Chemical composition and rumen degradability of protein of browse and shrubs fed to sheep in Ghana

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SUMMARY

The chemical composition and protein degradability of *Antiaris africana, Delonix regia, Milletia thonningii, Khaya senegalensis, Griffonia simplicifolia, Ritchea reflexa* and *Securinega virosa* as well as treated or untreated rice straw were studied. The rice straw was treated with either sodium hydroxide (4.42 per cent w/w) or urea (7.55 per cent w/w) was used in the treatment of the straw. Wethers averaging 23.2 ± 0.60 kg liveweight and fitted with rumen canulae were fed with the straw and browse and 5 g sample placed in a nylon bag and incubated in the rumen. Data were fitted to the equation $P = a + b(1-e^{-ct})$ where *P* is extent of degradation at time *t*, *a* is percentage loss of water soluble component, *b* is percentage loss of water insoluble component, *c* is rate of degradation of component *b*, and *(a + b)* is the maximum percentage loss of protein. Significant differences ($P<0.05$) were observed in the chemical composition of browse, with protein values ranging between 13 and 22 per cent. For the straw, the crude protein ranged between 5 and 10 per cent. Similarly, significant differences ($P< 0.05$) were observed in the values of *a, b, (a + b)* and *c* among browse and straw. For the browse, the values for *a* ranged between 11 and 25 per cent, *b* varied between 40 and 60 per cent, *(a + b)* varied between 51 and 84 per cent, while *c* ranged between 0.011 and 0.043 h^{-1}. The corresponding range of values for the straw were 6.1- 10.5, 38-50, 44-61 per cent and 0.020-0.011 h^{-1} for *a, b, (a + b)* and *c*, respectively. The browse and shrubs are very good sources of protein supplements, especially when used with straws.

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RÉSUMÉ

FLEISCHER, J. E., SOTTIE, E. T. & AMANING-KWARTENG, K.: *La constitution chimique et la dégradabilité rumen de la protéine de brouts et d'arbrisseaux nourris aux moutons au Ghana.* Une expérience s'est déroulée pour étudier la constitution chimique et la dégradabilité de la protéine de *Antiaris africana, Delonix regia, Milletia thonningii, Khaya segegalensis, Griffonia simplicifolia, Ritchea reflexa et Securinega virosa* et la paille de riz traitée et non-traitées. La paille de riz était traitée avec soit l'hydroxide de sodium (4.42 pour cent w/w) soit l'urée (7.55 pour cent w/w) était utilisée pour le traitement de la paille. Les béliers châtrés ayant la moyenne de 23.2 ± 0.60 kg de poids dynamique et attachés aux canules de rumens étaient nourris avec la paille et le brouts et un échantillon de 5g placé dans un sac de nylon et incubé dans le rumen. Des données étaient fixées à l'équation $P = a + b(1 - e^{-ct})$ où P est degré de dégradation à un tempts t, a est le pourcentage de perte des éléments solubles dans l'eaus, b est le pourcentage de perte des éléments insoluble dans l'eau, C est la proportion de dégradation d' éléments b, et (a + b) est le pourcentage de perte maximum de protéine. Des différences considérables ($P< 0.05$) étaient observées dans la constitution chimique de brouts, avec les valeurs de protéine variant entre 13 et 22 pour cent. Pour la paille, la protéine brute variait entre 5 et 10 pour cent. De la même façon, des différences considérables ($P< 0.05$) étaient observées dans les valeurs de a, b, (a + b) et C parmi les brouts et les pailles. Pour les brouts les valeur pour 'a' variaient entre 11 et 25 pour cent, 'b' variaient entre 40 et 60 pour cent, (a + b) variaient entre 51 et 84 pour cent pendant que 'C' variaient entre 0.011 h^{-1} et 0.043 h^{-1}. Les valeur de variations correspondantes pour la paille étaient 6.1 - 10 5, 38 - 50, 44 - 61 pour cent et (0.020 - 0.11h^{-1}) respectivement pour a, b, (a + b) et C. Les brouts et les arbrisseux sont de trés bonnes sources de suppléments protéiques surtout quand elles sont servies avec les pailles.

Introduction

Ruminant livestock in Ghana depends on the natural grassland for their sustenance and productivity. However, the natural grasslands are

relatively low in crude protein content, averaging about 5 to 6 per cent in the rainy season, but falling to about 2 to 4 per cent in the dry season (Landsbury, Rose Innes & Mabey, 1965). Furthermore, in the dry season, they are very low in digestible energy and, therefore, unable to maintain the bodyweight of animals.

To overcome this weight-loss problem during the dry season, farmers sometimes coppice browse and shrubs for the animal. Apart from the chemical composition and the digestibility, not much is known about the degradability of browse and shrubs in Africa.

Thus, the study aimed to determine the chemical composition and protein degradability of some browse and shrubs commonly used in Ghana as well as treated or untreated rice straw.

Materials and methods

The experiment was carried out at the University of Ghana's Agricultural Research Station (ARS-Legon). Browse and shrub samples were collected from the neighbourhood of ARS-Legon between October and December. The browse and shrubs used in the study were *Antiaris africana, Delonix regia, Milletia thonningii* (Schum and Thonn), *Khaya senegalensis* (Desr.) A jurs., *Griffonia simplicifolia* Vahl ex DC Baill, *Grewia carpinifolia, Ritchea reflexa,* and *Securinega virosa.* The straw used with the browse and shrubs was rice straw treated with sodium hydroxide (4.42 g w/w). The NaOH-treated straw was compared with the untreated straw and urea treated straw (7.55 w/w). Wethers, averaging 23.2 ± 0.60 kg liveweight, were placed in metabolic crates. The animals were fitted with rumen fistula. Each animal was assigned to one browse or shrub.

The design was a 4 × 4 latin square design and the switch-over period was after every 4 weeks of feeding. Ten days change-over period was allowed to avoid carry-over affects of treatment. The animals were fed browse or shrubs that they could consume within 1 h as described by Dube & Ncube (1992). Sodium-hydroxide-treated rice straw was then given *ad libitum* with the browse.

Five grams of feed sample, browse or shrubs, treated or untreated rice straw, milled through 1-mm sieve were placed in nylon bags (12 cm × 6 cm; pore size 0.1 mm) and were incubated in duplicate. Bags were withdrawn at 0, 3, 6, 9, 12, 24, 48, and 72 h, doused in absolute alcohol to arrest microbial breakdown, washed under running tap water until the latter was clear then dried in an oven at 60 °C to a constant weight. The degree of degradation was then fitted to the equation $P = a + b(1-e^{-ct})$ developed by Orskov & McDonald (1979) for protein, where

P = extent of degradation at time t,
a = percentage loss of water soluble component,
b = percentage loss of water insoluble component,
c = rate constant for degradation of component b,
a + b = maximum percentage loss of feed dry matter of protein.

All browse, shrubs and straw, both treated and untreated were analyzed for dry matter, crude protein, neutral detergent fibre, acid detergent fibre, cellulose, and acid detergent lignin according to procedures outlined in AOAC (1990). *In vitro* dry matter digestibility (IVD) was determined according to the method described by Minson & McLeod (1972).

The data were analyzed according to procedures outlined by Snedecor & Cochran (1976).

Results

Table 1 shows the chemical composition and *in vitro* dry matter digestibility of some browse and shrubs used in Ghana. Significant differences ($P<0.05$) were observed in all parameters analyzed. The dry matter content ranged between 32 and 45 per cent for *Milletia* and *Ritchea*, respectively. Crude protein content ranged from 13 per cent for *Khaya* to 22 per cent for *Milletia.* Apart from *Khaya* and *Antiaris* which had protein contents of 13 and 15 per cent, respectively, all the others had a value of at least 18 per cent. Neutral detergent fibre content ranged from 27 per cent in

TABLE 1

Chemical Composition and In Vitro *Digestibility of Some Browse and Shrubs Used in Ghana*

Species	*Dry matter*	*Crude protein*	*Neutral detergent fibre*	*Acid detergent fibre*	*Cellulose*	*Acid detergent lignin*	In vitro *digestibility*
A. africana	44.26d	14.66a	43.91b	29.57b	16.07ab	7.87ab	70.35cd
D. regia	34.27ab	19.91b	56.45bc	34.63b	12.10a	22.02d	52.86ab
G. carpinifolia	37.69bc	18.16a	62.33c	45.63c	31.04c	14.78bcd	58.41bc
G. simplicifolia	40.60cd	18.16b	55.59bc	37.43bc	13.23abc	19.05cd	53.10ab
K. senegalensis	34.85abc	12.91a	55.37bc	35.38bc	20.50bc	14.60bc	50.94ab
M. thonningii	31.54a	21.88c	63.23c	37.99bc	25.61bc	11.85bc	40.70a
R. reflexa	44.54d	19.69bc	52.97bc	32.05b	22.75bc	8.87ab	60.11bc
S. virosa	44.33d	18.82bc	26.52a	14.15a	10.15a	3.32a	75.05d
SE	5.20	2.91	4.91	9.08	6.94	6.12	4.00

Figures in each column with different letters are significantly different ($P<0.05$)
SE = standard error

Securinega to 63 per cent in *Milletia*. Acid detergent fibre varied from 14 per cent in *Securinega* to 46 per cent in *Grewia*. Cellulose content varied from 10 per cent in *Securinega* to 31 per cent in *Griffonia*. Acid detergent lignin ranged from 3 per cent in *Securinega* to 22 per cent in *Delonix*. Except for *Milletia* which had a low IVD value of 41 per cent, all the others had an IVD value which ranged from 51 to 75 per cent.

Table 2 shows that chemical composition and *in vitro* dry matter digestibility of rice straw treated with either sodium hydroxide or urea or untreated. Except for cellulose and acid detergent lignin which were not influenced by treatment, all other parameters were significantly affected ($P<0.05$) by treatment. Dry matter content was decreased significantly ($P<0.05$) by treating the rice straw, though no significant difference was observed between treatments. Crude protein content significantly increased ($P<0.05$) only with urea treatment. Although NDF content decreased with treatment, a significantly low value was observed only with urea-treated straw. On the contrary, acid detergent fibre significantly increased with both treatments. Both treatments increased IVD values but no significant difference was observed between treatments.

Table 3 shows the rumen degradation

TABLE 2

Chemical Composition and In Vitro *Digestibility of Rice Straw Treated with Either Sodium Hydroxide or Urea or Untreated*

Sample	*Dry matter*	*Crude protein*	*Neutral detergent fibre*	*Acid detergent fibre*	*Cellulose*	*Acid detergent lignin*	In vitro *dry matter digestibility (V)*
Untreated rice straw	86.06a	5.34a	80.70a	50.35a	32.00a	9.55a	40.86
NaOH-treated rice straw	79.17b	7.08a	73.05a	54.55b	33.40a	9.02a	50.98b
Urea-treated rice straw	84.70b	10.45b	62.40b	56.80b	34.12a	8.98a	52.05b
SE	3.65	2.60	8.96	3.27	1.08	0.32	6.17

Figures in each column with different letters are significantly different ($P<0.05$)
SE = standard error (n-6)

TABLE 3

Rumen Degradation Characteristics of Protein of Some Browse and Shrubs Used in Ghana

Species	*Rumen degradation characteristics*			
	a	*b*	*a + b*	*c*
A. africana	15.70ab	56.00c	71.70bc	0.043e
D. regia	11.00a	39.60a	50.60a	0.039de
G. carpinifolia	18.40bc	52.02bc	70.41bc	0.023b
G. simplicifolia	23.00ed	51.00bc	74.00bc	0.023b
K. senegalensis	22.70cd	46.10ab	68.80b	0.011a
M. thonningii	13.00ab	40.20a	53.30a	0.031c
R.reflexa	25.10d	58.40c	83.50c	0.034cd
S.virosa	22.90cd	59.80cd	82.70bc	0.017b
SE	5.26	7.80	12.07	0.004

a = Percentage loss of water soluble component
b = Percentage loss of water insoluble component
c = Rate constant for degradation of water insoluble component
a + b = Maximum percentage loss of protein
SE = Standard error
Figures in the same column with different letters are significantly different (P<0.05)

characteristics of protein of some browse and shrubs used in Ghana. Significant differences (P<0.05) were observed among the species in all parameters. Water soluble component, a, varied from 11 per cent in *Delonix* to 25 per cent in *Ritchea.* Degradability of water insoluble component, b, ranged from 40 per cent in *Delonix* to 60 per cent in *Securinega.* The maximum percentage loss of protein, (a + b), ranged from 51 per cent in *Delonix* to about 84 per cent in *Ritchea.* The rate constant of degradation of water insoluble component, c, varied from 0.011 per cent h^{-1} in Khaya to 0.043 per cent h^{-1} in *Antiaris.* Browse intake varied from 62 g in *Khaya* to 250 g in *Grewia,* while straw intake ranged from 325 g in *Delonix* to 461 g in *Milletia.*

Table 4 shows the rumen degradation characteristics of protein of rice straw either treated or untreated. Sodium hydroxide treatment did not affect (P>0.05) the degradation parameters. On the contrary, urea treatment improved (P<0.05) all the parameters.

Discussion

The variation observed in chemical composition of the browse and shrubs has been observed in an earlier report (Sottie *et al.*, 1997). Of particular significance is the crude protein whose range of values (13-22 per cent) fall within the range of values (12-30 per cent) reported for browse and shrubs (Norton, 1991). The values are higher than those reported by Lansbury, Rose Innes & Mabey (1965) for grasses (2-4 per cent) in the dry season. Furthermore, except for *Milletia* whose IVD value was only 41 per cent, all the others had an IVD value of at least 50 per cent which is higher than the IVD values for grasses (36-44 per cent) in the dry season (Mohammed-Saleem, 1986). Thus, the use of any of these

TABLE 4

Rumen Degradation Characteristics of Protein of Rice Straw Treated with Either Sodium Hydroxide or Urea or Untreated

Sample	*a*	*b*	*a + b*	*c*
Untreated rice straw	6.10a	37.70a	43.80a	0.023a
NaOH-treated rice straw	7.20ab	40.10a	47.30a	0.020a
Urea-treated	10.50b	50.40b	60.90b	0.041b
SE	1.15	3.37	4.52	0.003

a = Percentage loss of water soluble component
b = Percentage loss of water insoluble component
c = Rate constant for degradation of water insoluble component
a + b = Maximum percentage loss of protein
SE = Standard error (n-6)
Figures in the same column with different letters are significantly different (P<0.05)

browse and shrubs would, therefore, improve the supply of protein to the animal. Again, the treatment of the rice straw improves the digestibility, but it is only when urea is used that the nitrogen supply is improved.

Africa lacks information on the rumen degradation characteristics of protein of browse and shrubs. Although all the species had fairly high crude protein content, the degradability of the protein varied considerably. A similar observation was made by Van Straalen & Taminga (1990). The water soluble component (a) value

(11-25 per cent) obtained in this study lies within the range of values (4.0-27 per cent) reported by Addo-Kwafo (1996). On the contrary, the value (40-60 per cent) of the potentially degradable component (b) was higher than the value (29-41per cent) that has been reported, while the rate constant for the degradation of *b* (0.02-0.04 per cent h^{-1}) was lower than the values (0.06-0.09 per cent h^{-1}) reported by Addo-Kwafo (1996). It has been suggested that when *c* is small and *b* is large, the protein source degrades slowly but with time it can be degraded to a high extent (Orskov, Hughes-Jones & McDonald, 1981).

Thus, it would seem that these browse and shrubs have a higher degradability. The degradation of the browse and shrubs is, however, affected by anti-nutritive factors such as tannin (Norton, 1991). *Milletia*, *Khaya*, and *Grewia* were reported to contain tannin (Watt & Breyer-Brandwijk, 1962). Thus, when fed properly these browse/shrubs can make substantial contribution to the animal's protein nutrition requirement.

In conclusion, the study has shown that these browse and shrubs contain high levels of crude protein, and that apart from *Milletia*, they also have moderate to very high digestibility compared to rice straw. The protein degradability characteristics indicated that the browse plants are very good protein sources which can be used to improve animal production especially in the dry season when available feeds are generally of poor quality.

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