IN SACCO DRY MATTER DEGRADATION CHARACTERISTICS OF SOME FORAGES AND AGRO-INDUSTRIAL BY-PRODUCTS IN GUINEA SAVANNAH ZONE OF NIGERIA.

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ABSTRACT

A study was conducted to evaluate the degradation characteristics of some forages and agro-industrial by-products using three rumen fistulated goats in Northern Guinea Savanna Region of Nigeria. The forages include L. purpureus, P. purpureum, B. bryzontha, S. pumila and P. padicellatum, while the agro-industrial by-products are Groundnut cake, Maize offal, Rice offal, Brewers dried grains, Cotton seed cake and three Red Sokoto Goats. The chemical composition and dry matter content of forages and agro-industrial by-products were determined. The dry matter content was lowest in P. padicellatum (87.00%) and highest in L. purpureus (93.00%) while groundnut cake had(87.00%) and maize offal (95.00%). Crude protein content was lowest in P. purpureum (5.70%) and highest in P. padicellatum (25.00%) while rice offal had(4.40%) and groundnut cake (41.50%). Crude fibre content was lowest in P. padicellatum (31.00%) and highest in L. purpureus (38.00%) while maize offal had(5.00%) and cotton seed cake (38.00%). Ash content was lowest in P. padicellatum and S. pumila (8.00%) and highest in B. bryzontha (18.00%) while groundnut cake had (6.50%) and rice offal (22.00%). Ether extract content was lowest in S. pumila (0.60%) and highest in P. purpureum (2.10%) while rice offal had (1.20%) and groundnut cake (5.10%). Nitrogen free extract content was lowest in L. purpureus (21.50%) and highest in P. padicellatum (51.20%) while cotton seed cake had (34.30%) and rice offal (69.30%). ADF content was lowest in P. padicellatum (41.90%) and highest in S. pumila (45.60%) while maize offal had (7.90%) and rice offal (54.00%). NDF was lowest in P. purpureun (49.00%) and highest in P. padicellatum (54.00%) while groundnut cake had (30.00%) and cotton seed cake (66.54%). The mean rumen degradation characteristics of forages and agro-industrial by-products were 51.06%, 49.58%, 38.58%, 40.53%, 36.15% and those of agro-industrial by-products were; 66.21%, 69.11%, 27.68%, 52.91%, 5460% both at 6, 12, 24, 48 and 72 hours respectively. The forages almost reached 50% degradability at 48 hours, while the agro-industrial by-products reached 50% degradability at 12 hours and from these findings, forages and agro-industrial by-products used in this trial are suitable feeds to promote livestock production.

Key Words: Agro-industrial by-products, degradation, forages, goat, rumen**.**

Introduction

Tropical countries face a perennial problem of inadequate quantity and quality of ruminant feeds, especially during the long dry season as it has been documented to be one of the most important factors limiting ruminant production in the traditional small holder sector of Nigeria (Aduku, 2004). The situation exists in many regions of the tropics where sheep and goats are raised in traditional systems mostly roaming freely in fallow land, forest and grassland. The main feed resources for animals are native grasses and legumes that occur naturally in grassland, tree leaves and crop residues.

These natural pastures have their values declining with the stage of growth and such changes in nutritional status results in irregular growth and weights (Osuji *et. al.*, 1993 and Mbahi *et. al..*, 2006), and small holder farmers cannot afford the cost of establishing a pasture and as such depend solely on the natural pastures and agro-industrial by-products to feed their animals (Smith *et. al.*, 1991).

Animals are fed on these poor quality feed resources during post harvest and the dry season when these feed materials becomes their main sources of energy (Kibon and Orskov, 1993). In Guinea Savannah Zone of Nigeria and any other tropical regions, these feed resources are naturally available in large quantities, but little is known about their usefulness as feed to ruminants by the local farmers particularly as regards to their degradability in the rumen, therefore the use of polythene bags as feed evaluation technique by Orskov and Mcdonald (1979) is an important tool in the measurement of the quality of feeds by nutritionists. The effective use of forages and agro-industrial by-products in ruminant nutrition and livestock production in general depends on the availability of information on these feed resources, and their nutritive contents which are often compromised by the presence of anti-nutritional factors that limit the complete digestibility of these materials thereby affecting the productivity of the animal in one way or the other. Church (1989); Kankpukdee and Wanapat (2008) observed that most of these feed resources need to be supplemented. Previous research has shown that small scale farmers are increasingly relying on the use of forages and agro- industrial by-products to supplement roadside grazing during dry season and some of these feed

materials are potentially good feed resources which degrade readily in the rumen (Krishna, 1985; Odulami, 1988 and Smith *et. al.,* 1991). Other materials have been shown to be poor in terms of degradability and as such needs to be treated before they can contribute to animal nutrition (Smith *et al.,* 1988). Feed evaluation is important to farmers in deciding which feed to buy and also to livestock planners on how to assess production level with a view to plan for food import and strategies (Orskov, 2000)).

Therefore, this study was meant to evaluate the rumen degradability potentials of some selected forages and agro-industrial by-products commonly found in Guinea Savannah Zone of Nigeria.

Materials and Methods

The study was carried out in Yola, Adamawa state, Nigeria, which is located at the North-Eastern part of Nigeria. It lies between latitude 70^0 and 11^1 N of the equator and between longitudes 14^1 of the meridian. It shares boundaries with Taraba State in the south- west, Gombe State in the North-west and Borno State to the North. The State covers a land area of about 38,741 Km^2.

Adamawa State falls within the semi arid zones of West Africa and is characterized by short periods of rainy season which is between June and November and a mean temperature of about 37^0 C, the relative humidity ranges from 5-24% and the natural vegetation is typical of Sudan Savannah characterized by scattered trees, shrubs and herbs with short grasses. The area is generally flat but with rocky hills, numerous rivers and streams. (Adebayo and Tukur, 1999).

Feed sample collection

A total of five (5) forages were harvested (leaves and twigs) and five (5) agro-industrial by-products were obtained from the small scale grinding and milling machine operators and local beer brewers. The samples were sun dried to constant weight at 48hours in the oven at 65^0C and labeled for easy identification for subsequent rumen degradation and chemical analysis.

Management of experimental animals

Three fistulated goats weighing approximately 18, 20 and 22 kg were used for this study. The animals were provided with groundnut haulms, sorghum stover, salt lick and water were provided ad-lib that was able to meet the rumen microbial requirements for essential nutrients. The animals were subjected to adaptation period for two weeks.

Sample preparation and incubation of samples into the rumen

Three (3) grams of feed samples each in triplicate were weighed and put into nylon bags of size 7cm x 12.5cm and mesh (pore) size of $45_{um.}$ The bags are numbered for easy identification and then attached to PVC string with aid of a rubber band in an alternate position and incubated into the rumen of the fistulated goats for 6, 12, 24, 48 and 72 hours respectively. The animals were fed and removed from the feed 1-2 hours before the time of sample removal (Mbaya *et al.,* 2011).

Withdrawal of bags from the rumen, washing and drying

After each incubation time, the bags were removed from the rumen of the animal, individually washed for 5 minutes under running tap water to get clear water. The removal was according to specified incubation period as indicated on the plastic tube tags. The bags were sun dried for two hours before putting them in the oven for drying to constant weight at 65^{oC} for 48 hours to determine the amount of dry matter degradation rate. After drying, the bags with the content were weighed and recorded to determine the loss in weight which occurs due to degradation by the rumen microbes.

Washing loss

The washing loss is the soluble portion of feed at zero time dry matter (DM), disappearance was determined by soaking three bags of each feed sample in warm water (about 37^0C) for 30 minutes and the bags were removed, washed under running tap for 5 minutes to get clear water and then dried in the oven at 65^0C for 48 hours. Then, the percent actual dry matter disappearance was estimated.

Chemical analysis

The forages and agro-industrial by-products were analyzed for dry matter (DM), Ash, crude protein (CP), crude fibre (CF), either extract (EE), nitrogen free extract, Acid detergent fibre and Neutral detergent fibre according to the method described by AOAC (2000) methods.

Statistical analysis

The data obtained were analyzed using Fit Curve Macro (Chen X.B 1995) for Microsoft Excel (NEEWAY Excel). Degradation constant were estimated from the exponential equation $PD = a + b (1- e^{-ct})$ proposed by Orskov and McDonald (1979).

Results

Chemical Composition of forages and agro-industrial by-products

The result of the chemical composition of Forages and agro-industrial by-products is presented in Table 1. The dry matter content ranged from 87.00 to 93.00% in *P. padicellatum* to *S. pumila* and 87.00 to 95.00% in groundnut cake to maize offal. The crude protein content ranged from 5.70 to 25.40% in *P. padicellatum* to *L. purpureus* and 4.40 to 41.50% in rice offal to groundnut cake. Crude fibre content ranged from 31.00 to 38.00% in *P. purpureum* to *L. purpureus* and 5.00 to 38.00 in maize offal to cotton seed cake. Ash content ranged from 8.00 to 18.00% in *P. padicellatum* and *P. purpureus* to *S. pumila* and *B. bryzontha* and 6.50 to 22.00% in cotton seed cake to rice offal. Ether extract content ranged from 0.60 to 2.10% in *S. pumila* to *P. purpureum* and 1.20 to 5.10% rice offal to groundnut cake. Nitrogen free extract content ranged from 21.50 to 51.20% in *L. purpureus* to *P. padicellatum* and 34.30 to 69.30% in cotton seed cake to rice offal and the ADF content ranged from 41.90 to 45.60 in P. *padicellatum* to *S. pumila* and 7.90 to 54.00% in maize offal to rice offal, while the NDF content ranged from 49.00 to 54.00% in *P. purpureum* to *P. padicellatum* and 30.00 to 66.54% groundnut cake to cotton seed cake in forages and agro industrial by-products respectively.

Table 1: Chemical Compositions (%) of Forages and Agro-industrial by-products

Feed material	DM	CP	CF	Ash	EE	NFE	ADF	NDF	
Forages									
L. purpereus	89.00	25.40	38.00	14.00	1.10	21.50	42.40	50.00	
P. purpereum	89.00	8.80	31.00	8.00	2.10	50.10	43.50	49.00	
B. bryzontha	90.00	10.10	36.00	18.00	0.90	35.00	44.50	51.00	
S. pumila		93.00	7.00	37.00	18.00	0.60	37.40	45.60	52.00
P. padicellatum	87.00	5.70	34.00	8.00	1.10	51.20	41.90	54.00	
Agro-industrial by-products									
Groundnut cake	87.00	41.50	7.00	7.00	5.10	41.40	20.00	30.00	
Maize offal	95.00	12.30	5.00	12.00	2.20	68.50	7.90	32.98	
Rice offal	94.00	4.40	16.00	22.00	1.20	69.30	54.00	45.00	
Brewers dried grains	94.00	8.30	16.00	7.00	3.30	65.40	13.04	45.26	
Cotton seed cake	91.00	41.30	38.00	6.50	2.40	34.30	30.94	66.54	

Key: DM=dry matter CP=crude protein CR=crude fibre EE=ether extract
ADF=acid detergent fibre NDF=neutral detergent fibre

Rumen Degradability Studies

Degradation characteristics of forages and agro-industrial by-products

The result of the rumen degradability is presented in Table 2. At 6 hours incubation, the Actual Dry Matter Disappearance (%ADMD) for the forages and agro-industrial by-products ranged from 23.20 to 41.50% in *P. padicellatum* to *L. purpureus* and 18.80 to 52.21 in rice offal to groundnut cake for the agro-industrial by-products. At 12 hours it ranged from 30.30 to 48.30% in *P. purpureum* to *L. purpureus* and 28.20 to 72.50% in rice offal to groundnut cake. At 24 hours, it ranged from 32.60 to 53.40% in *P. purpureum* to *L. purpureus* and 31.30 to 82.30% in rice offal to maize offal. At 48 hours, it ranged from 46.40 to 65.30% in *P. padicellatum* to *L. purpureus* and 34.50 to 88.70% in rice offal to maize offal. At 72 hours, it ranged from 58.00 to 71.20% in *S. pumila* and *P. padicellatum* to *L. purpureus* and 37.60 to 91.80% in rice offal to maize offal respectively.

Table 2: Dry Matter degradation at different incubation time in the rumen of cannulated goats.

Sample	%DM	0 hour	6 hour	12hours	4hours	48hours	72hours	Mean
Forage								
L. purpureus	89.0 0	26.70	41.50	48.30	53.40	65.30	71.20	51.06
P. purpureum	89.00	17.80	26.70	30.30	32.60	50.40	62.30	9.58
B. bryzontha	90.00	15.00	27.00	39.00	39.00	57.00	60.00	38.58
S. pumila	93.0 0	18.60	31.00	43.40	43.40	55.00	58.00	40.53
P. padicellatum	87.00	17.40	23.20	38.40	38.40	46.40	58.00	36.15
Agro-industrial by-products								
Groundnut cake	87.00	37.70	52.20	72.50	75.40	78.30	81.20	6.21
Maize offal	95.00	44.30	50.60	57.00	82.30	88.70	91.80	69.11
Rice offal	94.00	15.70	18.80	28.20	31.30	34.50	37.60	27.68
Spent sorghum residues	94.00	15.70	34.40	53.30	65.80	72.10	72.60	52.91
Cotton seed cake	91.00	42.50	42.50	51.60	57.60	63.70	66.70	54.60

Effective Dry Matter Degradability (ED %) of forages and agro-industrial by-products

The result of the Effective Degradability (ED) is presented in Table 3. The effective dry matter degradability of the forages and agro-industrial by-products at degradability constants a, b, c, and rumen outflow rate K=0.02, 0.05, and 0.08. The rumen out flow rate is an inverse of the mean retention time (MRT) of feed stuffs inside the rumen of the animals. A fractional outflow rate of 0.02-0.10 $^{h-1}$ and 0.017-0.05^{h-1} was predicted for protein supplements and roughages respectively. It implies that the MRT for protein supplements is 10-50 hours and roughages 20-60 hours. The effective degradability values obtained are the predicted degradability of the forages and agro-industrial by-products if fed to the animals and are retained in the rumen for 50,20 and 12.5 hours (K=0.02, 0.05, 0.08). The effective degradation of feed in the rumen depends on the length of retention of the feed in the rumen which is also a function of the quality of the feed fed to the animal (Reddy, 2001).

The effective degradability obtained for the forages and agro-industrial by-products ranged from 43.40 to 58.10% (*P. padicellatum* to *L. purpureus*) and 31.30 to 78.30% (rice offal to maize bran) at fractional outflow rate (K) of 0.02 (i.e MRT=50 hours). At outflow rate (K) of 0.05 (i.e MRT=20 hours) it ranged from 32.70 to 48.70% (*P. purpureum* to *L. purpureus*) and 26.70 to 66.20% (rice offal to maize bran), while at outflow rate (K) of 0.08 (i.e MRT=12.5hours) it ranged from 28.20 to 43.90% (*P. purpureum* to *L. purpureus*) and 24.10 to 61.30% (rice offal to groundnut cake) for forages and agro-industrial by-products respectively.

Table 3: Effective Dry Matter Degradability (%) of forages and agro-industrial by-products at degradability constants a, b, c and fractional outflow rate K=0.02, K=0.05, K=0.08 ED= a+[bc/c + k] (Orskov and Mcdonald, 1979).

Sample	a	b	c	RSD	k=0.02	k=0.05	k=0.08
Forage							
L. purpereus	28.90	42.70	0.043	3.16	58.10	48.70	43.90
P. purpereum	20.00	143.6	0.005	2.97	48.00	32.70	28.20
B. bryzontha	16.40	49.70	0.031	2.90	46.60	35.40	30.30
S. pumila	20.00	40.30	0.042	2.05	47.30	38.50	33.90
P. padicellatum	18.40	46.30	0.024	3.22	43.40	33.20	28.90
Agro-industrial by-products							
Groundnut cake	36.60	43.50	0.103	4.12	73.30	66.10	61.30
Maize offal	41.90	55.00	0.041	5.60	78.30	66.20	60.10
Rice offal	15.00	22.20	0.056	2.20	31.30	26.70	24.10
Spent sorghum residues	14.90	60.50	0.076	2.35	62.60	51.20	44.20
Cotton seed cake	41.80	27.20	0.035	0.99	59.10	53.00	50.10

KEY: a - Fitted Insoluble but Degradable fraction
b- Degradation Rate Constant
k - Fraction Outflow Rate from the Rumen at 50, 20 and 12.5 Hours.
ED-effective degradation
RSD- regression standard deviation

Comparative Actual Dry Matter Disappearance (%ADMD) of forage and agro-industrial by-products with (50% and above) and %ADMD at 6, 12, 24, 48 and 72 hours incubation periods

The result of the comparative Actual Dry Matter Disappearance (%ADMD) of forages and agro industrial by-products that attained a minimum degradation of 50% and above at incubation periods at 6, 12, 24, 48 and 72 hours respectively is presented in Table 4. At 6 hours incubation period, maize offal and groundnut cake had 50.60% and 52.20% (agro-industrial by-products). At 12 hours, it ranged from 51.60 to72.50% (cotton seed cake to groundnut cake) for agro-industrial by-products. At 24 hours, the forage had 53.40% (*L. purpureus*) and it ranged from 57.60 to 82.30% (cotton seed cake to maize offal) for agro-industrial by-products. At 48 hours, it ranged from 58.00 to 71.20% in *P. padicellatum* and *S. pumila* to *L. purpureus* (forage) and 66.70 to 91.80% in cotton seed cake to maize offal (agro-industrial by-products) and finally at 72 hours, it ranged from 58.16 to 71. 35% in *P. padicellatum* to *L. purpureus* (forage) and 66.85 to 91.89% in cotton seed cake to maize offal (agro-industrial by-products) respectively.

Table 4: Comparative Actual Dry matter (%ADMD) Disappearance of feed materials with Dry matter degradation values of (50% above)

Incubation Period (hr)	Forage	%	AIBPs	%
06	-	-	Maize offal	50.60
			GNC	52.20
12			GNC	72.50
			Maize offal	57.00
	-	-	SSR	53.30
	-	-	CSC	51.60
24	*L. purpereus*	53.40	Maize offal	82.30
			GNC	75.40
			SSR	65.80
			CSC	57.60
48	*L. purpereus*	71.20	Maize offal	91.80
	p. purpereum	62.30	GNC	81.20
	B. bryzontha	60.00	SSR	76.20
	S. pumila	58.00	CSC	66.70
	P. padicellatum	58.00		
72	*L. purpereus*	71.35	Maize offal	91.89
	P. purpereum	62.30	GNC	81.20
	B. bryzontha	60.00	SSR	76.20
	S. pumila	58.15	CSC	66.85
	P. padicellatum	58.16		

Key- AIBPs=Agro- industrial by-products

Discussion

Chemical composition of forages and agro-industrial by-products

The chemical composition of the forages obtained are similar to the earlier reports by Smith *et al.* (1991); D'mello (1992); Tolera and Sundstol (2000) that crude protein in most forages reduces with age and the slight difference observed in this study could be attributed to soil or age at harvest since forages develop their structures and morphology based on age and management.

The chemical composition of the agro- industrial by-products obtained also agreed with the reports : Turki and Atcham (2011); Jacob (2011); Bogoro (2006) and Arigbede *et. al. (*2002). They attributed the slight differences could be due to time of harvest, location, length of storage and processing methods or handling.

Percentage rumen degradation characteristics of forages and agro-industrial by-products

The mean degradation values obtained at incubation periods of 06, 12, 24, 48 and 72 hours for the forages were 36.15%; 40.53%; 38.58%; 49.58% and 51.06% respectively. The degradability values obtained for the forages shows that they are good as livestock feed and agrees with the report by Njwe and Olubajo (1989); Smith *et. al*. (1991); Girma *et al.* (1994); Khalil *et al.* (1994); Nguyen (1997); The reports further suggested that during the long dry periods, because of high cell wall contents of forage, the quality is too low to sustain animals and as such should be balanced with browse and by- products or crop residues. Also, Mbahi *et al*. (2006) showed that, digestibility of poor quality feed increases with increase in quantity of supplements. Bohnert *et al.* (2002) in a separate report indicated a range of 50-59% digestibility of low quality forage with or without supplementation but concluded that supplementation increases digestibility.

The mean degradation values obtained for agro-industrial by-products were given as 27.68%; 52.91%; 54.60%, 66.21% and 69.11% respectively. This agree with reports; Kummenda and Msiska (1990); Adebowale (1992); Arigbede *et. al.* (2002); Turki, (2002); Jacob (2011) and Turki and Atcham, (2011); at a similar incubation periods. The slight variations in degradability values obtained in this study may perhaps be an indication of readily available energy and protein supplements when fed to ruminants (Barnejee, 1998; Faria-marmol *et al.,* 2002); Bogoro *et al.,* 2006 and Mbaya *et. al.,* 2010.

Effective Dry Matter Degradability (ED %) of the forages and agro-industrial by-products at degradability constants a, b, c and fractional outflow rate K=0.02, 0.05 and 0.08, ED= at [bc/c+k]

The effective degradation (rate of degradation in the rumen) depends on how long the feed remains in the rumen and this is also a function of the quantity and quality of the feed fed to the animal (Reddy, 2001); Malau- aduli *et al.* (2003) and Turki and Atcham (2011. The effective degradability (ED) obtained in this study were predicted, degradability of forages and agro-industrial by-products if fed to the animals and are retained in the rumen for 50, 20 and 12.5 hours respectively (K= 0.02. 0.05, 0.08 MRT).

The ED values for the forages and the agro-industrial by-products at the degradability constants a, b, c and the rumen outflow rate k=0.02, 0.05 and 0.08 indicates that the rumen outflow rate (k) is an inverse of the mean retention time (MRT). However, the effective dry matter degradability of the agro-industrial by-products obtained follows the same trend with that of the forages and was similar to earlier reports: by Osuji *et al.* (1993) and Reddy (2001). The reports stated that, factors like stage of harvest, soil, storage and processing methods should be adhered to in order to achieve the desired result.

Comparative Actual Dry Matter Degradability (%ADMD) of forages and agro-industrial by-products with 50% and above values

The results of the comparative Actual Dry Matter Degradability (%ADMD) values of all the forages and agro-industrial by-products with 50% and above values of degradation at 6, 12, 24, 48 and 72 hours incubation time presented in Table 4 showed that, the actual dry matter degradability (%ADMD) of forages increases with incubation time and it started at 24 hours with *L. purpureus* and most of it reached 50% at 48 hours and subsequently the number increases.

The results obtained however, with agro-industrial by-products are the reverse, because most report used 50% degradability at 6 and 12 hours. This agrees with the reports; Smith *et. al.*(1991); Kibon and Orskov (1993); Jacob (2011); Dimas (2012 and Gworgwor *et al.* (2006). The reports placed emphasis to degradation at 48 hours incubation period. This is because, the highest and effective MRT is 50 hours and as such any feed that can be degraded within this time is considered good feed for livestock production.

The Actual Dry Matter Disappearance (%) of the forages reached 50% degradability at 48 hours while agro-industrial by-products reached 50% degradability at 12 hours incubation period. It can be concluded that most of the forages and agro-industrial by-products used in this study are good feeds for livestock production, while those that require more time to degrade will need supplementation because they are highly required during the peak of dry season when pastures are scarce and low in quality, also this study could be a guide to livestock producers.

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