Seasonal Changes in Chemical Composition, Preference and *In Sacco* Degradation of Eight Different Fodder Tree leaves

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Abstract

Livestock farmers in the Coastal Savannah of Ghana cut and feed leaves of various naturally occurring fodder tree species to supplement livestock diets, especially in the dry season. The aim of this study was to determine the seasonal changes in chemical composition, rumen degradation characteristics and preference of sheep for eight common indigenous fodder tree leaves, and ascertain their contribution to livestock production. Fodder leaves from *Albizzia lebbek* (AL), *Baphia nitida* (BN), *Blighia sapida* (BS), *Ficus exasperata* (FE), *Ficus polita* (FP), *Morinda lucida* (ML), *Moringa oleifera* (MO) and *Spondias mombin* (SM) were used. Fresh leaves were sampled in the wet and dry seasons to determine changes in seasonal chemical composition. Four Djallonke sheep (two males and two females) of average weight of 27.3 kg ±0.22 were offered fresh fodder leaves in a cafeteria system to determine preference. *In sacco* dry matter (DM) degradation was determined using four fistulated sheep in a repeated 4x4 Latin square design. Seasonal DM, crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) and lignin content of the fodder leaves ranged from 319.7 to 862.7 g kg^{-1}, 150.0 to 359.2 g kg^{-1} DM, 181.1 to 491.5 g kg^{-1} DM , 277.5 to 718.3 g kg^{-1} DM and 50.5 to 242.0 g kg^{-1} DM respectively. Crude protein content of AL and FP were higher for the wet season than dry season but BS had similar trend for both seasons. The soluble and potentially degradable fractions of DM ranged from 113.3-216.8 and 142.9-627.7 g kg^{-1}. It is concluded that the four most preferred fodder species were AL, FE, SM and MO. Their CP contents regardless of the season were higher than the minimum level considered as adequate for moderate ruminant production. It is expected that, these fodder leaves will contribute to by-pass protein and nitrogen retention and subsequently lead to weight gain when fed to sheep.

Keywords: crude protein degradation, dry matter degradation, rice straw, rumen pH, sheep

Introduction

In most parts of West Africa, grazing lands are diminishing and their soil fertility declining due to alternative uses and lack of proper management. This has led to both qualitative and quantitative decline in forage production with their attendant effect on ruminant livestock production, especially in the dry season (Alhassan et al., 1999). This deficiency in forage quantity and quality is a critical constraint to livestock production in the tropics (FAO, 2012). To ameliorate this problem, livestock farmers harvest leaves of fodder trees for their animals to supplement limited grazing (Adogla-Bessa et al, 2012).

The major determinants of nutritive value of feed for livestock include feed dry matter (DM), levels of nitrogen and fibre, digestibility of organic matter (OM), voluntary intake of DM and metabolisable energy (Minson, 1990, Idan et al., 2020, Sarkwa et al., 2020). Many fodder tree leaves contain high levels of digestible protein, minerals and vitamins which can play major roles in improving intake of roughage by ruminants (Bayer, 1990, Larbi et al., 1993, Idan et al., 2020), and hence improve low quality roughage utilization (Topps, 1992). The nutritive value of tropical fodder tree leaves have been found to be variable in quality at different seasons (Sottie et al., 1998; Anele et al., 2009) but the rate of fluctuation in their nutritive value with changing seasons is less drastic than that of grasses (Anugwa et al., 2000; Ukwanwoko and Ironkwe, 2013). Thus, fodder trees maintain high feeding value well into the dry season (Gohl, 1993, Sarkwa et al., 2020). Many fodder trees and shrubs are harvested and offered to animals by farmers but their consumption is affected by their palatability which depends on the physical and chemical nature of the feed.

The purpose of feed nutrient analysis is to predict the productive response of animals when they are fed rations of a given composition. Fonseca et al (1998) noted that DM degradation after 72 or 96 hours were the best predictors of organic matter digestibility. In Ghana, Addo-Kwafo (1996) and Fleischer et al (1998) reported on the nutritive value and rumen degradation characteristics of some fodder tree leaves. Information on nutritive value and rumen degradation of indigenous fodder tree leaves is scanty. This study sought to determine the dry and wet seasonal changes in chemical composition, measure the rumen degradation characteristics and determine the preference index of sheep fed eight indigenous fodder tree leaves.

Materials And Methods

Study site

The study was carried out at the Livestock and Poultry Research Centre, University of Ghana, Legon, situated in the Coastal Savannah zone of Ghana (GPS N: 05° 40' 572; W 00° 06' 280). The soil is mostly tropical black vertisol. Rainfall is bimodal with the major season in March to July and the minor season in September to October. The total annual rainfall is 881 mm, whilst temperature ranges between 32.22 ºC and 34.49 ºC (Sarkwa et al., 2020).

Collection of fodder tree leaves

Fresh leaves from eight fodder trees (browse) were collected weekly from the same site for about eight weeks in July-August and January-February to represent wet and dry seasons respectively (Nine sample collections per season). Trees were *Albizzia lebbek* (AL), *Baphia nitida* (BN), *Blighia sapida* (BS), *Ficus exasperata* (FE), *Ficus polita* (FP), *Morinda lucida* (ML), *Moringa oleifera* (MO) and *Spondias mombin* (SM). Samples were clipped at random from all parts of trees and then bulked. Only mature trees from 2-3 m tall were sampled.

Treatment of rice straw

Rice straw was chopped into approximately 3 cm pieces using a forage cutter (CeCoCo forage SFC1400, Central Commercial Company, Osaka Japan). To treat straw, chopped straw was spread in a concrete culvert lined with polythene sheets and each layer of 16 kg straw was sprayed with urea solution (75 g urea in 434.3 ml water kg^{-1} straw) as described by Fleischer et al.(2000).

Chemical analysis

Fodder tree leaves, untreated and urea-treated straw were oven dried at 55º C and ground through a 1 mm sieve before determining DM, OM and CP (A.O.A.C., 2016). Neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose and lignin contents were determined using methods described by Goering and Van Soest (1970).

Animal feeding and management

Preference trial

Four Djallonke sheep (2 rams, 2 ewes) of average weight 27.3 kg ±0.22 were housed in individual concrete floor pens (2 m x 1.5 m) with asbestos roofing and sides made of wooden rails. The sheep were each offered 200 g each of the eight fodder leaves in feed boxes in a cafeteria style at 08:00 hours. Water was provided *ad lib*. After an adjustment period of 7 days, the consumption of each fodder species during the first hour of feed offer was measured daily for another 7 days. The consumption of the fodder leaves was then used to rank the eight species in order of preference by the sheep as described by Adjorlolo et al. (2004).

In sacco degradation study

Four fistulated wethers (28.3±0.19 kg) were kept in individual metabolism crates (Length

= 1.6m, width = 1m and height = 1.3m) for the rumen degradation studies. The fistulation was carried out using the required surgical procedures for fistulation as documented by the Department of Primary Industries of New South Wales Government, Australia (NSW Government, 2012). Modified version of rumen cannulae as described by Elices et al. (2010) were used. The fistulated animals were fed urea ammoniated straw at 8:00 hours daily on *ad libitum* basis. Water was also provided *ad libitum*. The eight tree leaves were assigned to the animals in a double 4x4 Latin square design for 14 days adjustment and 4-day data collection. Dry matter and CP degradation were determined using Orskov et al. (1980) procedure. Each of the oven-dried (55º C) fodder leaves and air-dried rice straw samples were ground through a 1 mm sieve. Two grams each of the samples were then weighed into nylon bags (135 mm x 75 mm), which had been previously oven dried and weighed. The nylon bags containing samples were soaked in water for three hours to displace air before inserting into the rumen. Sixteen bags were incubated in each animal at a time. The bags were tied to a drop line consisting of nylon cords (200 mm x 0.70 mm) and weighted with 11 g steel bolt at one end. Nylon bags were removed 3, 6, 12, 18, 24, 48, 72 and 96 hours after incubation and immediately dipped into absolute alcohol to arrest microbial action. The bags were then individually washed with water until the rinsing water was clear. The unopened bags were oven dried to a constant weight and the residue weight noted. Individual forage residue were bulked for each incubation time and analysed for DM and CP before and after incubation. The degraded portions for each sample were determined as the difference between the values of the original samples and the incubated and dried residue. For each sample, DM and CP disappearance was plotted against incubation time. The rate of DM and CP disappearance from the nylon bags after incubation were fitted into the exponential equation by iteration using PROC NLIN procedure (SAS Institute, 1990).

$P = a + b(1-e^{-ct})$ (Orskov et al. 1980) where:

P = Potential degradability at time "t"
a = Soluble fraction
b = Insoluble but potentially degradable fraction (%)
t = Time
c = the rate constant for the degradation of "b"

The undegradable fraction (u) was calculated as: u=100-(a+b)

Rumen pH determination

Rumen liquor samples were obtained from four fistulated wethers (28.3±0.19 kg) through the rumen cannula by inserting a tube connected to a suction pump into different locations in the rumen. About 20 ml was collected every four hours, starting from the time of feeding till 24 hours after feeding. The rumen liquor was strained through a cotton gauze into a beaker and pH immediately determined with a pH meter (Milwaukee SM101, Romania).

Experimental design and data analysis

Data from seasonal chemical composition study, the preference trial and rumen pH were analysed as a completely randomised design (CRD). Data from rumen degradation study were analysed as repeated 4x4 Latin square design.

Statistical model for CRD:

$$Y_{ij} = \mu + T_i + E_{ij}$$

Y_{ij}: the response variable such as chemical composition, preference and rumen pH;
μ: the overall mean; T_i: the different fodder leaves; E_{ij}: the residual error.

The statistical model for Latin square was:

$$Y_{ij}k = \mu + \alpha_i + \beta_j + \Upsilon k + e_{ijk}$$

where $Y_{ij}k$: response variable such as rumen degradability (a+b, a, b, t and c); μ: overall mean;
α_i: treatments (Experimental diets); β_j: row; Υ k: column; e_{ijk} : residual error. The Least Significant Difference was used to separate significant means (p<0.05) (Steel and Torrie,

1980) after analysis of variance.

Results

Chemical composition

Spondias mombin (SM) was lowest in DM, whilst *Ficus exasperata* (FE) was highest for dry season. *Moringa oleifera* (MO) had the lowest DM and FE had the highest value for wet season (Table 1). Regarding CP, MO had the highest for wet and dry seasons. FE had the lowest value for wet season whilst *Ficus polita* (FP) was lowest in the dry season in CP level (Table 1). With total ash levels, FE had the highest value for both seasons. *Albizzia lebbek* (AL) had the lowest ($p<0.05$) ash level for wet season and *Baphia nitida* (BN) had the lowest ($p<0.05$) value for dry season. (Table 1). *Moringa oleifera* had the lowest ADF values ($p<0.05$) and *Blighia sapida* (BS) had the highest values ($p<0.05$) for both seasons (Table 1). *Baphia nitida* had the highest NDF ($p<0.05$), hemicellulose and lignin values for both seasons. For hemicellulose contents, FP had the lowest values for both wet and dry seasons. (Table 1). Regarding cellulose levels, ML had the highest value and MO had the lowest value for wet season. *Blighia sapida* had the highest cellulose value and ML had the lowest value for dry season (Table 1). In the case of lignin content, FE had the lowest values for both seasons. (Table 1). The DM, CP, ash and cellulose of ammoniated rice straw

TABLE 1

Seasonal nutrient composition of eight indigenous fodder tree leaves

Component	Season	Fodder tree leaves							
		AL	BN	BS	FE	FP	ML	MO	SM
DM (g kg^{-1})	Wet	439.8	459.6	501.4	539.7	348.3	395.1	319.7	387.3
	Dry	719.0	811.4	738.3	862.7	671.7	745.3	484.7	476.5
	Mean*	579.4	635.5	619.9	701.2	510.0	570.2	402.2	431.9
	SE	±69.8	±88.0	±59.2	±80.8	±80.9	±87.6	±41.3	±22.3
Nutrient (g kg^{-1} DM)									
CP	Wet	317.3	255.8	194.2	154.0	190.8	231.9	359.2	171.4
	Dry	260.3	222.0	197.8	163.0	150.0	234.3	267.9	159.6
	Mean*	288.8	238.9	196.0	158.5	170.4	233.1	313.6	165.5
	SE	±14.3	±8.5	±0.9	±2.3	±10.2	±0.6	±22.8	±3.0
Ash	Wet	59.2	76.7	106.8	251.7	139.2	108.5	160.1	92.7
	Dry	120.8	99.2	125.5	218.2	174.7	157.4	189.3	113.6
	Mean	90.0a	88.0a	116.2a	235.0b	157a	133.0a	174.7b	103.2a
	SE	±15.4	±5.6	±4.7	±8.4	±8.9	±12.2	±07.3	±5.2
NDF	Wet	572.8	718.3	703.6	512.7	585.7	530.3	432.5	429.9
	Dry	441.4	597.8	576.5	414.5	428.4	428.5	277.5	456.5
	Mean	507.1a	658.1b	640.1b	463.6a	507a	479.4a	355.0a	443.2a
	SE	±32.9	±30.1	±31.8	±24.6	±39.3	±25.5	±38.6	±6.7
ADF	Wet	384.2	453.4	491.5	466.9	474.2	429.6	244.4	334.0
	Dry	311.4	360.0	411.1	358.2	344.9	292.9	181.1	383.5
	Mean	347.8b	406.7b	451.3b	412.6b	40.9b	361.3b	212.8a	358.3b
	SE	±18.2	±23.4	±20.1	±27.2	±3.23	±34.2	±15.8	±12.6
Lignin	Wet	182.2	242.0	213.5	86.8	194.4	233.2	165.3	145.6
	Dry	126.4	200.4	158.4	50.5	85.2	178.6	63.7	187.5
	Mean*	154.3	221.2	186.0	68.7	139.8	205.9	114.5	166.6
	SE	±14.0	±10.4	±13.8	±9.1	±27.3	±13.7	±25.4	±10.5

*Not Significant, Means in the same row with common superscripts are not different ($p>0.05$), DM: Dry matter, CP: Crude protein, NDF: Neutral detergent fibre, ADF: Acid detergent fibre, SE: Standard error.

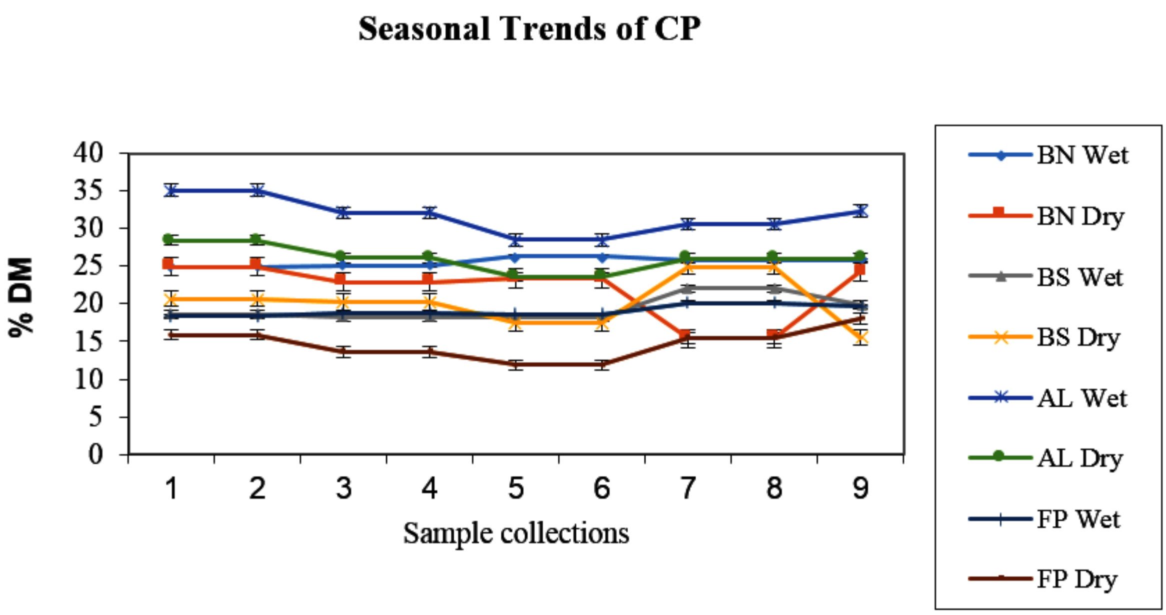

Figure 1 Seasonal Trend of Crude Protein with standard error bars

were higher than those of untreated rice straw (Table 3). However, NDF, ADF, hemicellulose and lignin of untreated rice straw were higher than those of ammoniated rice straw (Table 3). Trend of CP according to the standard error bars indicated that, AL and FP had wet season values higher than dry season values (Figure 1). However, in BS both seasons were almost the same whilst in BN initially both seasons were similar until the 6th sample collection, then dry season values were lower than wet season values toward the end of sample collection (Figure 1). Trend of ash showed that FE, MO and ML initially had lower wet season values than dry season (Figure 2). Trend of NDF revealed a higher wet season values than dry season values for BN (Figure 3). In the case of SM, wet season values of NDF were higher than dry season for the first two sample collections and then from the 3rd sample collections onward, wet season was lower than dry season (Figure 3).

TABLE 2

Rumen degradation characteristics, mean consumption and rumen pH of eight indigenous fodder tree leaves

		Fodder tree leaves							
Degradability (g kg^{-1} DM)		AL	BN	BS	FE	FP	ML	MO	SM
DM	a	189.7^{i}	166.5^{g}	113.3^{d}	119.7^{e}	177.6^{h}	216.8^{k}	151.8^{f}	216.3^{j}
	b	284.6^{g}	168.4^{f}	142.9^{d}	627.0^{e}	415.3^{h}	434.2^{k}	426.3^{i}	152.1^{e}
	c*	0.40	0.25	0.19	0.44	0.46	0.16	0.40	0.47
CP	a	335.6^{g}	295.4^{f}	295.6^{f}	295.5^{f}	295.5^{f}	230.6^{e}	340.0^{g}	167.4^{d}
	b	484.4^{d}	544.2^{e}	544.4^{e}	544.2^{e}	544.2^{e}	479.4^{d}	488.6^{d}	481.4^{d}
	a+b	820.0^{f}	839.6^{h}	840.0^{h}	839.7^{h}	839.7^{h}	710.0^{e}	828.6^{g}	648.8^{d}
	u	180.0^{f}	160.4^{d}	160.0^{d}	160.3^{d}	160.3^{d}	290.0^{g}	171.4^{e}	351.2^{h}
	c*	0.49	0.77	0.44	0.65	0.63	0.48	0.37	0.72
Mean consumption (g Hour^{-1})		147.5^{g}	55.9^{b}	77.8^{c}	138.9^{f}	51.9^{a}	52.1^{a}	116.7^{d}	128.7^{e}
Hours(after feeding fistulated animals)		0	4	8	12	16	20	24	
pH		6.42 ^{c}	6.49 ^{d}	6.27 b	6.15 ^{a}	6.25 ^{b}	6.18 ^{a}	6.60 ^{e}	

*Not Significant, Means in the same row with common superscripts are not different (p>0.05). DM: Dry matter; CP: crude protein; URS: Untreated rice straw, ARS: Ammoniated rice straw; c (g kg^{-1} DM hr^{-1})

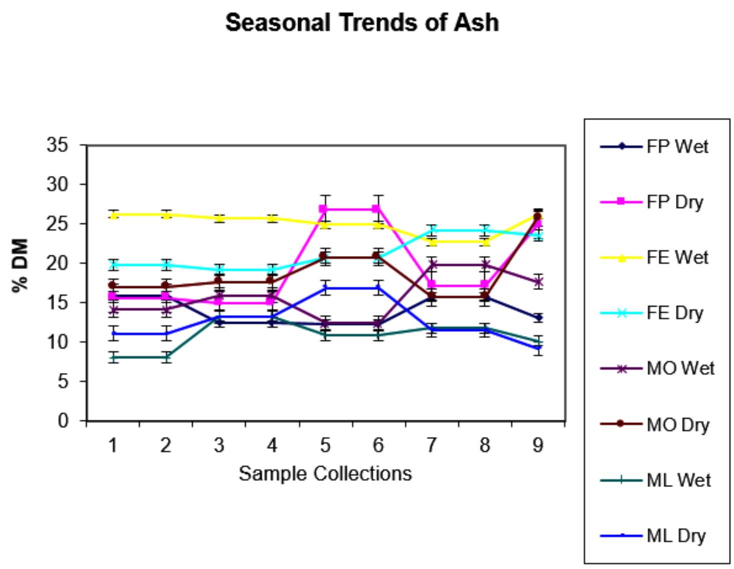

Figure 2 Seasonal Trend of Ash with standard error bars

Rumen Degradation

For the potentially degradable DM fraction (b) for the fodder leaves, FE was highest ($p<0.05$) whilst BS was the lowest ($p<0.05$) (Table 2). Untreated and ammoniated straw recorded 274.1 g kg^{-1} DM and 514.5 g kg^{-1} DM degradation respectively (Table 3). The rate constant for DM degradation of 'c' for the fodder leaves was lowest in ML and highest in SM (Table 2). Untreated and ammoniated straw recorded 0.95 g kg^{-1} DM hr^{-1} and 0.49 g kg-1 DM hr^{-1} respectively (Table 3). *Moringa oleifera* had the highest soluble CP fraction (a) for the fodder leaves whilst SM was the lowest (Table 2). Untreated and ammoniated straw recorded 78.9 g kg^{-1} and 114.4 g kg^{-1} respectively (Table 3). Regarding

TABLE 3

Chemical composition and rumen degradation characteristics of rice straw

Parameters	Untreated rice straw	Ammoniated rice straw
Dry matter(g kg^{-1})	900.4	907.2
Crude Protein (g kg^{-1} DM)	60.4	99.4
Ash (g kg^{-1} DM)	173	195
Neutral Detergent Fibre (g kg^{-1} DM)	619.9	578.2
Acid Detergent Fibre (g kg^{-1} DM)	547.6	537.5
Hemicellulose (g kg^{-1} DM)	66.3	40.7
Cellulose (g kg^{-1} DM)	329.2	380.1
Lignin (g kg^{-1} DM)	66.6	49.5
Rumen Degradation (g kg^{-1} DM)		
Dry Matter Degradation		
a	10.8	28.70
b	277.4	514.4
c (g kg^{-1} DM hr^{-1})	0.95	0.49
Crude Protein Degradation		
a	78.9	114.4
b	345.6	495.6
a+b	424.5	610
u	575.5	390
c (g kg^{-1} DM hr^{-1})	0.38	0.46

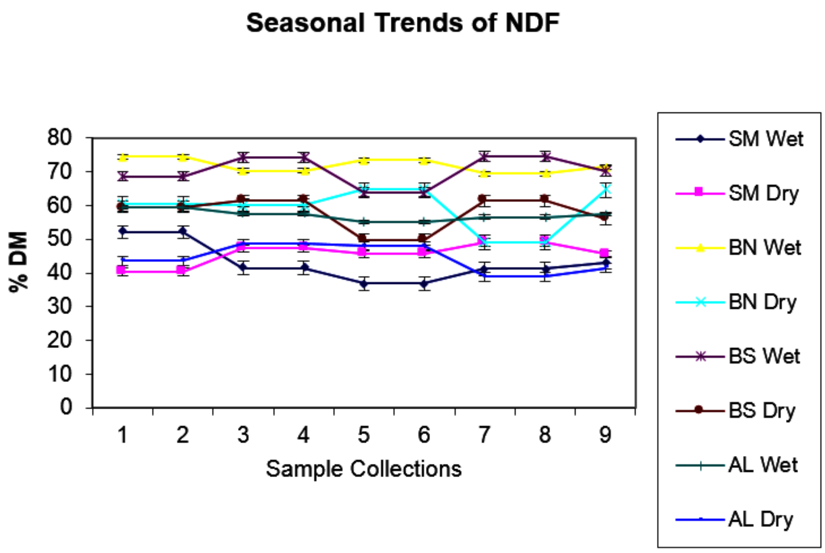

Figure 3 Seasonal Trend of Neutral Detergent Fibre (NDF) with standard error bars

the potentially degradable CP fraction (b) for the fodder tree leaves, ML had the lowest and the highest was BS (Table 2). The maximum percentage loss of protein (a+b) for the fodder tree leaves ranged from 648.8 g kg^{-1} DM in SM to 840.0 g kg^{-1} DM in BS (Table 2). The undegradable protein fraction (u) for the fodder tree leaves ranged from 160.0 g kg-1 DM in BS to 351.2 g kg^{-1} DM in SM (Table 2). The undegradable protein fraction (u) for untreated and ammoniated straw was 575.5 g kg^{-1} DM and 390.0 g kg^{-1} DM respectively (Table 3). The rate constant for CP degradation 'c' for the fodder tree leaves ranged between 0.37 g kg^{-1} DM hr-1 in MO and 0.77 g kg^{-1} DM hr^{-1} in BN. Untreated and ammoniated straw recorded 0.38 g kg^{-1} DM hr^{-1} and 0.46 g kg^{-1} DM hr^{-1} respectively (Table 3). The rumen pH values obtained ranged from 6.15 to 6.60 (Table 2).

Preference

Albizzia lebbek had the highest ($p<0.05$) mean consumption of 147.50 g whilst FP had the lowest ($p<0.05$) of 51.86 g. The order of preference was as follows: *AL> FE>SM>MO>BS>BN> ML> FP* (Table 2).

Discussion

The DM values obtained show that the fresh forages contained about 150-700g kg^{-1} moisture. With moisture content above 600 g kg^{-1}, there may be low DM intake and consequently a drop in total nutrient supply and animal production response (Crowder and Chheda, 1982). There is therefore the need to reduce the moisture content of fodder species with moisture content above 600 g kg^{-1} by wilting before feeding to animals so as to enable the animal consume more DM. However, fodder spp. with moisture content below 500 g kg^{-1} need not be wilted before feeding. Minimal differences were observed in CP for both seasons even though it was higher during the wet season in *AL, MO, FP* and *BN.* This confirmed the report by Anugwa et al. (2000) and Ukwanwoko and Ironkwe (2013) that, the rate of fluctuation in the nutritive value of fodder tree leaves is less drastic. The CP values obtained for both seasons were higher than the minimum level of 110 -120 g kg^{-1} DM considered adequate for moderate level of production for ruminants (ARC, 1980). If *BS, FE, FP* and *SM* leaves are used as supplement to straw with CP content as low as 60 g/kg DM (as in the case of untreated rice straw), they will be able to maintain weight and provide minimal weight gains whilst *AL, BN, ML* and *MO* will be able to provide moderate weight gains or better. This study indicates that the fodder tree leaves can be used as nitrogen supplements to improve protein content of diet all year, especially during dry season.

For the *in sacco* degradability study, the range of values for the fodder tree leaves for soluble fraction (a) of DM reported by Addo-Kwafo (1996) (280-490 g kg^{-1}) were higher than was obtained (113.3-216.8 g kg^{-1}) in this study. However, the values in this study were similar to those reported by Sottie (1997), Fleischer et al. (1998) and Takele et al. (2014) (37-217 g kg^{-1}). The range of values for potentially degradable fraction of DM reported by Sottie (1997) (259.0-588.3 g kg^{-1}) and Takele et al (2014) (142.9-627g kg^{-1}) falls within the values obtained in this study (142.9-627.0 g kg^{-1}). The values for the rate of constant for degradation of 'b' obtained in this study were lower than the values reported by Addo-Kwafo (1996). The values of soluble fraction, potentially degradable fraction and maximum percentage loss of protein reported by Fleischer et al. (1998) have been confirmed by this study. The variation in the results reported by different workers could be due to differences in climatic conditions, locations, stage of growth of the plants as well as the composition of the basal diet and the level at which it was fed to the animals (Orskov et al., 1980).

The moderate potentially degradable fraction and low to moderate levels of undegradable protein obtained in this study indicates that, they have high protein value. The undegradable fraction for the fodder tree leaves indicates that, a substantial fraction will escape rumen microbial degradation especially SM and this could enhance the supply of by-pass protein and nitrogen retention (Nherera, 1999; Acamovic and Brooker, 2005) and increased amino acid in the small intestines of the animal (Acamovic and Brooker, 2005). Thus potentially there may be improvement in animal performance when fed as supplements (Min et al., 2003, 2015; Eckard et al., 2010). A high protein value of feed is obtained when the degradation of protein in the rumen is low and the rumen undegraded protein passing the small intestines has high digestibility (Mgheni, 1994). It has been suggested that when the rate of degradation (c) is small and insoluble but degradable fraction (b) is large, the protein source degrades slowly but with time, it can be degraded to a high extent (Orskov, 1982). The potentially degradable CP fraction indicates that moderate amount will be broken down by microbes in the rumen and substantial amount will escape rumen microbial breakdown hence providing protein for both rumen microbes and also directly to the ruminant. Thus, when these fodder tree leaves are fed as supplement to fibrous feeds, they will be able to provide protein for the rumen microbes which will enable them to breakdown the fibrous feed and also contribute immensely to by-pass protein and nitrogen retention making amino acids available in the small intestines which potentially can support weight gain and other beneficial functions.

The moderate degradation of the fodder tree leaves could be attributed to high NDF values of the species. This moderate degradability suggests that enough material is broken down hence sufficient energy is released to the animal. This has been confirmed by the values of the ratio of Metabolisable Energy Intake to Metabolisable Energy Required for Maintenance of fodder supplementation (2.23-3.38) reported by Adogla-Bessa et al (2021) which was more than one, implying that they could be able to meet maintenance requirement and provide some amount of growth. Ahn et al. (1989) reported that drying of tree legumes leaves decreases their tannin content and increased CP degradability. Therefore, moderately drying these fodder tree leaves before feeding them to animals could improve intake, CP degradation and hence improve growth. The rumen pH values obtained (6.15-6.60) were lower than the values of 6.7 -7.2 reported by Orskov (1982) as optimum.

Preference could have been influenced by the content of insoluble proanthocyanidins in the fodder tree leaves. This has been reported by Reed et al. (1990) that, intake of *Acacia cyanophylla* was lowest due to its very high content of insoluble proanthocyanidins. The report by Reed et al. (1990) is supported by the report by Provenza et al. (1990) and Estell (2010) that, animals avoid tanniferous fodder tree leaves whenever possible. The elaboration and accumulation of tannins in plant tissue may be bitter-tasting, poisonous or offensively odoured (Harborne, 1993; Basha et al., 2012; du Toit and Olff, 2014). It may be possible that, *FP, ML, BS* and *BN* contain high levels of tannins or they were offensively odoured and therefore not highly preferred. Fodder tree leaves which were high in NDF, ADF and lignin were less preferred. For instance, *BN* and *BS* were high in NDF, ADF and lignin and were less preferred compared to the fodder leaves with low NDF, ADF and lignin. This is in agreement with the report by Papachristou et al. (2005) which indicated that sheep and goats prefer feeds with low levels of lignin and NDF. Multipurpose trees such as *Leucaena leucocephala* and *Sesbania sesban* which are known to have good nutritive value had high palatability (Kaitho et al., 1996). Although all the eight fodder tree leaves had high nutritional value, *AL, FE, MO* and SM were considered as better supplements because they were the four most preferred fodder tree leaves.

Conclusion

The seasonal changes in chemical composition of the fodder tree leaves were found to be less drastic, which implies that, the fodder tree leaves can be used as supplementary feed throughout the year regardless of the season. The CP values obtained were higher than the minimum level of 110-120 g kg^{-1} DM considered adequate for moderate level for ruminant production. Therefore, the CP of the eight fodder leaves may be able to supply more than the minimum requirement of CP for moderate production of ruminant if fed as a complete diet. However, if fed as a supplement to untreated rice straw, they may be able to provide small or moderate weight gains. Fodder tree leaves with low fibre contents were more preferred and could be more useful as supplement than those with high fibre content. The potentially degradable CP fraction indicates that moderate amount will be broken down by microbes in the rumen and substantial amount will escape rumen microbial breakdown hence providing protein for both rumen microbes and ruminants directly. Hence, when these fodder tree leaves are fed as supplement to fibrous feeds, they will be able to provide protein for the rumen microbes which will enable them better utilize fibrous feed and improve animal performance. Although all the eight fodder tree leaves had high nutritional value, *Albizzia lebbek, Ficus exasperata, Moringa oleifera* and *Spondias mombin* are recommended as better supplements because they were the four most preferred fodder tree leaves.

Ethical Clearance

The use of animals was approved by Noguchi Institutional Animal Care and Use Committee of University of Ghana, Legon (Protocol number 2017-02-2R).

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Competing Interest

The authors of this paper declared that they do not have any competing interest for this joint publication.

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