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Ruminal evaluation of nutrient profiles of some legume forages, agricultural by-products and Baobab bark in sheep

A.B.J. Aina, N.K. Oyesanya, T.A. Fadipe, O.R. Oluwasanmi, O.A. Farinde, O.E. Akanbi, and O.A. Akinsoyinu*

Department of Animal Production and Health, University of Agriculture, P M B 2240, Abeokuta, Nigeria

**Animal Science Department, University of Ibadan, Ibadan, Nigeria*

Abstract

The crude protein (CP) ether extract (EE), acid detergent fibre, (ADF), neutral detergent fibre (NDF), Calcium (Ca), Phosphorus (P), Magnesium (Mg) and Copper (Cu) degradability profiles of two legume forages (Tephrosia bracteolata and Stylosanthes hamata), two agricultural by-products (wheat offal and Rice bran) and Adansonia digitata (Baobab) bark that usually form part of feed materials commonly used in compounding small ruminant concentrate feed were estimated using nylon-bag technique, based on 5 x 5 factorial arrangements in randomized complete block design in 2-way classification. Factor A was the different feedstuffs (Tephrosia, Stylo, Baobak bark, Wheat offal and Rice bran) while factor B was the different incubation periods (0, 6, 12, 24 and 48h) using individual animal as replicate. Results indicated that as incubation periods increased, the extent of disappearance of the test nutrients of each sample increased while the rate of degradation of each sample varied accordingly. The trends of the extent of nutrient disappearance were in the following order:

CP: Tephrosia (15.2 $\pm$ 0.14%) > Wheat offal (13.10$\pm$0.13%) > Stylo (12.24$\pm$0.36)> Rice bran (5.16 $\pm$ 0.09%) > Baobab bark (3.05 $\pm$0.33%)

EE: Stylo (9.53 $\pm$ 0.22%) > Rice bran (5.74 $\pm$ 0.21%) > Wheat offal (2.13 $\pm$0.34%)= Baobab bark (2.13 $\pm$ 0.33%)> Tephrosia (0.35 $\pm$ 0.13%).

ADF: Rice bran (53.94 $\pm$ 7.21%)> Baobab bark (46.87 $\pm$ 5.34%)> Stylo (34.31$\pm$3.07%)> Tephrosia (31.01$\pm$4.46%)>Wheat offal (21.50 $\pm$ 2.08%).

NDF: Rice bran (58.11$\pm$6.29%)>Baobab bark (47.26$\pm$7.12%)>Tephrosia (44.14$\pm$3.05%)>Stylo (40.46$\pm$3.22%)>Wheat offal (25.29$\pm$4.21%)

Ca: Tephrosia (0.855$\pm$0.18%)> Stylo (0.843$\pm$0.19%)> Rice bran (0.308$\pm$0.09%)> Wheat offal (0.204$\pm$0.04%)>Baobab bark (0.140$\pm$0.09%).

P: Wheat offal (3.09$\pm$0.26%)>Rice bran (1.95$\pm$0.10%)> Baobab bark (0.76$\pm$0.21%)>Stylo (0.45$\pm$0.19%)> Tephrosia (0.09$\pm$0.01%).

Mg: Tephrosia (0.495$\pm$0.31%)>Rice bran (0.234$\pm$0.21%)>Wheat offal (0.179$\pm$0.30%)>Stylo (0.160$\pm$0.23%)>Baobab bark (0.116$\pm$0.23%)

Cu: Stylo (46.65$\pm$8.17%)>Rice bran (37.79$\pm$4.7%)>Baobab bark (26.89$\pm$2.6%)>Tephrosia (18.51$\pm$2.70%)>Wheat offal (11.44$\pm$2.8%).

Baobab bark was the least and slowest in the extent and rate of nutrients released into the rumen. Rice bran was also the second highest in terms of fast release of EE, P, Mg and Cu into the rumen, *suggesting that it can supply a reasonable level of EE, P, Mg and Cu, in addition to fastest release of ADF and NDF when fed or included in the concentrate supplement for ruminants. Wheat offal is also reasonably rich in crude protein and phosphorus. The two agricultural by-products are therefore good sourses of nutrients for ruminants. The two legume forages (Tephrosia and Stylo) are fairly richer in CP, EE, Ca, Mg and Cu than other feedstuffs and they readily released their nutrients faster, and to a larger extent, than other feedstuffs. The inclusion of the two forages in the concentrate supplement, or fed as hay or silage can therefore be recommended in ruminant production, particularly when fast release of the nutrients is required while Baobab bark can be recommended when slow release of nutrient will be beneficial to the requirement of the animal.*

Keywords: Ruminal evaluation, Degradability profile, nylon-bag technique.

Introduction

Forage and feedstuff analysis is an important management tool in the development of a proper sheep feeding programme. The knowledge of the quality of a feed helps to determine where, when and in what quantity to use of the said feed (Taiwo, et. al. *1995)*. The utilization of different feedstuffs by ruminants is largely dependent upon microbial degradation within the rumen. Therefore, the description of different feedstuffs in terms of their degradation characteristics would provide a useful guide for ranking on the basis of nutritive value (Hovell, *et. al.*, 1986).

The nylon-bag technique provides a means of ranking feeds according to the rate and extent of degradation of dry matter, organic matter, minerals and other nutritional parameters. It involves incubating samples of feeds in the rumen of fistulated animals for periods from 6 to 120 hours and subsequent determination of disappearance of the different feed components (Osuji, *et. al.* 1993). The nylon-bag technique also allows the nutrient content of feedstuffs to be separated into three fractions: (1) immediately released fraction, i.e. soluble plus small particles sifting through the bag pores. This would be released from the feedstuff without the feedstuff undergoing fermentation in the rumen.

It is calculated as the initial quantity in the sample minus the quantity remaining in the plant residue at hour zero. The 0-h sample was washed without ruminal incubation; (2) time-dependent released fraction is that quantity released during the digestion process in the rumen. It is calculated as the initial quantity in the sample minus the immediately released quantity minus the unreleased quantity; (3) the unreleased fraction is that quantity remaining in the residue after maximal extent of released is reached i.e. after maximum incubation period (Emanuele and Staples, 1990). The present study evaluated the crude protein (CP), ether extract (EE), acid detergent fibre (ADF), neutral detergent fibre (NDF), Calcium (Ca), Phosphorus (P), Magnesium (Mg) and Copper (Cu) profiles of *Tephrosia bracteolata, Stylosanthes hamata, Adansonia digitata* (Baobab) bark, Rice bran and Wheat offal using nylon-bag technique (Orskov *et al*, 1980) in the rumen of cannulated Ouda rams to (a) determine the rate and extent of release of each nutrient at different incubation periods from each feedstuff (b) estimate the potential amount of each nutrient available to rumen micro-organism (c) recommend appropriate combination of feedstuff that will meet a particular requirement in sheep and (d) assess the profile of each nutrient in the different feedstuffs at the different ruminal incubation periods.

Materials and Methods

The test feed samples *Tephrosia bracteolata* and *Stylosanthes hamata*, young shoots, rice bran, wheat offal and Baobab bark (*Andasonia digitata)* were collected from the Teaching and Research

Farm of the University of Agriculture, Abeokuta, Ogun State, Nigeria (7°15'N, 3°25'E) while the degradation experiment was carried out during the onset of rainy season (May) in the Small Ruminant Section of the International Livestock Research Institute (ILRI) Research Farm (7°30'N, 3°54'E) situated in the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria.

Experimental animals.

The *in sacco* technique was used in each of three Ouda rams weighing 24-25kg and fitted with rumen cannula. The animals were fed with cowpea husk and sorghum residues (50:50) *ad libitum* and had free access to clean water.

Sample collection and preparation.

Weighed fresh samples (300g each) of *Tephrosia bracteolata,* and *Stylosanthes hamata* leaves (8 weeks old each) as well as Baobab bark were collected at the onset of rainy season (April/May) from a similar soil and under similar environmental conditions from the Pasture Seed Multiplication Plot of the Teaching and Research Farm, University of Agriculture, Abeokuta, Nigeria, while samples of Rice bran and wheat offal (100g each) which have been purchased from commercial feed millers in the town, were collected from the Small Ruminant Feed store. All the samples were thereafter oven-dried at 65°C to constant weight. After drying, the samples were milled and allowed to pass through a 2mm sieve. Stylo and Tephrosia were cut at 8 weeks of age because this is the age when they are usually cut and fed to small ruminants on the farm.

Experimental design.

The experimental design was based on 5 x 5 factorial arrangements in randomized complete block design in 2-way classification. Factor A was the different feedstuffs (Tephrosia, Stylo, Wheat offal, Rice bran and Baobab bark) while Factor B was the different incubation periods (0, 6, 12, 24, 48h) using individual animal as replicate.

Incubation procedure

Five grams of each milled feedstuff (2mm particle size) was placed in a nylon-bag measuring 65mm x 140mm with pore size of 45µm. One bag of each feedstuff was inserted into the rumen of each of the three rams through the cannula. Each bag was tied with a fishing line twine before insertion into the rumen. The 48h degradation bags were inserted first, followed by 24h, 12h and 6h incubation periods, respectively. All the bags were taken out at the same time from the rumen at the end of each incubation period (McDonald, 1981). The incubated samples together with those not subjected to any rumen fermentation (representing 0h) were immediately washed under cold running tap water until the rinsing water becomes clear. The residual samples were placed on metal trays and dried in a forced-air oven at 65°C to constant weight to determine the undegraded dry matter contents of the incubated samples (Dzowela, *et. al.* 1995).

Laboratory analysis

Proximate analysis of samples before and after incubation was carried out according to AOAC (1990) methods. The fibre fractions (ADF, NDF) were determined using Goering and Van Soest (1970) method of analysis.

The ether extract (fat) content was estimated using Soxhlet Extraction Method. The cations (Ca, Mg, Cu) in the samples were estimated using atomic absorption spectrophotometer with wavelengths: Ca = 422.7nm; Mg = 285.2nm and Cu = 324.8nm. The phosphorus was analysed using Technicon II Auto-analyser which is based on colorimetric method. Reading was taken at 630nm wavelength as described by the Ministry of Agriculture, Fisheries and Food (1982).

Statistical analysis.

The degradation properties of the dry sample of each feedstuff at 0, 6, 12, 24 and 48h incubation periods was determined by the differences between the 5g samples and the weight (g) of the residue. Degradation constants were estimated using the mathematical model developed by Orskov and McDonald (1979): $P=a+b(1-e^{-ct})$

Where: p = degradation after time 't')
a = rapidly degradable fraction at time zero, i.e. the intercept of the degradation curve at time zero.
b = slowly degradable fraction
c = fractional rate at which the fraction described by b will be degraded per hour
t = time of incubation
a+b = the potential extent of degradation (P)
Data collected were analysed using General Linear Model of statistical analysis system (SAS, 1989). Where means obtained were significant, Duncan (1955) Multiple Range Test was used to separate means.

Results

The proximate composition (%) of the different feedstuffs before incubation is presented in Table 3.1. The proportion of each nutrient CP, EE, CF, ADF and NDF, as well as minerals (Ca, P, Mg and Cu) varied in the different feedstuffs. The CF was highest in Baobab bark and also comparatively high in rice bran and Tephrosia. The Cp content was highest in Tephrosia, EE content was highest in Stylo; ADF was highest in rice bran; while NDF was highest in wheat offal. However Mg was highest in Tephrosia, Ca and Cu in stylo and P in Wheat offal.
Table 3.2 shows the potential extent and rate of degradation of the samples. Crude protein disappearance was faster in Tephrosia (3.8%) than in other feedstuffs, while the percent degradability (P = a+b) of crude protein was significantly (P<0.05) higher in Tephrosia and Stylo than in other feedstuffs in the following order:
Tephrosia > Stylo > Baobab bark > Wheat offal > Rice bran. The parameter 'a' (water-soluble fraction) was highest in Tephrosia (4.25), followed by stylo (4.22), wheat offal (0.67), Baobab bark (0.65) and Rice bran (0.51) respectively. The water-insoluble fraction (b) was in the order: Baobab bark (0.16) > Tephrosia and wheat offal. (0.11) > Stylo (0.10) > Rice bran (0.08). The extent of degradation after time t also varied in the following order: Tephrosia (4.31)>Stylo (4.27)>Baobab bark (0.73)>Wheat offal (0.72)>Rice bran (0.55). The degradability coefficients with regard to EE of the test feedstuffs are shown in Table 3.3. The water-soluble fraction (a) varied in different feedstuffs and was highest in Tephrosia (2.45), followed by the Stylo (2.28), wheat offal (0.65), Baobab bark (0.62) and least in Rice bran (0.35). As the water soluble fraction was increasing, the water-insoluble fraction (b) decreased in each feedstuff accordingly. Variations were also observed in the other degradation constants.
In Table 3.4 the order of water-soluble fraction (a) of ADF was: Rice bran (64.99)>Baobab bark (43)> wheat offal (38.57)>Stylo (35.96)> Tephrosia (30.10) while NDF was: wheat offal (80.10)>Rice bran (68.54)>Tephrosia (59.05)>Baobab bark (54.31)>Stylo (51.97). The NDF significantly (p<0.05) degraded to a larger extent than ADF in all the feedstuffs while ADF and NDF were lower in water-soluble fraction of the legume shrubs than other feed samples. Other degradability coefficients also varied in the different feedstuffs.

The respective degradation coefficients of Ca, P, Mg and Cu are presented in Tables 3.5, 3.6, 3.7 and 3.8. The order of extent and rate of release of each mineral in the different feedstuffs after 48h incubation period was:

Ca:Tephrosia>Stylo>Rice bran>What offal>Baobab bark

P:Wheat offal>Rice bran>Baobab bark>Stylo>Tephrosia

Mg:Tephrosia>Rice bran>Wheat offal>Stylo>Baobab bark

Cu: Stylo>Rice bran>Baobab bark>Tephrosia>Wheat offal

Calcium was significantly (p<0.05) more released (a = 1.29; p=1.57) in Stylo (Table 3.5) than in other feedstuffs. This was followed by Baobab bark (a = 0.971, p = 1.25) and Tephrosia (a = 0.86; p = 1.14). The rate of Ca released in Rice bran (0.06) was significantly (p<0.05) low. Phosphorus was more readily released in Wheat

Table 1: *Proximate Composition of different feedstuffs before incubation (%)*

Feedstuff	Crude protein	Ether extract	Crude fibre	Acid detergent (ADF)	Neutral detergent (NDF)	Calcium	Phosphorus	Magnesium	Copper (ppm)	Ca:P
Tephrosia	15.28	7.5	32.0	36.24	66.31	0.95	0.60	0.53	29.46	3:2
Stylosanthes	14.03	8.0	28.0	41.23	62.14	1.81	0.54	0.19	54.69	4:1
Rice bran	5.81	7.0	34.0	66.32	71.53	0.52	2.19	0.26	42.10	1:4
Wheat offal	13.86	8.5	10.0	41.51	83.26	0.24	3.22	0.23	20.20	1:16
Baobab bark	3.48	6.5	58.0	47.28	60.21	1.28	0.84	0.20	41.43	2:1

Table 2: *Degradability coefficients of crude protein.*

Constant	Tephrosia	Stylo	Rice bran	Wheat offal	Baobab bark	SEM
a	4.25^{a}	4.22^{b}	0.51^{e}	0.67^{c}	0.65^{d}	1.31
b	0.11^{b}	0.10^{c}	0.08^{d}	0.11^{b}	0.16^{a}	0.09
c	0.0382^{a}	0.0318^{c}	0.0310^{d}	0.0318^{c}	0.0332^{b}	0.002
p (a+b)	4.36^{a}	4.32^{b}	0.59^{c}	0.78^{d}	0.81^{c}	2.11

a,b,c,d,e Means within the same row with different superscripts are significantly different ($p<0.05$)

Table 3: *Degradability coefficients of ether extract*

Constant	Tephrosia	Stylosanthes	Rice bran	Wheat offal	Baobab bark	SEM
a	2.45^{a}	2.28^{b}	0.35^{e}	0.65^{c}	0.62^{d}	0.17
b	0.05^{c}	0.12^{d}	0.19^{a}	0.16^{b}	0.15^{c}	0.03
c	0.0600^{a}	0.0200^{d}	0.0200^{d}	0.0232^{c}	0.0432^{b}	0.01
p (a+b)	2.50^{a}	2.40^{b}	0.54^{c}	0.81^{c}	0.77^{d}	0.61

a,b,c,d,e Means within the same row with different superscripts are significantly different ($p<0.05$)

Table 4: *Degradability coefficients of ADF and NDF*

			ADF			
Constant	Tephrosia	Stylosanthes	Rice bran	Wheat offal	Baobab bark	SEM
a	30.10^{c}	35.96^{d}	64.99^{a}	38.57^{c}	43.00^{b}	13.01
b	14.81^{c}	15.23^{a}	0.18^{c}	14.18^{d}	14.98^{b}	0.91
c	0.0600^{a}	0.0500^{b}	0.0300^{d}	0.0400^{c}	0.0600^{a}	0.03
p (a+b)	44.91^{c}	51.19^{d}	65.17^{d}	52.75^{c}	57.98^{b}	11.31
			NDF			
Constant	Tephrosia	Stylosanthes	Rice bran	Wheat offal	Baobab bark	SEM
a	59.05^{c}	51.97^{c}	68.55^{b}	80.10^{a}	54.31^{d}	21.81
b	7.79^{b}	7.62^{d}	7.70^{c}	7.88^{a}	7.33^{c}	0.83
c	0.0300^{b}	0.4002^{a}	0.4001^{a}	0.4003^{a}	0.4001^{a}	0.1010
p (a+b)	66.84^{a}	59.59^{c}	76.24^{b}	87.98^{a}	61.64^{d}	11.31

a,b,c,d,e Means within the same row with different superscripts are significantly different ($p<0.05$)

Table 5: *Rumen degradation coefficients of calcium*

Constant	Tephrosia	Stylosanthes	Rice bran	Wheat offal	Baobab bark	SEM
a	0.86^{c}	1.29^{a}	0.06^{e}	0.19^{d}	0.97^{b}	0.05
b	0.28^{a}	0.28^{a}	0.16^{c}	0.19^{b}	0.28^{a}	0.02
c	0.1043^{a}	0.1043^{a}	0.0477^{d}	0.0814^{c}	0.0983^{b}	0.03
P(a+b)	1.14^{c}	1.57^{a}	0.22^{e}	0.38^{d}	1.25^{b}	0.01

a,b,c,d,e Means within the same row with different superscripts are significantly different ($p<0.05$)

Table 6: *Rumen degradation coefficients of phosphorus*

Constant	Tephrosia	Stylosanthes	Rice bran	Wheat offal	Baobab bark	SEM
a	0.18^{b}	0.09^{d}	0.08^{e}	0.19^{a}	0.11^{c}	0.01
b	0.08^{d}	0.10^{c}	0.12^{b}	0.19^{a}	0.10^{c}	0.01
c	0.0582^{c}	0.4300^{a}	0.0382^{d}	0.0814^{b}	0.0300^{e}	0.02
p(a+b)	1.26^{b}	0.19^{e}	0.20^{d}	0.38^{a}	1.21^{c}	0.01

a,b,c,d,e Means within the same row with different superscripts are significantly different ($p<0.05$)

Table 7: *Rumen degradation coefficients of Megnesium*

Constant	Tephrosia	Stylosanthes	Rice bran	Wheat offal	Baobab bark	SEM
a	0.48^{d}	0.79^{b}	0.30^{e}	0.49^{c}	0.92^{a}	0.03
b	0.14^{b}	0.12^{c}	0.10^{d}	0.08^{e}	0.15^{a}	0.006
c	0.07^{c}	0.09^{a}	0.08^{b}	0.05^{d}	0.05^{d}	0.41
p (a+b)	0.62^{c}	0.91^{b}	0.40^{e}	0.57^{d}	0.07^{d}	0.001

a,b,c,d,e Means within the same row with different superscripts are significantly different ($p<0.05$)

Table 8: *Rumen degradation coefficients of copper*

Constant	Tephrosia	Stylosanthes	Rice bran	Wheat offal	Baobab bark	SEM
a	10.97^{d}	18.14^{c}	7.92^{e}	30.65^{a}	18.69^{b}	17.03
b	7.31^{a}	0.29^{b}	0.28^{c}	0.29^{b}	0.27^{d}	2.01
c	0.12^{b}	0.10^{d}	0.13^{a}	0.09^{c}	0.11^{c}	0.02
p(a+b)	18.28^{d}	18.43^{c}	8.20^{e}	30.94^{a}	18.96^{b}	3.23

a,b,c,d,e Means within the same row with different superscripts are significantly different ($p<0.05$)

offal ($a = 0.19$; $p=0.38$) and Tephrosia ($a = 0.18$; $p = 0.26$) than in other feedstuffs.

Magnesium release (a) was ranked highest in Baobab bark (0.92) and lowest in Rice bran (0.30) with significant differences ($p<0.05$) occurring among the feedstuffs. Variations were also observed in the other degradation constants. However, rice bran was the least in Mg release.

Wheat offal was highest in soluble fraction (30.65) in term of Cu release and also highest degradability (30.94) while the least was in the Rice bran (7.92 and 8.20, respectively). The highest insoluble fraction (7.31) was noticed in Tephrosia while the least was in Baobab bark (0.27). Wheat offal appeared to contain the highest potential degradable fraction among the feedstuffs, though it recorded the lowest Cu content before incubation (Table 1).

Discussion

The variations in the nutrient content considered in each sample could be an indication of relative bio-availability in the samples. Tephrosia, Stylosanthes and Wheat offal appeared to be adequate in all nutrients considered to meet any productive and physiological requirements of sheep and goat (Irving, 1964; Ranjhan, 1980; Church, 1984; Bell, 1997).

Any concentrate supplement that contains Tephrosia, Stylo or wheat offal (releasing 15.21; 12.24 and 13.10 crude protein, respectively) may be considered as having adequate protein for small ruminants (NRC, 1975). The crude fibre content ranged between 10% in wheat offal and 58% in Baobab bark; however the wheat offal crude fibre content met the recommended 10% CF in the diet of sheep by ODNRI (1988). Microbial attachment to food particles in the rumen (Kudo, *et. al* 1995) would ensure effective degradation of the fibre especially since ruminants have been known to cope with diets of fibrous forages so much so that it does not utilize low-fibre diet efficiently (Steg, *et. al.* 1988; Owens, 1991; Fajuke, 2002). A combination of Tephrosia, Stylo and wheat offal in a compounded ration will appear to be adequate to meet all the nutrient requirements in sheep and goat. The maximum dietary level of P that can be tolerated by sheep without development of caculi lies between 0.37 and 0.69% of the diet dry matter (Bushman, *et. al.* 1965). The proportion of P in each of the feedstuff above 0.54 – 3.22% (Table 1.) suggests that any of the feedstuff will supply adequate P without further P supplement. When high Ca level is required in a ration, Stylo inclusion may be suggested as a forage of choice or basal diet while wheat offal may be appropriately recommended for high P inclusion in the diet.

The CP disappearance in Tephrosia, Stylo and Wheat offal during the 12 to 48h incubation period (8.30 ± 0.30 to 15.21 ± 0.14%) would meet the maintenance (9.4%), flushing (9.1%) and non-lactating (9.3%) requirements of sheep (NRC, 1985). The release of CP during the incubation period followed the proximate composition of the different feedstuffs before incubation. Thus, Tephrosia, Stylo and wheat offal were well degraded in term of crude protein. However, Rice bran and Baobab bark were shown to be poorly degraded similar to the reports from other studies (Smith, *et. al.* 1989). Rice bran and Baobab bark may serve as supplements in high protein feeds as calorie diluents while Tephrosia and Stylo may be fed to ruminants for improved growth performance and lactation. Mertens Ely (1979) reported that forage having cell walls that are degraded rapidly may promote greater rate of ruminal digestion and passage and allow the animal to consume more food. From the extent of degradation it can be suggested that feedstuffs that are highly degradable, such as Tephrosia, Stylo and Wheat offal, may be fed to an animal that requires fast release of protein from the fed feedstuff particularly the young and actively growing animals as well as the animals exhibiting protein deficiency for fast replenishment. However, others with slower degradation rate and smaller extent may be fed to older or dry animals for maintenance, or animals that require slow release of protein from diet. Orskov (1977) reported that proteins with low degradation are especially valuable to ruminants with high protein requirements like dairy cows in early lactation and early-weaned lambs and calves. This is because forages (Orskov 1992) have a very long retention time and usually very little of their protein leaves the rumen undegraded.

From Tale 1, Stylo, Tephrosia and Baobab bark contained normal Ca: P ratios (4.1; 3.2; 2.1) as recommended by Haenlein (1987) in the ruminant diets. Where high Ca level is required, Stylo may be recommended while wheat offal with very high P ratio will be incorporated in a diet requiring high P inclusion. The variations in the proportions of soluble fraction (a) could be due to possible variations in fibre content of the samples. The variations in the rate and extent of degradation (disappearance) could also be attributed to rumen environment, properties of the feedstuffs, solubility, maturity of the feedstuffs when harvested as well as the rate of fermentation of fibre and chemical structure of lignin and its concentration (Brice and Morrison, 1982; Akin, 1988 and Shaver, *et. al*. 1988). In an animal that requires fast release of energy such as energy deficient animals or young and actively growing animals, a combination of Tephrosia, Stylo and Wheat offal would seem to be appropriate if fed to such animals, while Rice bran and Baobab bark can form part of maintenance ration supplied to animals requiring slow release of energy, or be combined with high energy feedstuff to cut down caloric density in the long run to reduce fat-laying tendency of such animal.

The results of ADF disappearance in Stylo and Tephrosia seemed to indicate that Tephrosia at the same age with Stylo (8 weeks) under the same soil and environmental conditions contained more fibre fraction than Stylo, and that Tephrosia was richer in ADF than Stylo. This observation was further established from the results of proximate composition (Table 1) Thus Stylo contained higher indigestible fibre than Tephrosia while Tephrosia contained higher total fibre than Stylo. The significantly ($P<0.05$) higher ADF release in Rice bran and Baobab bark at the end of 48h incubation period suggested a decrease in energy value compared with other feedstuffs while a significant ($P<0.05$) increase in NDF release as observed in the two feedstuffs could also lead to decreased feed intake (Bell, 1997). Keay *et al*(1965) noted that Baobab bark produced a strong fibre that was usually stripped for domestic uses including fattening of rams at the approach of Muslim religious Festival (Eid-Kabir). Wheat offal was the least degraded and slowest to degrade in terms of ADF ($21.50 \pm 0.058\%$) and NDF $5.29 \pm 0.21\%$) after 48h incubation period. It however, contained the least fibre content (10%: Table 1), hence, it can be considered a low-fibre feedstuff (Smith *et. al*. 1989). The levels of ADF and NDF in the un-incubated samples (Table 3.1) and the extent of disappearance after 48h incubation period (Table 3.6) suggested that Rice-bran, Wheat offal, Tephrosia and Stylo could meet the requirements for ADF and NDF in small ruminants (McDonald, *et. al*. 1990).

NRC (1980) has informed that the Ca content of natural feed varies widely depending upon the species of plant, portion of plant fed and the stage of maturity. The significantly ($p<0.05$) low release of Ca from Rice bran could be attributed to the low level of calcium (0.52%) in the un-incubated sample (Table 1) or that the Ca ion could have formed complexes with other unidentified anti-nutrients or anti-metals such as phytate or/and oxalate in Rice bran which did not allow the easy release of Ca. However, the faster release of Ca from Stylo ($p=1.57$) than other feedstuffs could be an advantage in a situation that requires fast release of Ca from feedstuff, for instance, Ca deficiency in an animal or young and actively growing animals.

Phosphorus was released more significantly ($p<0.05$) in wheat offal (a=0.19; p=0.38) and Tephrosia (a=0.18; p=0.26) than in the other feedstuffs. Animals suffering from deficiency or the young animals that are actively growing could benefit during oesteogenesis from feeding on wheat offal and Tephrosia-containing supplements, while P, being part of nucleic acids (DNA & RNA) could be beneficial for muscle growth (Irvings, 1964). Most animals require a fairly narrow Ca: P-ratio usually no wider than 2:1. However, ruminants can tolerate wider ratios than monogastrics animals provided the P ratio is adequate (NRC, 1980; Beeson *et. al.* 1975).

Feeding a combination of Stylo, Tephrosia, Wheat offal and Baobab bark could meet Ca and P requirements of sheep (Ranjhan, 1980) since these two minerals play major roles in the bone formation process by animals. Irving (1964) had observed that when Wheat offal is fed to the animal there are continuous metabolic processes in every body cell. Mackie and Therion (1984) also reported that Ca is more important for the stability of cell walls and membranes. It is the major cation found in the middle lamella. A diet or supplement containing Stylo and Wheat offal would be recommended for dairy and lactating animals (NRC, 1980). Wheat bran has been reported to be a good source of P (Ranjhan, 1980). Maximum release for Ca and Mg often require longer incubation time than K, P, Cu or Zn (Emanuele and Staples, 1990). However, when one considers the cost of synthetic Ca and P, the combination of Stylo, Tephrosia, Baobab bark and wheat offal would be of higher benefit because other nutrients are also supplied that are important to the animals' need, apart from Ca and P. Calcium was released at the same rate (0.28) in Tephrosia, Stylo and Baobab bark suggesting that any of them can be substituted in compounded feed to supply Ca to the animal. Since they have the same level of insolubility in water and the same level of slow rate of release, it means that rumen microbes would have more time to work on them making the animal to get more of the mineral (Ca) from them. They would be useful feedstuffs for animals that require slow release of Ca or in maintenance ration.

The significantly ($p<0.05$) low release of Mg in Rice bran could suggest a very strong bond between Mg and its fibre content (Smith, *et. al.* 1989). Variations in rumen degradation constants have been observed (Dzowela *et. al.* 1995) and these may be related to the age of plant when harvested. It was generally observed that Baobab bark had the hghest soluble fraction (0.92) in terms of Mg release and potential degradability (1.07). This could be an indication that Baobab bark is a potential feedstuff for Mg release. This may be a feedstuff of choice for the animals suffering from grass Tetany or animals that require readily released Mg in their diet. In addition, any animal that exhibits deficiency in Mg may require Baobab bark as supplement for quick replenishment. Lactating animals could also benefit from feeding Baobab bark containing rations. Wheat offal appeared to be a potential feedstuff that could supply adequate Cu (7-11 ppm) in the diet to meet sheep requirement for growth (NRC, 1985).

In general, it has been observed that the location of a mineral in the forage structure may influence its release. Minerals associated with the plant cell wall may have a lower bio-availability or may require longer fermentation time for maximal release. Plant species growing on similar soil types and under similar environmental conditions differ in mineral contents (Emanuele and Staples, 1990). The forages (Tephrosia and Stylo) and Baobab bark were higher in Ca than agricultural by-products (Rice bran and wheat offal) while P was higher in agricultural by-products than in the forages. Legumes forages were higher in crude protein than agricultural by-products and Baobab bark.

It was observed that the nutrients' release (CP, EE, ADF and NDF) increased with increasing incubation hours. The release of the minerals also followed similar trends with the nutrients. The values recorded for minerals were lower than those reported by Rooke *et. al.* (1983) and Emanuele and Staples (1990). The differences might have resulted from differences in maturity of forages used (percent release decreases as plant maturity increases; (Van Eys and Reid, 1987) or differences in washing procedures (Playne *et. al.* 1978). However, the extent of release indicated above did not imply that the nutrients were highly available for absorption from the rumen, but rather that they were available to ruminal micro-organism while bacterial action can render minerals unavailable in the rumen (Emanuele and Staples, 1990).

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