysis and Calculation

Feeds, refusals and faecal samples were analyzed for dry matter (DM) by drying in an oven at 55°C. Organic matter (OM) was determined as DM less the residual ash obtained after ashing at 550°C for 6 hours.

OM in feed and faeces, DM intake and Digestible OM in dry matter (DOMD) were thus determined. These data were used according to Ministry of Agriculture, Food and Fishery, MAFF (1975) to calculate Metabolisable Energy Intake (MEI) and then estimate the ratio of MEI to Metabolisable Energy required for maintenance (Mm) for each diet.

5.2.3 Growth Trial

This was also carried out in two phases.

5.2.3.1 Animals and Management

Twenty-four Nungua Black Head X Djallonke gimmers with an average liveweight of 14kg were used to measure growth responses to the experimental diets. The animals were housed in individual pens, which had concrete floors, asbestos roofing and the sides made of wooden rails. No bedding was provided.

Two weeks prior to the commencement of the experiment, the animals were treated for ectoparasite with Bayticol (Bayer Leverkusen) and endoparasite with Abendazol (Dapharama, Raamsdonskeveer, Holland).

5.2.3.2 Experimental Design

The twenty-four animals were divided into four groups of six animals per group. One group each was assigned to each of the experimental diets in a completely randomized design for 10 weeks to evaluate the effect of the diets on growth rate and feed conversion efficiency. Feed adjustment period was two weeks. Live weight was measured every two weeks after a 12 hour starvation period.

Water and mineral salt licks were provided *ad libitum* to all animals during the experiment. The mineral salt lick had the following composition (mg/kg): Mg : 2500; Fe : 1800; Mn : 380; Zn : 280; Co : 110; and Se : 3.

5.2.3.3 Feeding

Animals on NaOH treated rice straw supplemented with browse species were fed *ad lib* the browse from 9.00a.m. to 10.00a.m. followed by the rice straw which was fed *ad lib*. Those on urea ammoniated rice straw were offered the feed at 9.00a.m. and fed *ad lib*.

In the first phase of this study, animals were fed 4 diets (urea ammoniated rice straw; NaOH treated rice straw supplemented with *S. virosa*, *M. thonningii* and *D.*

regia). For the second phase of the study, the animals were fed urea ammoniated rice straw; NaOH treated rice straw supplemented with *K. senegalensis*; *G simplicifolia* and *G carpinifolia*.

5.3 RESULTS

Table 5.1 shows the dry matter intakes and the growth rates of wethers on the test diets for a period of two weeks.

Table 5.2 gives the average DMI and growth rates of animals on diets. The trend was similar to that shown in Table 5.1. The exception was the dramatic change in the average daily gain in animals on *D regia* which was 44.3g/d as against -44.29g/d for animals fed two weeks in the metabolism cages.

Table 5.3 shows the metabolizable energy intake (MEI) relative to maintenance energy requirement (Mm).

Table 5.1 Browse and straw intakes of sheep fed a period of two weeks
(Preliminary study)

Diet	<u>Mean Dry Matter Intake (g/d)</u>		
	Browse	Straw	Total
<i>M. thomningii</i> + STS	107.04	359.90	466.94
<i>S. virosa</i> + STS	110.13	326.59	436.72
<i>D. regia</i> + STS	75.03	325.01	400.04
<i>G. carpinifolia</i> + STS	245.18	391.89	637.07
<i>G. simlicifolia</i> + STS	175.47	404.05	579.52
<i>K. senegalensis</i> + STS	61.48	410.65	472.13
UTS	-	473.17	473.17

STS = Sodium hydroxide treated rice straw

UTS = Urea treated rice straw

Table 5.2 Average Dry Matter Intake and growth rates of sheep fed NaOH treated rice straw supplemented with browse: and urea ammoniated rice straw for ten weeks.

Diet	Mean Dry Matter Intake (g/d)			Initial wt (kg)	Final wt (kg)	Average Daily Gain (g/d)	FCR
	Browse	Straw	Total				
<i>M. thonningii</i> + STS	102.21 ^C (26.04%)	290.29 ^A	392.50 (90.47%)	14.1 ^B	17.9 ^{BC}	54.3 ^B	7.23
<i>S. virosa</i> + STS	103.29 ^C (27.34%)	274.45 ^A	377.74 (87.07%)	12.8 ^A	17.2 ^B	62.9 ^{CD}	6.01
<i>D. regia</i> + STS	73.92 ^B (19.93%)	296.89 ^A	370.81 (85.47%)	14.8 ^B	17.9 ^{BC}	44.3 ^A	8.37
<i>G. carpinifolia</i> + STS	100.00 ^C (25.61%)	290.40 ^A	390.40 (89.99%)	12.3 ^A	16.9 ^B	65.7 ^D	5.94
<i>G. simplicifolia</i> + STS	94.00 ^C (24.37%)	291.71 ^A	385.71 (88.91%)	12.7 ^A	17.5 ^{BC}	68.6 ^D	5.62
<i>K. senegalensis</i> + STS	42.00 ^A (12.39%)	297.00 ^A	339.00 (78.14%)	12.1 ^A	14.7 ^A	37.1 ^A	9.13
UTS		433.84	433.84	15.1 ^B	19.0 ^C	55.7 ^{BC}	7.79

NOTE Figures in brackets under the browse intake indicate the per cent DMI of browse relative to total DMI. Those under the total DMI indicate the per cent total DM consumed as compared to DM urea ammoniated straw consumed.

Means in the same column with different superscripts are significantly different ($p < 0.05$).

STS = Sodium hydroxide treated rice straw. UTS = Urea treated rice straw.

Table 5.3 Metabolizable Energy Intake (MEI) relative to Maintenance Energy Requirement (Mm) by sheep fed the experimental diets

Parameter	UTS	Milletia +	Delonix +	Securinega	Grewia +	Griffonia +	Khaya +
		STS	STS	+ STS	STS	STS	STS
Mean live weight(kg)	24.4	22.8	22.5	22.3	22.3	22.6	23.1
DOMD(%)	63.96	76.52	70.65	81.97	54.52	61.89	61.56
MEI(MJ/d)	4.54	5.36	4.24	5.37	5.21	5.38	4.36
Mm	4.37	4.16	4.12	4.10	4.10	4.14	4.20
MEI : Mm	1.04	1.29	1.03	1.31	1.27	1.30	1.04

DOMD = Digestible Organic Matter in Dry matter

$$= \frac{100 (\text{OM intake} - \text{faecal OM})}{\text{OM intake}}$$

OM intake

MEI = DOMD \times 0.15 \times Dry Matter Intake (MAFF, 1975)

Mm = 1.2 + 0.13(Body weight in kg) (MAFF, 1975)

UTS = Urea ammoniated rice straw

STS = Sodium hydroxide treated rice straw

5.4 DISCUSSION

5.4.1 Growth Responses

Apart from the growth responses of animals on Delonix which showed a dramatic change (see Table 5.1 and 5.2) the rest had similar trends. It could be due to the fact that animals took a longer period to adapt to Delonix. This was similar to an observation made by Woodward and Reed (1989), when they fed sheep with different browse species, it took over 7 weeks for the performance of animals on *Acacia seyal* to improve. This shows that animals take different time to adapt to different browse species. Observation showed that it took the animals much shorter time to consume

Securinega, Grewia and Griffonia than Milletia, Delonix and Khaya. It is possible that the first three species were relatively more palatable than the last three. Intake of Delonix was initially very low but improved with time as the animals got used to it. The intake of Khaya however was very low throughout the feeding period indicating that it might not be palatable as suggested by Toutain (1980) or due to its high content of tannin (Bate-Smith, 1973).

Apart from Khaya, the DMI of all the browse species offered *ad lib* fell within the range proposed by Le-Houerou (1980) that browse should form between 20-30% of the total DMI if it is used effectively as nitrogen supplement. Tannins in browse are known to precipitate digestive enzymes and salivary microproteins and at high levels in the diet may depress intake and digestibility (Topps, 1992). The very low intake of Khaya (12.4% of the total diet) could account for the lower growth rate of the animals on Khaya.

Animal growth rate reflect total intake and availability of nutrients in the diet. Although animals on urea ammoniated straw consumed a significantly higher feed than those on the browse, the performance of animals on some of the browse species were better than those on urea ammoniated straw. This result was similar to observations made by Woodward *et al.* (1989) and Tanner (1988), when they compared the performances of animals on browse to those on other non-tanniferous nitrogen supplements. They observed that whenever there was a reduction in total intake due to the fibre or phenolic content of the browse, growth rate was low compared with that obtained with the non-tanniferous supplements.

The results indicate that supplementation with browse species is able to improve performance of animals.

5.4.2 MEI relative to Mm

The Ministry of Agriculture, Food and Fisheries, MAFF (1975) proposed that for research purposes, the most useful indicator of feed to meet maintenance requirement is the use of the ratio of MEI to Mm. If the ratio is greater than one, then the feed is adequate for maintenance.

The results in this study show that all the diets had ratios greater than one, which indicate that the diets could provide all the required maintenance energy and even provide for growth.

This suggests that ammoniation and treatment of low quality roughage with NaOH and supplementing with browse could help improve the performance of ruminants during the dry season.

Egyir (1994) found out earlier that ensiling low quality roughage with urea improved its feeding quality and had the potential of meeting maintenance requirement.

CHAPTER SIX

6.0

GENERAL DISCUSSION

The chemical composition, rumen degradation, dry matter intake and growth responses were some of the parameters used in this study to determine the performance of sheep fed crop residue supplemented with browse.

Many researchers have found the nutritive value of browse to be better than that of crop residues (Le-Houerou, 1980, Woodward and Reed, 1989, Topps, 1992). The results obtained in Chapter 3 (Tables 3.1 and 3.2) show that though the browse species and the rice straws (untreated and treated) had good nutritional values, the browse species had higher nutritional values. These materials will be particularly useful as supplementary feeds during the dry season when forage quality is low. The mean CP values obtained for all the browse species were about three times higher than the value (5%) reported by Rose-Innes and Mabey (1964) for grass during the dry season.

The *in situ* dry matter degradability values obtained in Chapter four, will be useful in identifying the good feed materials for use in practical ruminant diets. According to Devendra (1985) a feed that meets maintenance requirement of an animal should have a crude protein level of 6 - 7%, a dry matter digestibility of 50 - 55% and a dry matter intake of about 1.7% of body weight. Most of the browse species had appreciably high rumen dry matter and nitrogen degradabilities making them potential good feed materials. Ensiling the rice straw with urea and treatment with NaOH increased its digestibility because the ammonia from the urea and the NaOH could have loosened the ligno-cellulotic bonds in the rice straw. This enhanced the digestibility of the rice straw.

The diets consumed gave a rumen ecosystem (pH and $\text{NH}_3\text{-N}$ level) that ensured optimum conditions for fibre degradability. A rumen pH between 6 and 7 and the minimum rumen $\text{NH}_3\text{-N}$ level that ensures adequate fibre digestion is 5mg/100ml. Alvarez *et al* (1983) observed that the rate of dry matter loss of alkali-treated maize

cobs from nylon bags in the rumen increased linearly as rumen ammonia concentration was raised from 3 to 12mg/100ml. of rumen fluid. The diets in this study provided the right rumen conditions. Rumen ammonia concentration is an indicator of nitrogen available for microbial protein synthesis. There was rise in the rumen ammonia concentration with the supplementation of the straw with the browse species.

In Chapter five, the formula proposed by Ministry of Agriculture, Food and Fisheries (1975) was used to determine whether the experimental diets would be able to meet maintenance requirements (Mm) of the animals. All the diets were able to meet the maintenance needs of the animals and provide some amount of growth. Khaya was not palatable and it took quite some time for the animals to get used to Delonix. Despite these situations, the performance of the animals on these diets was quite good. This gives an indication that during the dry season when forage quality is low, a proper use of treated rice straw supplemented with browse species could be used by small-holders to maintain the liveweight of their animal

CHAPTER SEVEN

7.0

CONCLUSION

The performance of animals fed crop residues during the dry season can be improved if the feed material is treated with sodium hydroxide to enhance its digestibility and improve its voluntary intake and then supplemented with browse species. The feeding of browse species has been shown to improve the digestibility of the diet and leads to improvement of the animals' performance.

Though urea ammonification of straw and NaOH treatment of straw are quite laborious and involve addition cost of chemicals, farmers stand to benefit if they apply these methods and supplement the treated straws with browse.

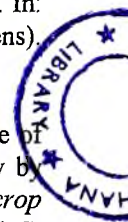
Considering the abundant quantity of crop residues produced and the wide variety of shrubs and tree plants available in this country, farmers with small number of animals may be able to feed their animals to maintain their weights during the dry season.

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APPENDICES**APPENDIX I**

ANOVA showing %DM for untreated (RS), NaOH treated (STS) and urea ammoniated (UTS) rice straws (Table 3.3)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	2	79.91	39.93	71.36*	5.14
Error	6	3.36	0.56		
Total	8	83.27			

$$SD = (2 \times 0.56/3)^{1/2}$$

$$= 0.611$$

$$LSD = 0.611 \times 2.5$$

$$= 1.53$$

Means of DM values

79.17^A 84.70^B 86.06^B



APPENDIX II

ANOVA showing %CP for untreated (RS), NaOH treated (STS) and urea ammoniated (UTS) rice straws (Table 3.3)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	2	40.497	20.249	397.03*	5.14
Error	6	0.306	0.051		
Total	8	40.803			

Least significant difference (LSD)

$$\text{Standard deviation (SD)} = (2 \times \text{EMS}/r)^{1/2}$$

where,

EMS = Error mean square

r = Replicate

$$\therefore \text{SD} = (2 \times 0.051/3)^{1/2}$$

$$= 0.184$$

$$\text{LSD} = 0.184 \times 2.5$$

$$= 0.46$$

$$5.74^A \quad 6.08^A \quad 10.45^B$$

APPENDIX III

ANOVA showing %NDF for untreated (RS), NaOH treated (STS) and urea ammoniated (UTS) rice straws (Table 3.3)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	2	481.39	240.70	8023.17*	5.14
Error	6	0.17	0.03		
Total	8	481.56			

$$SD = (2 \times 0.03/3)^{1/2}$$

$$= 0.1414$$

$$LSD = 0.1414 \times 2.5$$

$$= 0.35$$

Means of NDF values

62.40^A 73.05^B 80.20^C

APPENDIX IV

ANOVA showing %ADF for untreated (RS), NaOH treated (STS) and urea ammoniated (UTS) rice straws (Table 3.3)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	2	64.31	31.155	918.71*	5.14
Error	6	0.21	0.035		
Total	8	64.52			

$$SD = (2 \times 0.035/3)^{1/2}$$

$$= 0.1528$$

$$LSD = 0.1528 \times 2.5$$

$$= 0.38$$

Means of ADF values

50.35^A 54.55^B 56.80^C



APPENDIX V

ANOVA showing IVDMD for untreated (RS), NaOH treated (STS) and urea ammoniated (UTS) rice straws (Table 3.3)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	2	228.78	114.39	12710*	5.14
Error	6	0.05	0.009		
Total	8	228.83			

$$SD = (2 \times 0.009/3)^{1/2}$$

$$= 0.077$$

$$LSD = 0.077 \times 2.5$$

$$= 0.19$$

Means of IVDMD values

40.86^A 50.98^B 52.05^C

APPENDIX VI

ANOVA showing the DM Readily fermentable fraction (a) of the tree leaves and shrubs (Table 4.1)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	7	1084.18	154.88	619.52*	2.42
Error	24	5.97	0.25		
Total	31	1090.15			

$$SD = (2 \times 0.25/4)^{1/2}$$

$$= 0.353$$

$$LSD = 0.353 \times 2.064$$

$$= 0.73$$

Means of 'a' values

8.95^A 9.67^A 10.50^B 11.00^B 16.00^C 20.00^D 23.00^E 24.00^F

APPENDIX VII

ANOVA showing the DM Potentially degradable fraction (b) of the tree leaves and shrubs (Table 4.1)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	7	4514.96	644.99	178.17*	2.42
Error	24	86.91	3.62		
Total	31	4601.87			

$$SD = (2 \times 3.62/4)^{1/2}$$

$$= 1.345$$

$$LSD = 1.345 \times 2.064$$

$$= 2.78$$

Means of 'b' values

27.90^A 27.75^A 47.10^B 48.90^B 49.00^B 54.94^C 57.50^{CD} 58.83^D

APPENDIX VIII

ANOVA showing the DM Rate constant (c) for the degradation of the tree leaves and shrubs (Table 4.1)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	7	0.023	0.00033	79.2*	2.42
Error	24	0.0001	0.0000042		
Total	31	0.0024			

$$SD = (2 \times 0.0000042/4)^{1/2}$$

$$= 0.00144$$

$$LSD = 0.00144 \times 2.064$$

$$= 0.003$$

Means of 'c' values

0.025^A 0.032^B 0.036^C 0.037^C 0.039^{CD} 0.041^D 0.051^E 0.052^E

APPENDIX IX

ANOVA showing the Readily fermentable fraction (a) of N for the tree leaves and shrubs (Table 4.1)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	7	773.42	110.49	5764.6*	2.42
Error	24	0.46	0.019		
Total	31	773.88			

$$SD = (2 \times 0.0192/4)^{1/2}$$

$$= 0.098$$

$$LSD = 0.098 \times 2.064$$

$$= 0.202$$

Means of 'a' values

11.00^A 13.00^B 15.70^C 18.40^D 22.70^E 22.90^{EF} 23.00^F

APPENDIX X

ANOVA showing the Potentially degradable fraction (b) of N for the tree leaves and shrubs (Table 4.1)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	7	1703.36	243.34	10428.86*	2.42
Error	24	0.56	0.023		
Total	31	1703.92			

$$SD = (2 \times 0.0233/4)^{1/2}$$

$$= 0.108$$

$$LSD = 0.108 \times 2.064$$

$$= 0.223$$

Means of 'b' values

39.60^A 40.20^B 46.10^C 51.00^D 52.01^E 56.00^F 58.40^G 59.80^G

APPENDIX XI

ANOVA showing the Rate constant (c) for the degradation of N for the tree leaves and shrubs (Table 4.1)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	7	0.0034	0.000490	58.2*	2.42
Error	24	0.0002	0.000008		
Total	31	0.0036			

$$SD = (2 \times 0.0000083/4)^{1/2}$$

$$= 0.002$$

$$LSD = 0.002 \times 2.064$$

$$= 0.0042$$

Means of 'c' values

0.011^A 0.017^B 0.023^C 0.023^C 0.031^D 0.034^D 0.039^E 0.043^E

APPENDIX XII

ANOVA showing the DM Readily fermentable fraction (a) of the treated and untreated rice straws (Table 4.2)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	2	60.19	30.095	338.15*	4.26
Error	9	0.80	0.089		
Total	11	60.99			

$$SD = (2 \times 0.089/4)^{1/2}$$

$$= 0.211$$

$$LSD = 0.211 \times 2.26$$

$$= 0.4767$$

Means of 'a' values

0.7^A 5.0^B 5.8^C

APPENDIX XIII

ANOVA showing the Potentially degradable fraction (b) of treated and untreated rice straw (Table 4.2)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	2	101.43	50.72	8.55*	4.26
Error	9	53.40	5.93		
Total	11	154.83			

$$SD = (2 \times 5.93/4)^{1/2}$$

$$= 1.722$$

$$LSD = 1.722 \times 2.26$$

$$= 3.89$$

Means of 'b' values

45.88^A 49.32^{AB} 53.00^B

APPENDIX XIV

ANOVA showing the DM Rate constant (c) for the degradation of treated and untreated rice straw (Table 4.2)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	2	0.00082	0.00041	0.44	4.26
Error	9	0.00844	0.00094		
Total	11	0.00926			

APPENDIX XV

ANOVA showing the Readily fermentable fraction (a) of N for the treated and untreated rice straws (Table 4.2)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	2	42.56	21.28	24.46*	4.26
Error	9	7.80	0.87		
Total	11	50.36			

$$SD = (2 \times 0.87/4)^{1/2}$$

$$= 0.6595$$

$$LSD = 0.6595 \times 2.26$$

$$= 1.49$$

Means of 'a' values

6.10^A 7.20^A 10.50^B

APPENDIX XVI

ANOVA showing the Potentially degradable fraction (b) of N for the treated and untreated rice straws (Table 4.2)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	2	390.59	195.30	65.98*	4.26
Error	9	26.64	2.96		
Total	11	417.23			

$$SD = (2 \times 2.96/4)^{1/2}$$

$$= 1.2166$$

$$LSD = 1.2166 \times 2.26$$

$$= 2.75$$

Means of 'b' values

37.70^A 40.10^A 50.40^B

APPENDIX XVII

ANOVA showing the Rate constant (c) for the degradation of N for the treated and untreated rice straws (Table 4.2)

Source of variation	Degree of freedom	Sum of squares	Mean square	F-calculated	F-table
Treatment	2	0.0010	0.000500	45.45*	4.26
Error	9	0.0001	0.000011		
Total	11	0.0011			

$$SD = (2 \times 0.000011/4)^{1/2}$$

$$= 0.00236$$

$$LSD = 0.00236 \times 2.26$$

$$= 0.0053$$

Means of 'c' values

$$0.020^A \quad 0.0023^A \quad 0.041^B$$