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Effect of Level of *Zizyphus mauritiana* Leaf Meal Inclusion in Concentrate Diet on Rumen Degradation Characteristics

Salisu Bakura ABDU*, Mohammed Rabiu HASSAN, Hanwa Yusuf ADAMU, Suleiman Makama YASHIM

ABSTRACT [ENGLISH/ANGLAIS]

The inclusion levels of *Zizyphus mauritiana* leaf (ZLM) meal at 0, 10, 20, 30 and 40 percentages in supplementary concentrate diets were determined by evaluating the dry matter (DM) ruminal degradation characteristics soluble fraction (a), potential degradation (PD), effective degradation (ED), degradable fraction (b), rate of degradation (c) at rumen outflow rates of 2, 3, 4 and 5% using fistulated Yankasa rams. Dry matter (DM), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF), tannins and ash contents were also determined. Results showed significant ($p < 0.05$) differences in the degradation characteristics at the different level of ZLM inclusion. Supplementary concentrate diet with inclusion of ZLM up 20% significantly ($p < 0.05$) had more feed value than supplementary feeds with higher inclusion levels of ZLM, chemical composition of the supplementary concentrate diets and their rumen degradation characteristics proved that inclusion of up to 20% ZLM in supplementary diet is excellent feed sources that could be utilized by ruminants for both maintenance and production.

Keywords: Effective degradation, potential degradation, Yankasa, Zizyphus

RÉSUMÉ [FRANÇAIS/FRENCH]

Le taux d'inclusion des Zizyphus mauritiana feuille (ZLM) repas à 0, 10, 20, 30et 40 pourcentages dans les régimes complémentaires ont été concentrésdéterminé par l'évaluation de la matière sèche (MS) des caractéristiques de dégradation dans le rumen fraction soluble (a), la dégradation potentielle (DP), la dégradation en vigueur (DEV), la fraction dégradable (b), le taux de dégradation (c) au taux de sortie du rumen de 2, 3, 4 et 5% en utilisant des béliers fistulées Yankasa. Matière sèche (MS), des protéines brutes (PB), en fibres au détergent neutre (NDF), les fibres au détergent acide (ADF), le contenu des tanins et des cendres ont également été déterminées. Les résultats ont montré significative (p <0,05) des différences dans lescaractéristiques de dégradation au niveau des différents de l'intégration ZLM.Régime alimentaire se concentrent supplémentaire avec l'inclusion de ZLMjusqu'à 20% de façon significative (p <0,05) avaient plus de valeur que denourrir des aliments de complément à des niveaux plus élevés de l'inclusionZLM, la composition chimique de l'alimentation complémentaire et concentrentleurs caractéristiques dégradation dans le rumen a prouvé que l'inclusion d'un maximum de 20% ZLM dans le régime complémentaire est excellente sources d'alimentation qui pourrait être utilisé par les ruminants à la fois pour l'entretienet la production

Mots-clés: La dégradation de l'efficacité, la dégradation potentielle, Yankasa, Zizyphus

Affiliations:

Department of Animal Science, Ahmadu Bello University, Zaria, NIGERIA

* Email Address for Correspondence/ Adresse de courriel pour la correspondance: sbabdu@gmail.com

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INTRODUCTION

The major constraint to livestock productivity in this region is inadequate nutrition because the primary feed resources (natural pastures and cereal crop residues) are bulky, high in fibre, low in nitrogen and of poor digestibility, hence resulting in low intake and consequently affecting the of performance ruminant animals.

Supplementation with concentrates feed are expensive, therefore there is the need to find an alternative means of improving the quality of the ruminants feed at reduced cost. Browse plants, are one of the cheapest sources of feed for ruminants, having crude protein of 14 to 25% [1, 2] for foliage from fodder trees. Their year round evergreen presentation and nutritional abundance provides for year-round provision of fodder [3]. They provide vitamins and frequently mineral elements which are lacking in grassland pastures [4].

Therefore, the inclusion, of browse plants with in concentrate supplementary feed for livestock will hopefully reduce feed cost. So far, several indigenous browse plants have been evaluated for the development

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of integrated crop-livestock agro-forestry technology such as alley farming in the humid tropical lowlands of West Africa [5].

A considerable number of these species have potential as forage [6]. Zizyphus mauritiana is one of such browse plant with the potential. Gupta [7] reported that the leaves of contain 15.4% crude protein. The leaf of *Z. mauritiana* are readily eaten by camels, cattle, sheep, goats and browsing wild animals and is considered a nutritious fodder [8]. The present study was conducted to evaluate the inclusion level of ZLM in supplementary concentrate diets using fistulated Yankasa rams.

MATERIALS AND METHODS

Supplementary concentrate diets

Five supplementary concentrate diets with 0, 10, 20, 30 and 40% inclusion levels of Zizyphus mauritiana leaf meal were formulated to contain 12% crude protein (table 1). Other ingredients used for the supplementary diets include maize, cotton deed cake, rice offals, wheat offal salt and bone meal.

Sample collection and preparation

Fresh leaf samples of the browse plants were harvested from various farm locations. The samples were duplicated and about 300 g of each of the samples were sun dried and oven at 60^{0}C until a constant weight was obtained and DM determined. The samples were thereafter milled to pass through a 2.5 mm sieve using a Christy Hunt Laboratory mill. This sample was used to determine *in situ* dry matter (DM), using fistulated Yankasa rams

Management of animals

Three rumen fistulated Yankasa rams with an average weight of 26 kg were used for the DM degradation study. The animals were placed in individual pens and fed maize stover *ad libitum* as basal diet. Each ram was fed with concentrate supplementary diet of 1.5 % of its body weight per day. The animals were given free access to mineral licks and clean drinking water for the duration of the experiment.

In situ dry matter degradation

Three (3) g each of the oven dried and milled feed samples were weighed and placed in labelled nylon bags measuring 90 mm x 120 mm with a pore size of 40μ. The bags were incubated in duplicates for 3, 6, 12, 24, 36, and 48h in the rumen of three fistulated Yankasa rams.

At the end of each incubation period, the bags were withdrawn from the rumen, soaked in a bucket of water at about 30^{0}C and later rinsed thoroughly under clean running tap water for about 25 min. The residues were then air-dried in a Gallenkamp oven for 48 h at 60^{0}C for computing DM disappearance (DMD) for each incubation period.

The degradation constants were estimated by fitting data to the exponential model of [9]:

y = a + b (1-c-ct)

Where: y = dry matter disappearance at time t

a = the soluble water fraction

b = insoluble fraction that will degrade in time t

c = rate of degradation (% h-1) of the b fraction

The constants were used in computing the potential degradation (PD) and effective degradation (ED), as

PD = potential degradability or extent of degradation (a + b) in time t

ED was estimated from the equation:

ED = a + b*c/(c + k),

Where *k* is the rumen outflow rate of digesta at 2, 3, 4 and 5%

Chemical analysis

Dried samples were ground with a hammer mill to pass through a 1 mm screen. The dried and ground samples were stored in sealed polythene bags and kept away from direct sunlight. The chemical compositions (Table 1) of the six browse plants were determined with these samples. Nitrogen (N) was determined using the Kjeldahl process [10] and crude protein (CP) calculated as N x 6.25. Crude fibre and ash contents were analyzed according to AOAC [10] methods. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) analysis were carried out according to the procedure of Goering and Van [11]. Concentrations of tannin were determined using the method described by Wheeler [12].

Statistical analysis

Data were subjected to analysis of variance, using statistical analysis systems [13]. Data were analyzed as a completely randomized design (CRD) with three replications. Differing treatment means were separated using the Duncan Multiple Range Taste option of the SAS package

RESULTS

Chemical composition of experimental feeds

The results of the chemical composition of the supplementary diets are presented in Table 2. The Zizyphus leaf meal had 13.9, 45.9 and 37.31% CP, NDF and ADF results respectively.

The tannin level of the ZLM is 181.13 mg/100g. NDF content in the concentrate supplementary diets increased as the level of ZLM inclusion increased from 0 to 40% (27.6 to 37.8 %). ADF values also increased from 17.20 in diet with 0% ZLM to 19.94 % in diet with 40% ZLM inclusion. The level of tannin increased from 46.15g/100mg in diet with 10% inclusion level to 66.67, 70.00, and 73.39 mg/100mg in treatment diets with 20, 30 and 40% level of ZLM inclusion respectively.

In situ dry matter degradation

Table 3 present the *in situ* dry matter degradation characteristics of the supplementary concentrate diets. Significant ($p < 0.05$) differences were observed in the DM degradation of soluble fractions of the supplementary diets. Inclusion level of ZLM at 0% had the highest value (27.63/100 g DM) and 40% inclusion level the least (20.10/100 g DM). There was significant ($p < 0.05$) differences in the DM degradable fractions of the supplementary concentrate diets. Inclusion of ZLM at 10% had significantly ($p < 0.05$) higher degradable fractions (38.56g/100g DM) than the other diets. Diets with 30 and 40% inclusion had statistically similar values, (21.44 and 20.52g/100g DM) respectively. The rate of degradation was highest ($p < 0.05$) at 0% inclusion ($0.089h^{-1}$) and least at 30 and 40% inclusion levels of ZLM (0.037 and $0.035h^{-1}$, respectively). There was a marked increase from 40.62g/100g DM at 40% inclusion level to 74.64/100g DM at 10% inclusion level, which significantly ($p < 0.05$) had the highest PD value.

Effective degradation

Effective degradation showed a marked decrease as the rumen out flow rate increased. Also there was a decrease with increase in level of ZLM inclusion in the concentrate diet. ED was significantly ($p < 0.05$) similar and highest at 0 and 10% inclusion level (54.68 and 53.58 % h^{-1}) and lowest at 30—and 40% inclusion (36.55 and 33.15% h^{-1}) at 2% out flow rate and also at 3% out flow rate followed similar pattern. There were however, significant ($p < 0.05$) differences in ED at the 4 and 5%, being higher at 0% inclusion level and least at 30 and 40% inclusion levels.

DISCUSSION

In situ dry matter degradation

The significant ($p < 0.05$) differences observed in soluble fractions in Table 3, could be due to variations in the chemical compositions in the contents of the readily fermentable carbohydrates (Table 1). Soluble fraction was highest ($p < 0.05$) at 0% inclusion level (18.97g/100g DM) and least at 40% inclusion of ZLM. The increase in soluble fractions may have resulted from the more soluble carbohydrates in the maize content in the supplementary concentrate, which decreased with increased inclusion level of ZLM. According to Van Soest [14], the soluble carbohydrates ferment faster than structural carbohydrates. The decrease in the DM degradable fractions of the supplementary concentrate diets with increase in the level of ZLM is in line with Dzowela et al. [15], Antoniewiez et al. [16], and Khazaal et al. [17], who reported low degradable fraction with high ADF and NDF content. Differing PD of the samples, as the inclusion level of ZLM in the diet increased may have been as a result of their variable chemical compositions, especially the proportion of cell wall and its composition [18].

The rate of degradation was significantly ($p < 0.05$) higher at 10% inclusion level and lower at 30 and 40% inclusion level. High NDF and ADF (Table 2), suggest a high lignin content of the Zizyphus cell wall which may have resulted in the low rate of degradation. This agreed with Cherney et al. [19], that the limiting factor in the rate of degradation may have been due to the proportion of lignin. Tannins which are also associated with NDF fraction may be responsible for the lower rate of degradation.

TABLE 1

Table 1 shows ingredients composition of supplementary concentrate diets with varying levels of *Zizyphus mauritiana* leaf meal

Constituents	Inclusion levels of Zizyphus leaf meal				
	0	10	20	30	40
Maize	37	33	28	24	19
Cotton seed cake	31	25	20	14	9
ZLM	-	10	20	30	40
Wheat bran	20	20	20	20	20
Rice bran	10	10	10	10	10
Bone meal	1.5	1.5	1.5	1.5	1.5
Common salt	0.50	0.50	0.50	0.50	0.50
Total	100	100	100	100	100

TABLE 2

Table 2 shows chemical composition of supplementary diets and *Zizyphus mauritiana* leaf meal (% DM basis)

Parameters	Inclusion levels of ZLM (%)					
	0	10	20	30	40	ZLM
Dry Matter	93.4	93.4	93.4	93.5	93.8	89.7
Organic Matter	86.78	86.80	87.11	87.00	87.40	79.4
Crude Protein	14.6	14.5	14.2	14.0	14.1	13.9
Total ash	6.6	6.6	6.3	6.5	6.4	4.1
NDF	27.6	31.2	32.7	33.2	37.8	45.9
ADF	12.0	15.7	16.0	18.8	21.54	37.31
Tannin mg/100g	-	46.15	66.67	70.00	73.39	181.13

ADF = acid detergent fiber, NDF = neutral detergent fiber, ZLM = Zizyphus leaf meal

TABLE 3

Table 3 shows ruminal DM disappearance and characteristics of supplementary concentrate diets incubated in the rumen

Parameters	Inclusion levels of ZLM					
	0	10	20	30	40	SEM
a	27.63^a	24.66^b	24.21^b	22.64^c	20.10^d	0.26
b	33.14^b	38.56^a	26.18^c	21.44^d	20.52^d	0.41
a+b	60.77^b	63.23^a	50.39^c	44.08^d	40.62^e	0.30
c	0.089^a	0.060^b	0.055^c	0.037^d	0.035^d	0.03

[abc] Mean values with different superscripts within a row differ significantly ($p < 0.05$), a = water soluble fraction (%), b = water insoluble but potentially degradable fraction (%), a+b = potential degradability, c = rate at which b is degraded (rate constant) (%/h)

TABLE 4

Table 4 shows effective DMD of supplementary concentrate diets incubates in different passage rate

Parameters	Inclusion levels of ZLM (%)					
	0	10	20	30	40	SEM
Passage rate (h^{-1})						
0.02	54.68^a	53.58^a	43.40^b	36.55^c	33.15^c	5.10
0.03	52.41^a	50.36^a	41.15^b	34.48^c	31.14^c	4.34
0.04	50.49^a	47.79^b	39.36^c	32.94^d	29.67^d	4.23
0.05	48.84^a	45.69^b	37.92^c	31.73^d	28.54^d	2.33

[a, b, c] mean values with different superscripts within a row differ significantly ($p < 0.05$)

The results of ED at rumen outflow rates of 2, 3, 4 and 5% h^{-1} presented in table 4 followed a characteristic pattern. There was a marked decrease in ED as the rumen outflow rate increased. This might be due to the reduced time spent in the rumen as the outflow rate increased. This trend suggests that the higher rate of degradation at lower inclusion level of ZLM in the concentrate may also be responsible for the lower ED. The presence of tannins, which may affect nutritive qualities of plants through their binding effects on nutrients [15], may be implicated in the low ED at high ZLM inclusion. Fractional rate of flow through the rumen [20] has a major effect on rumen degradability. Increased fractional rate of passage [21] decreases fractional rate of rumen protein degradability. This may have been responsible for the decreased ED when rumen outflow rate increased.

CONCLUSION

There were significant ($p < 0.05$) differences in the degradation characteristics of the concentrate at various inclusion level of the *Z. mauritiana* in the diets.

The rumen degradation characteristics indicate that *Z. mauritiana* leaf meal could be included in supplementary concentrates both maintenance and production in sheep to reduce cost of expensive concentrate feed.

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CONFLICT OF INTEREST

No conflict of interest was declared by the authors.