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ORGANIC MATTER & NEUTRAL DETERGENT FIBRE DEGRADABILITY OF SEMI-ARID BROWSE SPECIES CONTAINING ANTINUTRIENTS

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ABSTRACT

Three ruminally cannulated bulls were used to determine variations in dry matter (DM) degradability of forage consumed by ruminants in the semi-arid region of north Nigeria. Organic matter and crude protein (CP) contents were higher (P< 0·05) in all the browse forages. Higher numerical values of neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin and cellulose were recorded. Condensed tannin varied from 0.08 mg/g DM in Kigalia africana to 0.41 mg/g DM in Maerua angolensis. A range of 0.24 mg/g DM in Olea hochstteteri to 0.48 mg/g in Khaya senegalensis was obtained for phenolic. Saponin content of the experimental leaves range from 1.08 mg/g DM in Poupartia sirrea to 2.95 mg/g DM in Garderna sokotensis. Oxalate in the browses used ranged from 4.59 mg/g DM in Maerua angolensis to 8.14 mg/g DM in Olea hochstteteri. The highest value of 5.81 mg/g DM was obtained in Khaya senegalensis while Olea hochstteteri had the lowest value of 2.02 mg/g DM for Phytic acid in the browses studied. The hydrogen cyanide and Fluoroacetate are generally low in all the browse samples studied. The result showed no significant difference among the browse forages.NDF degradability after 24 and 48 h of ruminal incubation were higher (P< 0·05) in all the browses. Higher values (P< 0·05) in DM bag losses at zero time ('a' fraction) were high for the browses. The insoluble but fermentable NDF ('b' fractions) were low (P< 0·05) among browse forages. Numerically lower values of NDF 'c' fraction were found in browses except for Kigalia africana, whereas NDF potential degradability were higher (P< 0·05) in all the experimental leaves. High (P< 0·05) contents of CP in the browse forages, NDF degradability after 48 h of ruminal incubation, and a+b, were observed in the browse leaves. Thus, these results may be related to both the better feeding value of forage consumed by the animals and better performance of livestock during in these areas. Then, the NDF degradability after 48 h, together with the soluble fraction 'a' and insoluble but fermentable fraction 'b' and the c fraction permit the nutritive value of the forage consumed by grazing goats to be accurately described. The rate of OM disappearance was highest for Garderner sokotensis 97.20% though the values were generally high for all the browse forages studied. The soluble fraction 'a', rate of degradation 'c' and effective degradability 'ED' were generally low for all the browse forages while the insoluble but degradable fraction

KEYWORDS

In situ, browse, antinutritive, degradation, neutral detergent fibre, organic matter

'b' and potential degradability a+b were high for all the browse forages. Based on these findings, it can be concluded that the browse forages are of good nutritive value and can be used as supplement.

Introduction

Inadequate nutrition due to shortage of feed and year round quality forage is one of the major problems facing ruminant production [1], crop residues or by-products [2] which result in reduced livestock productivity in the tropical countries [3]. Browses are important in providing nutrient to grazing ruminants in arid and semi-arid environments where inadequate feeds are a major constraint for livestock production [4]. Tree fodders maintain higher protein and mineral contents during growth than grasses, which decline rapidly in quality with maturity [1]. Tree fodders are important source of nourishment for grazing ruminants and as supplements to improve the productivity of herbivores fed on low quality feeds. Browse forages form part of the complex interactions between plants, animals and crops [4], the positive aspect of which is to help balance a plant-animal-soil ecosystem from which there is sustainable source of feeds [5]. The availability of a variety of these feeds and the selection process enables the herbivores especially the goats to extend as well as meet their feed preferences. Traditional farmers in the semi-arid region of Nigeria allow their goats, sheep and cattle to browse on tree forages, in the range lands and they also cut and feed these tree foliages as supplements based on experience and convenience. Leguminous trees and shrubs often have thorns, fibrous foliage and growth habits which protect the crown of the tree from defoliation. Many plants also produce chemicals which are not directly involved in the process of plant growth (secondary compound) but act as deterrents to insects and fungal attack. These compounds also affect animals and the nutritive value of the forages. Mycotoxins (fungal metabolites) produced by saprophytic and endophytic fungi are also a potential source of toxins in forages (Norton, 1994).

The objective of these study is to evaluate the nutritive value of some selected browse forages of semi-arid environment using the in sacco technique.

Materials and Methods

2.1 Description of site and samples

All forages were harvested from Gwoza local government area (11.05^0 N; 30.05^0 E; 364m above sea level) of Borno State, North Eastern part of Nigeria. The ambient temperature ranges between 30 and 42^0C during the hottest period (March to June) and decreases to 19 - 25^0C between November and February [6]. Two browse forage species commonly found in the Semi-arid and derived Savannah zones were used in this experiment; the species were Garderna sokotensis, Khaya senegalensis, Kigalia Africana, Leptadenia lancifolia, Maerua angolensis, Olea hochstteteri, and Poupartia sirrea. The browse forages were harvested from at least 10 trees per species selected at random in four locations within the study area at the end of rainy season. The samples were sun-dried, milled and sub- sampled for analysis.

2.2 Sample preparation

About 500g of the harvested and pooled samples from each plant were oven dried at 105^0C for 24hours, cooled and weighed. The weight difference between the initial weights and dried weights was taken as the moisture content of the leaves and then converted to percentage. Percent dry matter content was then obtained as the difference between 100 and percent moisture content [7]. The dried weekly samples were then bulked according to plant species and each shared into two portions. One portion was sun dried and milled to pass through 2mm sieve, labelled and stored in sealed polythene bags for degradability and in vitro studies. The other portion (also milled to pass through 1mm sieve) was labelled and as well stored for proximate analysis.

2.3 Chemical analysis of browse forages

The samples were analyzed in triplicate for crude protein (CP), according to AOAC [7] procedures. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin were determined as described in Van Soest et al. [8]. Hemicellulose was estimated as NDF-ADF and cellulose as ADF-lignin. To determine the organic matter content of the residues, sub-samples (500 mg) were placed in crucibles and burnt for 2 hours at 500°C. The ash was weighed and the value was subtracted from the values for dry matter. The balance sample residues after milling were then used for other chemical analyses. Nitrogen was analyzed according to standard [7] procedure. Crude protein was calculated by multiplying the percent nitrogen content by the factor 6.25.

2.4 Anti-Nutritional Factors Assessment in the Samples

Some anti-nutritional constituents that were determined in the browses include Phytate estimated as phytic acid using the method prescribed by [9], while hydrogencyanide (HCN) was determined by the Knowels and Watkins distillation method as described by Pearson [10]. Saponins and total condensed tannin were determined as reported by Babayemi et al., [2] and Polshettiwar et al., [11]. Phenolics were determined using Folin Ciocalteu metho as described by Makkar [12].

2.5 Management and feeding of Animals

Three ruminally cannulated bulls were used for this experiment. They were housed in individual pens with concrete floors bedded with wood shavings. The beddings were changed weekly. In these pens they were offered corn bran, cowpea husk and salt lick as supplements daily. The animals also had free access to fresh clean water daily. The diet provided the animals were to allow the rumen microbial population meet their requirement for essential nutrients as well as provide optimum rumen environment for degradability. The area around the opening of the cannulae was cleaned regularly with warm water and detergent to prevent infection by pathogens.

2.6 In Sacco NDF and OM degradability study

The rate of nutrient disappearance in the browse species was determined by the use of nylon bag technique. Milled (<1.0mm) samples were oven-dried overnight (24 hrs) at 70^{o}C prior to weighing into the bags measuring 140x20mm when laid flat. A piece of marble was included in each bag containing 5g of feed sample to prevent the bag from floating in the rumen. The weight of each bag and its content was then recorded. Ten bags containing the sample were incubated at the same time in each animal. A bag was removed from each of the three animals at 3, 6, 12, 24, 48, 72 and 96 hours for observation of nutrient disappearance. The experiment was carried out in two periods so that each of the fistulated bulls will have 10 bags/sample. The bags were tied using a nylon twine and carefully inserted into the rumen. After each incubation period, the bags were carefully removed and rinsed with tap water until the water was clean and clear. The washing procedure took 30 min and then the bags were oven-dried. The bags were allowed to air-calibrate to room temperature for about three hours in a desiccator before weighing to determine bag plus marble plus feed sample residue weight for dry matter determination. The difference between the initial and final weights of each sample was regarded as degraded material and thereafter expressed as a percentage of the initial weight. After incubation, all the bags were withdrawn from the rumen at the same time and immediately placed under running cold tap water until the rinse water became clear. This was done to wash off ingested feed particles adhering to the bags as well as stop further fermentative processes. The bags with the sample residues were then oven dried at 65^{0}C for 48hours and the weight of the bags plus residues measured and recorded. The zero-hour washing losses that is, losses due to non-incubation, were determined by soaking 5g of each of the samples in triplicates in warm water (37^{0}C) for 1 hour which was followed by washing and drying of the bags as done with the incubated sample residues. NDF and OM losses was computed as the

difference between the determined NDF and OM content of the pre- incubated samples and the determined NDF and OM content of the incubated residues.

NDF or OM disappearance (%) = Initial NDF or OM - final NDF or OM X 100
Initial NDF or OM

Digestion characteristic of NDF and OM were obtained by fitting data to the equation [13]: P = a + b (1- e-ct), Where:

P = Potential degradability after time‘t’ a = Water Soluble Fraction (zero hour) b = Insoluble but degradable fraction after time‘t’ c = Rate of degradation of slowly degradable fraction b t = Incubation length i.e. 3, 6, 12, 24, 36, 48, 72, 84 and 96 hours e = exponential

The effective ruminal degradability of NDF (EDNDF) and OM (EDOM) were calculated according to Ørskov and McDonald [14]: EDNDF = b × (c/(c + k)) where k = $0.12h^{-1}$ and EDOM = (a+b)c/(c+k) ($e^{-(ct)LT}$) where $k=0.12h^{-1}$

2.7 Statistical Analysis

Data obtained from the degradation characteristic of the incubated plant species at the different hours were subjected to analysis of variance [15] using the completely randomized design. Treatment means were separated by Duncan’s multiple range test.

Results

3.1 Chemical composition of the browse forages

The proximate composition of the browse forage leaves determined in this study is presented in Table 1. Dry matter content ranged from 838.30 g kg^{-1} DM in Poupartia sirrea to 983.00 g kg^{-1} in Garderna sokotensis on DM basis. Generally, the examined plant leaves had high crude protein values. The mean content of this nutrient was 147.64% ranging from 132.20 g kg^{-1} DM in Poupartia sirrea to 174.30 g kg^{-1} DM in Maerua angolensis. Values obtained for organic matter content of the browse for ages ranged from 742.60% in Poupartia sirrea to 868.70 g kg^{-1} DM in Khaya senegalensis.

3.2 Fiber content of semi-arid browse forages

The highest neutral detergent fibre content of 688.10 g kg^{-1} DM was recorded in Kigalia africana while Leptadenia lancifonia had the lowest value of 433.10 g kg^{-1} DM. The acid detergent fibre levels in the experimental leaves ranged from 206.80 g kg^{-1} DM in Olea hochstteteri to 255.20 g kg^{-1} DM in Kigalia afrcana. The least lignin content of 96.70 g kg^{-1} DM in the browse forages was recorded in Olea hochstteteri while Leptadenia lancifonia had the highest value of 152.80 g kg^{-1} DM. Cellulose levels in the browse forages were within the range of 131.20 g kg^{-1} DM in Leptadenia lancifolia to 183.20 g kg^{-1} DM in Garderna sokotensis while hemicellulose content of the browse leaves ranged from 189.20 g kg^{-1} DM in Leptadenia lancifonia to 432.90 g kg^{-1} DM in Kigalia africana.

3.3 Anti-nutritional factor levels of semi-arid browse forages

The result of anti-nutritional constituents in the browse forage leaves is shown in Table 2. Total condensed tannin varied from 0.08 mg/g DM in Kigalia africana to 0.41 mg/g DM in Maerua angolensis. A range of 0.24 mg/g DM in Olea hochstteteri to 0.48 mg/g in Khaya senegalensis was obtained for phenolic. Saponin content of the experimental leaves range from 1.08 mg/g DM in Poupartia sirrea to 2.95 mg/g DM in Garderna sokotensis. Oxalate in the browses used ranged from 4.59 mg/g DM in Maerua angolensis to 8.14 mg/g DM in Olea hochstteteri. The highest value of 5.81 mg/g DM was obtained in Khaya senegalensis while Olea hochstteteri had the lowest value of 2.02 mg/g DM for Phytic acid in the browses studied. The hydrogen cyanide and Fluoroacetate

are generally low in all the browse samples studied. The result showed no significant difference among the browse forages.

3.4 Neutral detergent fibre (NDF) disappearance

The NDF disappearance of the browse forages analysed is shown in Figure 1. An initial high rate in disappearance of NDF from the incubated leaves was observed at 3 hr with none of the leaves noticed to have lost less than 34% of its NDF content. However the trend of NDF disappearance in all the browse forages was slow from 3 to 96 hrs of incubation with all the browse forages having more than 60% of their NDF content degraded by 96 hrs of incubation except for Olea hochstteteri having 59.31%. NDF in Garderna sokotensis (70.59%), Kigalia africana (73.85%) and Poupartia sirrea (71.09%) were highly soluble and 96 hrs of incubation periods.

3.5 Organic Matter (OM) disappearance

The extent of disappearance of OM in the incubated browse leaves is shown in Figure 2. Organic matter content was highly degradable though it progressed slowly from 0 hour to 96 hours. The OM disappearance were generally low for all the browse forages at 0 - 24 hours incubation periods. Garderna sokotensis had the highest OM disappearance of 97.20%

3.6 Neutral detergent fiber (NDF) fermentation characteristics

The degradation characteristics for NDF in the browse leaves incubated in the rumen of bulls are as shown in Table 2. The means for the various characteristics measured varied significantly ($P<0.05$). The rapidly degradable fraction 'a' in the NDF component of the browse tested ranged from 35.93% in Olea hochstteteri to 62.20% in Kigalia africana. Results reported for the insoluble but degradable fraction ‘b' in the NDF content was low ranging between 12.46% and 24.91% in Maerua angolensis and Olea hochstteteri respectively. Potential degradation ‘a+b’ values obtained for NDF in the leaves studied was from 60.84% in Olea hochstteteri to 75.06% in Kigalia africana. The degradation rate c’’ of NDF in the leaves was observed lowest in Garderna sokotensis with a value of 0.027/hr and highest in Kigalia africana with a value of 1.035/hr. Effective degradability (ED) (0.12) estimates for NDF were observed to be generally fair in the leaves used for this study.

3.7 Organic matter (OM) fermentation characteristics

Organic matter degradation characteristics for the incubated browse leaves are shown in Table 3.
Except for rate of degradation ‘c’ which was not significant, all other characteristics varied significantly ($P<0.05$). Values obtained for the solubility of OM in browse leaves ranged from a low value of 2.23% in Maerua angolensis to a high value of 8.76% in Garderna sokotensis. With the insoluble but degradable fraction ‘b’, OM recorded the least value in Maerua angolensis (59.24%) while the highest was in Poupatia sirrea with 73.16%. No significant differences ($P>0.05$) were observed for degradation rate constant between the leaves studied. However, a range of 0.017/hr in Poupatia sirrea to 0.060/hr in Maerua angolensis was observed. At an outflow rate of 0.12, the effective degradability of OM was highest in Garderna sokotensis (20.70%) and lowest in Poupartia sirrea (12.30%).

I. Discussion

4.1 Chemical composition of selected browes forages of semi-arid

The crude protein (CP) content of the browse forages studied was generally higher, which is above the 7% CP requirement for ruminants that should provide ammonia required by rumen microorganism to support optimum microbial growth. The high CP content of browse species is well documented and is one of the main distinctive characteristic of browse compared to most grasses. [16] reported a range of CP contents from 12 to 30% for tropical tree legumes, and [17] gave a mean of 12.5% in West African browse species with about 17% for

leguminous species. Generally, the CP content in browse has been shown to be above the minimum level required (7%) for microbial activities in the rumen [16].

With regard to the fibre content, Rittner and Reed [18] reported similar mean for NDF and lignin contents across different ecological zones as follows 40.1% and 11.7% in the Sahelian zone, 45.7% and 10.5% in the sub-humid zone and 43.6% and 9.3% in the humid zone respectively. NDF and ADF contents in the browse forages studied were similar to the values reported by Njidda [19] and this can limit feed intake [20]. This species also had a high lignin content. Lignin is a component of the cell wall, and deposited as part of the cell wall-thickening process [21]. Lignin is in general higher in browse than in herbaceous plants. The content varies according to species, age and the plant parts. Positive correlations were reported between contents of lignin and soluble or insoluble proanthocyanidins [18].

Cellulose is closely associated with lignin thus the observed relatively high lignin content in the examined plant leaves may have resulted in the high cellulose levels in this study. In other words, the concentration of cellulose provides an insight as to the level to which the forage has been lignified. The high level of lignin in the studied leaves could be adduced to their maturation. This is likely so because according to Wilson [22] environmental factors, particularly temperature, significantly influence the content and digestibility of cell wall in forage through faster tissue maturation.

The cell wall content hemicellulose was observed to be fairly high. With a mean value of 310.27 g kg^{-1} DM in the investigated plants, they appeared quite high compared to reported levels in the common browse forages. These hemicelluloses levels in the plants may be acceptable levels although rumen microbes are incapable of adequately degrading this fibre component of plants. Going by the observations of Roger et al. [23] and Njidda [18] who noted that sun drying affected the chemical composition of tree legumes, the high hemicellulose content of the leaves in this study may have probably been due to the drying of samples of the plants before they were analyzed.

4.2 Anti-nutritive substances

Tannins are phenolic plant secondary compounds and are widely distributed through the plant kingdom, especially legumes and browses which affect animal performance in many countries [24]. The level of CT is lower than the range of 60 to100 g Kg^{-1} DM considered to depress feed intake and growth [25] but within the range 0.41 to 0.81 mg g^{-1} DM reported by Njidda et al. [26] for semi-arid browse forages. Feeding tannin containing plant can decrease ruminal protein degradation, promote microbial crude protein (CP) synthesis [27], and prevent excessive ruminal gas formation which can lead to bloat [28, 29]. However, in ruminants, dietary condensed tannins of 2 to 3% have been shown to have beneficial effects because they reduce the protein degradation in the rumen by the formation of a protein-tannin complex [30, 31] and increasing absorption of amino acids in the small intestine [32]. On this basis, they have been proposed as feed additives to improve digestive utilization of dietary protein [33]. While moderate concentrations of CT (2-4.5% DM) can exert beneficial effects on protein metabolism in ruminants, high dietary CT concentrations (>5.5% DM) can depress voluntary feed intake, digestive efficiency and animal productivity. However, effects are not the same for all CT as they depend upon its chemical structure [24]. Several ruminal microorganisms have been identified that can tolerate relatively high concentrations of both hydrolysable and condensed tannins (CTs) [34]. However, the mechanism for this tolerance has not been completely elucidated. The values for phenolic compounds in this study were lower compared to that reported by Osuga et al. [35]. Phenolic compounds are the largest single group of secondary plant compounds (SPCs), and total phenolics in plants can reach up to 40% of the dry matter [36]. In grasses, the major phenolic is lignin that

is bound to all plant cell walls, and is a significant limiting factor in their digestion in the rumen [34]. Lignin is also a limiting factor in the digestion of legumes, but is bound largely to the vascular tissue [38], with often high concentrations of other free and bound phenolic compounds (phenolic acids, coumarins and flavonoids) in floral, leaf and seed tissues [39].

Oxalate content in this present study was low. It has been reported that 20g/kg oxalate can be lethal to chicken [40]. Oxalate has been shown to deplete the calcium reserve, but these browse species were found to contain reasonable amount of calcium, magnesium and phosphorus. Ca and carbon are also released from the hydrolysis of Ca Oxalate some of which will be either absorbed or excreted by the ruminant animals. With Ca absorption rate of ruminants put at 31% [41] and P at 4% absorption [42] reasonable amount of the Ca and P intakes will be lost via faces and urine to the soil. Such voided minerals/nutrients are thereby recycled for further use to support plants which are ploughed back into the soil. When so much N is returned to the soil, this reduces the use of inorganic N fertilizer and lends weight to the use of organic manure in farming. However, given the time to adapt, the microorganisms in the rumen can metabolise moderate amounts of oxalate.

Saponins are group of compounds containing an a-glycone moiety linked to carbohydrates. Many plant species consumed by livestock contain saponins. Feedstuffs containing saponin have been shown to be defaunating agents [43] and capable of reducing methane production [44]. Saponins have effect on erythrocyte haemolysis, reduction of blood and liver cholesterol, depression of growth rate, bloat (ruminant), and inhibition of smooth muscle activity, enzyme inhibition and reduction in nutrient absorption [45]. Saponins have been reported to alter cell wall permeability and therefore to produce some toxic effects when ingested [46]. The ant nutritional effects of saponins have been mainly studied using alfalfa saponins. Sharma and Chandra [47] observed that 4-7 weeks of ad libitum feeding of albizia gave rise to toxic manifestation in sheep. Symptoms include listlessness, anorexia, weight loss and gastro-enteritis. The toxicity of saponins can be reduced by repeatedly soaking the feed in water. The level recorded in this present study may not pose any problem the animals.

Phytic acid is a phosphoric acid derivative of myo-inositol. It constitutes an important component of forage plants with the ability to chelate essential minerals including calcium, magnesium, iron, zinc and molybdenum [42]. The resulting chelates resist breakdown in the digestive tract and become unavailable thus inducing dietary deficiency of these elements [42]. Most of the phosphorus in plants is organically bound to phytic acid [9]. In this regard, it was reported that 40-50% and 28% respectively of the total phosphorus are present as phytate-phosphorus, which is unavailable for utilization by animals [48]. However, [42] noted that a phytic acid degrading enzyme phytase appears to be present in the gastrointestinal tract. This is possibly why phytic acid bound phosphorus can be utilized to some extent by ruminants [49]. The phytin levels reported in this study is lower than 13.80 to 25.20 mg/g DM reported by Okoli et al. [50] for the southeastern browses in Nigeria. These levels are unlikely to have any adverse effects on ruminants.

The HCN contents of the browse species examined were equally low. The lethal dose of HCN for cattle and sheep is 2.0 to 4.0 mg per kg body weight. The lethal dose for cyanogens would be 10 to 20 times greater because the HCN comprised 5 to 10% of their molecular weight [51]. However, the quantity of HCN produced by most of these species is too low to pose major animal health problems [52]. Animals suffering from cyanide toxicity must be immediately treated by injecting a suitable dose of sodium nitrate and sodium thiosulphate [53]. Generally, only plants that produce more than 20mg HCN/100 g fresh weight are considered deleterious [54]. The value for fluoroacetate was negligible to pose any problem to animals although if the compound is in large amounts it is

known to inhibit the Krebs cycle by formation of fluoroacetate [55] and is used as a poison for rats and rabbits [56].

Fibre digestion in the rumen is a function of both the rate of degradation as well is the retention time in the rumen [57]. Furthermore, [58] is of the view that fibre degradation in the rumen is positively related to dry matter intake by ruminant.

The degradation parameters of neutral detergent fiber varied between the plants leaves studied. This corroborates the assertion by Yang [59] that species of forage influence neutral detergent fiber degradation characteristics. The variation in the soluble fraction in which Faidhebia albida was observed to have the highest value, may have resulted from variation in the degree of lignifications. Negative effect of cell wall on digestibility has been earlier reported [60]. This result was similar to what [61] reported for the neutral detergent fiber in some multipurpose trees but higher than what [62] reported for oil palm fronds. All the leaves tested revealed relatively low levels of insoluble but degradable fraction of neutral detergent fibre. These figures were lower than the range of 40-56.3% reported for some browse species [63]. The rate of degradation ‘c’ of neutral detergent fibre in the leaves were generally low except for Kigalia Africana. This is likely to result in rumen fill and by extension reduce intake. Decreased rumen pH to affect rate of degradation in vitro [64] and in vivo [63] although this factor was not measured in this study. These low degradation rates of neutral detergent fibre degradation in the leaves may have been influenced by the long time it took the microbes to initiate cell wall degradation (lag time) of this nutrient. The neutral detergent fibre degradation rates in these leaves were lower than values reported by Moya-Rodrigucz et al. [63] for tropical browse species, Kigalia Africana had the highest potentially degradable neutral detergent fibre value in this study. This may have derived from the high level of insoluble fraction. Hendrickson et al.[61] however reported higher values for this parameter than was observed with the leaves of this study. Effectively and although moderately high in the leaves investigated, NDF in the browse forage leaves were better degraded than the others. This may have arisen from the high level of the soluble fraction in of the browse forages. Effective degradability of neutral detergent fibre in the leaves studied was observed lower than ealier reported values [61, 63].

Recorded values for fiber component disappearance from the studied leaves were generally high. These loss of neutral detergent fibre from the experiment leaves was slow such that during 48hrs incubation the highest value was 73.59% (Kigalia africana). This slow trend continued up till 96hrs of incubation. This may have resulted due to the slow rate of degradation 'c’ of this nutrient. This view is supported by the observation of Archimede et al. [65] that microbial digestion of fibre in the rumen is reduced when retention time of digesta in the rumen decreases. It is also thought that rumen pH may have been acidic. By the end of 96hrs incubation all the incubated browse leaves had more than 60% of their neutral detergent fibre content degraded except for Olea hochstteteri 59.31%. Disappearance values for this fibre component was least in Olea hochstteteri during 48hrs (56.91%) and 96hrs (59.31%) incubation periods.

Determining the degradation of organic matter in situ is essential. This is in view of the fact that microbial protein synthesis is highly dependent on availability of rumen degradable organic matter [66, 67] are of the view that rate of nitrogen and carbohydrate degradation especially from forage and concentrate mixtures, increase the efficiency of microbial protein synthesis due to improved rumen environment for the growth of more diverse bacteria species. The shrub and tree leaves used in this study varied in organic matter degradation characteristics,

Readily soluble fraction of organic matter in the test leaves was observed to be highest 18.76% in both Gardena sokotensis. This may be due to the presence of degradable carbohydrates, particularly the non-structural ones and

NDF proteins and fat, components that may make organic matter readily degradable in situ in the rumen [68]. In this regard, NRC [69]) suggests that feeding diets with at least 12% protein may be necessary to maximize organic matter fermentation in the rumen. On the contrary the least 'a' value recorded in Maerua angiogenesis indicates that this browse forage may be composed of slow degrading carbohydrates, likely to affect the efficiency of microbial protein synthesis [70]. Nevertheless, the organic matter solubility range reported in the shrub and tree leaves of this of this study (2.23 to 8.76%) were higher than values reported in some roughages [68]. The insoluble but degradable organic matter fraction 'b' was high in the plant leaves compared to values reported for some multipurpose tree species [71]. This may be the result of the organic matter solubility in the leaves indicating the possibility of a high amount of nutrients by-passing the rumen microbes. The potential degradability 'a+b' of the organic matter in the leaves studied was generally high and reflected the high soluble ('a') organic matter fraction in the leaves. This may have been due to the low rate of degradation constant 'c' as inferred by Kibon and Ørskov [72] with the potential degradability of dry matter in browse plants. Potential degradability values reported for roughages [68] were similar to what obtained in this investigation. Effective degradability values reported for organic matter in-the leaves studied showed this nutrient to be well degraded in situ at an outflow value of 0.12. However, [73] have observed variations in effective degradability amongst leaves to be associated with variability within the leaves.

Conclusion

In conclusion, the leaves of the browse forages showed high potential as a feed supplement to ruminant animal in the semi-arid especially in terms of crude protein supply for effective microbial activity in the rumen.

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