Influence of forage legume supplementation of maize stover on the performance of West African Dwarf sheep

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Abstract

Maize is commonly grown in many parts of Nigeria with its attendant production of underutilized maize stover, which could benefit sheep feeding systems if adequately enhanced with forage legumes. A 90-day experiment was conducted in a complete randomized design with twenty growing West African Dwarf (WAD) sheep aged 1 to 2 years with an average weight range of 10.97-15.61kg to determine the effect of forage legumes supplementation on the utilization of maize stover. The sheep were randomly assigned to five treatment groups, made of concentrate mixtures namely; maize stover at 20% of Concentrate for treatment 1 (MSC), maize stover with Gliricidia sepium (MSG), Enterolobium cyclocarpum (MSE), and Leucaena leucocephala (MSL) for treatments 2 to 4 respectively, and a sole concentrate with no maize stover as treatment 5 (Control). 300g of concentrate mixture was fed to the experimental animals with 400g of Panicum maximum as basal feed based on each treatment. Data were collected on feed intake, weight gain, nutrient digestibility, and nitrogen balance. Results showed that forage legume supplementation of maize stover improved feed intake and body weight gain. Dry matter intake and weight gain (g/day) ranged from 462.52 to 552.77, and 34.11 to 46.56, respectively in sheep fed MSC and MSL diets. The feed conversion ratio was best in sheep-fed MSL (11.87) and least in MSC (13.56) diets. Digestibility values improved ($P < 0.05$) across the forage legume-supplemented diets with best values observed in MSL across nutrients. Nitrogen balance was also positively enhanced with the supplementation of forage legumes ranging from 2.87 to 4.03 g/day in control and MSL diets, respectively. In conclusion, forage legume supplementation of maize stover significantly improved feed utilization, resulting in increased weight gain, better feed conversion ratio, and nutrient digestibility, with the best performance in sheep-fed MSL diets.

Keywords: Maize stover, forage legume, sheep, performance, digestibility, nitrogen balance
Running title: forage legume supplementation of maize stover on sheep performance

Influence de la supplémentation en légumineuses fourragères des tiges de maïs sur les performances des moutons nains d'Afrique de l'Ouest

Résumé

Le maïs est couramment cultivé dans de nombreuses régions du Nigéria, ce qui entraîne une production de tiges de maïs sous-utilisées, lesquelles pourraient bénéficier aux systèmes d'alimentation ovine si elles étaient adéquatement enrichies en légumineuses fourragères. Une expérience de 90 jours a été menée selon un plan randomisé complet auprès de vingt moutons nains d'Afrique de l'Ouest (WAD) en croissance, âgés de 1 à 2 ans et pesant en moyenne entre 10,97 et 15,61 kg, afin de déterminer l'effet de la supplémentation en légumineuses fourragères sur l'utilisation des tiges de maïs. Les moutons ont été répartis aléatoirement en cinq groupes de traitement, composés de mélanges concentrés, à savoir : Canne de maïs à 20 % de concentré pour le traitement 1 (MSC), canne de maïs avec Gliricidia sepium (MSG), Enterolobium

cyclocarpum (MSE) et Leucaena leucocephala (MSL) pour les traitements 2 à 4 respectivement, et un seul concentré sans canne de maïs pour le traitement 5 (témoin). 300 g de mélange de concentré ont été donnés aux animaux expérimentaux avec 400 g de Panicum maximum comme aliment de base en fonction de chaque traitement. Des données ont été recueillies sur la consommation alimentaire, le gain de poids, la digestibilité des nutriments et le bilan azoté. Les résultats ont montré que la supplémentation en légumineuses fourragères de canne de maïs améliorait la consommation alimentaire et le gain de poids corporel. La consommation de matière sèche et le gain de poids (g/jour) variaient de 462,52 à 552,77 et de 34,11 à 46,56, respectivement chez les moutons nourris avec les régimes MSC et MSL. L'indice de consommation était optimal avec les régimes MSL nourris aux moutons (11,87) et le plus faible avec les régimes MSC (13,56). Les valeurs de digestibilité se sont améliorées (p < 0,05) dans les régimes supplémentés en légumineuses fourragères, les meilleures valeurs étant observées avec les régimes MSL pour tous les nutriments. Le bilan azoté a également été amélioré avec la supplémentation en légumineuses fourragères, allant de 2,87 à 4,03 g/jour dans les régimes témoin et MSL, respectivement. En conclusion, la supplémentation en légumineuses fourragères des tiges de maïs a significativement amélioré l'utilisation des aliments, entraînant une augmentation du gain de poids, un meilleur indice de consommation et une meilleure digestibilité des nutriments, avec les meilleures performances avec les régimes MSL nourris aux moutons.

Mots-clés: tiges de maïs, légumineuse fourragère, mouton, performance, digestibilité, bilan azote

Introduction

The exorbitant cost of concentrate diets for sheep production has demanded the continuous search for less expensive and highly nutritive feedstuffs that could represent cost-effective supplements for sheep feeding on poor-quality crop residues. Maize stover in Nigeria is a readily available crop residue from maize which is generated annually and increases as more people venture into maize cultivation. Still, they have been underutilized because of their low feeding value due to their possession of poor protein content, energy, minerals, and vitamins (Akinfemi *et al.,* 2009). However, supplementation is perhaps a cheaper and simpler way of improving its feeding value as maize stover fed alone is typically accompanied by low voluntary intake and poor animal performance (Tolera and Sundstøl, 2000). Foliage from tree legumes and shrubs persists during the dry season when pasture is scarce or of poor quality. They have been beneficial to ruminants as they offer a cheaper alternative to supplementation of poor-quality roughages (Odeyinka, 2001, Mwangi *et al.,* 2024), contributing to protein-rich forage, digestible energy, and minerals when used either as supplements or as sole feed (Bello *et al.,* 2017; Castro-Montoya and Dickhoefer, 2020). Forage tree leaves offer a range of essential nutrients that contribute to sheep's overall health and productivity. They are recognized as valuable forage options in feeding sheep due to their high nutritional content. Their inclusion in the diet of small ruminants has been found and reviewed to stimulate rumen function by providing protein-rich forage (Barros-Rodríguez, 2013; Fasae and Adelusi, 2024) in improving the utilization of the low-quality forages and crop residues, thereby having various positive effects on sheep performance. Therefore, this study was designed to evaluate the supplemental effects of forage legume species *Leucaena leucocephala, Gliricidia sepium,* and *Enterolobium cyclocarpum* on the utilization of maize stover by West African dwarf sheep.

Materials and Methods

Twenty growing West African Dwarf sheep were used for the experiment at the Small Ruminant

Experimental Unit of the Directorate of University Farms, Federal University of Agriculture, Abeokuta, Nigeria. The experimental animals were allotted randomly into five treatments with four replicates, each in an intensively managed slatted floor individual pens with feed and water provided for the animals daily. Leaves from forage legumes namely *Leucaena leucocephala, Gliricidia sepium,* and *Enterolobium cyclocarpum* were harvested after two years of planting from established plots, air-dried to10 -12% the required moisture content. and then compounded into treatment groups (Table 1) made of concentrate mixture namely maize stover only for treatment 1 (MSC), maize stover with *Gliricidia sepium* (MSG), *Enterolobium cyclocarpum* (MSE), *and Leucaena leucocephala* (MSL) for treatments 2 to 4, and concentrate with no maize stover as treatment 5 (Control). The concentrate diet of 300g and *Panicum maximum* of 400g were fed *ad-libitum* to each experimental animal daily. The feeding trial lasted for ninety days.

Table 1. Ingredient composition (kg) of experimental diet fed to West African Dwarf sheep.

Ingredients	MSC	MSG	MSE	MSL	Control
Maize stover	20.00	10.00	10.00	10.00	0.00
Gliricidia sepium	0.00	10.00	0.00	0.00	0.00
Enterolobium cyclocarpum	0.00	0.00	10.00	0.00	0.00
Leucaena leucocephala	0.00	0.00	0.00	10.00	0.00
Wheat offal	20.00	20.00	20.00	20.00	20.00
Palm kernel cake	20.00	20.00	20.00	20.00	35.00
Rice bran	15.00	15.00	15.00	15.00	15.00
Maize offal	20.00	20.00	20.00	20.00	25.00
Bone meal	3.50	3.50	3.50	3.50	3.50
Common salt	1.50	1.50	1.50	1.50	1.50
Total	**100**	**100**	**100**	**100**	**100**

MSC – Maize stover concentrate, MSG–maize stover/*Gliricidia sepium,* MSE–Maize stover/*Enterolobium cyclocarpum*. MSL – maize stover /*Leucaena leucocephala,*

The body weights of the animals were taken using a spring balance at the beginning of the experiment and weekly thereafter. Feed offered and left overs were also recorded to determine the daily feed intake of the experimental animals. At the end of the 90-day feeding trial, each animal on the supplementary treatments was transferred into individual metabolic crates and offered experimental diets for digestibility trial. Water was given *ad libitum*. Each digestion trial involved an adjustment period of 14 days to allow the animals to adjust the metabolic crates to the diets, followed by a collection period of 7 days, where total faeces and urine were collected and weighed daily. Aliquot of the total faeces and urine were collected and bulked for each animal. Two drops of concentrated sulphuric acid were added to each container daily after collection of each sample to prevent microbial growth, organic matter decay, and loss of nitrogen/nitrogen volatilization (Chen and Gomez, 1992). The nutrient digestibility of the feed was determined by subtracting faecal nutrient output from feed nutrient intake.

Chemical and statistical analysis of feed, faecal and urine samples

All feed, faecal and urine samples were analysed for their proximate constituents according to AOAC (1995). The neutral detergent fibre, acid detergent fibre, and acid detergent lignin were determined according to Van Soest *et al*. (1991). All data generated were subjected to a one-way

analysis of variance (SAS, 1999), with significant means separated using Duncan's Multiple Range Test (Duncan, 1955).

Results and Discussion

The chemical composition of the experimental diets is shown in Table 2. Maize stover concentrate had a low content of crude protein (11.63 %), ether extract with a high content of 7.29% and dry matter (96.46%). The CP content of these forage legumes was above 10-12 % as recommended by Gatenby (2002) for a moderate level of ruminant production, suggesting the potential of these forages to provide adequate nitrogen required by rumen microorganisms to maximally digest the dietary fibre components which will lead to the production of volatile fatty acids. Maize stover is characterized by high NDF contents, implying the material is high in lignocellulose components and low in nitrogen (Undi *et al.,* 2001).

Table 2: Chemical composition (%) of the forage legume based experimental diets

Parameters (%)	MSC	MSG	MSE	MSL	Control
Dry matter	96.46	95.34	94.70	95.05	95.56
Crude protein	11.63^{b}	16.59^{a}	17.23^{a}	17.31^{a}	14.65^{b}
Ash	6.48	10.82	8.28	10.48	6.25
Ether Extract	7.29^{a}	4.11^{b}	4.08^{b}	5.50^{b}	7.29^{a}
Neutral detergent fibre	58.88	60.18	56.49	54.30	58.23
Acid detergent fibre	41.27	38.51	40.51	36.65	36.79
Acid detergent lignin	15.15^{a}	12.58^{ab}	11.44^{b}	11.10^{b}	10.64^{b}

^{abc} *means with the same superscripts within the same rows are significantly different (P<0.05)* MSC – Maize stover concentrate, MSG–maize stover/*Gliricidia sepium*, MSE –Maize stover/*Enterolobium cyclocarpum*. MSL – maize stover / *Leucaena leucocephala,*

The effect of forage legume supplementation of maize stover on the growth performance of West African dwarf sheep is presented in Table 3. Feed intake was comparably higher in animals fed forage legume-supplemented concentrate. This assertion validates the suggestion of Idan *et al.* (2020) that sheep had a marked preference for forage legumes as small ruminants cannot survive on large amounts of low-quality forage due to the low reticule-rumen capacity, and have therefore, developed a selection mechanism for fodder tree leaves with high protein content.

Table 3: Performance indices of West African Dwarf sheep fed maize stover supplemented with forage legumes

Parameters	MSC	MSG	MSE	MSL	Control	SEM
Concentrate Intake (g/day)	241.52^{c}	258.80^{c}	275.16^{ab}	275.16^{ab}	271.57^{b}	3.71
Panicum maximum intake (g/day)	221. 22	227.77	244.01	264.43	223.63	2.71
Total feed Intake (g/day)	462.52^{bc}	486.57^{b}	519.16^{a}	552.77^{a}	495.20^{ab}	1.87
Initial body weight (kg)	10.97	14.07	15.61	14.86	14.27	0.65
Final body weight (kg)	14.04^{b}	17.70^{ab}	19.05^{a}	19.51^{a}	17.70^{ab}	0.38
Body weight gain (kg)	3.07^{c}	3.64^{b}	3.90^{b}	4.19^{a}	3.43^{b}	0.30
Body weight gain (g/day)	34.11^{c}	40.44^{b}	43.33^{ab}	46.56^{a}	38.11^{b}	4.72
Metabolic weight gain ($kg^{W0.75}$)	14.11^{b}	15.47^{ab}	16.89^{a}	17.86^{a}	15.87^{ab}	0.16
Feed conversion ratio	13.56^{a}	12.03^{bc}	11.98^{c}	11.87^{c}	12.99^{b}	0.86

^{abc} *means with the same superscripts within the same rows are significantly different (P<0.05)*

MSC – Maize stover concentrate, MSG–maize stover/*Gliricidia sepium*, MSE –Maize stover/*Enterolobium cyclocarpum*. MSL – maize stover supplemented with *Leucaena leucocephala*,

Feed intake is one of the major factors that determine the potential of animal performance and it's based on the measure of diet appreciation, selection, and consumption by an animal (Mafasu, 2006). This could be reduced through feeding low-quality forages such as maize stover which tend to hinder productivity due to lower palatability, Dry Matter intake and digestibility, high-fibre content, and lower nutritive value. Hence, enhancing maize stover with forage legumes increases microbial fermentation in the rumen thus maximizing total DM intake and improving sheep performance.

The average daily weight gain (ADG) of the experimental sheep varied ($P<0.05$) among the treatments, following the same trend with feed intake therefore reflecting better gain in weight with forage legume supplementation. This supports earlier reports on an increasing trend in weight gain as influenced by higher nutritious forage supplementation of maize stover (Tolera and Sundstøl, 2000; Lamidi and Mbah, 2022). The average daily weight gain of sheep on MSL and MSE supplementation were higher ($P<0.05$) with 46.56 and 43.33 g/day, respectively. Least ($P<0.05$) values of 34.11g/day were observed in sheep-fed MSC diets. The variations in ADG could be attributed to the complementary effects of rich nutrients embedded in leguminous forage compounded in the maize stover concentrate diets. The availability of digestible protein and energy reflected by the relatively low fibre levels of the forage legume with maize stover concentrate diets could have provided ready nutrients for the synthesis of body tissues in the lower gut. This could however be responsible for the higher weight gains and efficiency of feed utilization of sheep on the forage supplementary treatments. However, sheep fed MSC with lower ADG values could be attributed to the high fibre and lower level of crude protein contents of the maize stover which probably limits intake with a significant decrease in weight gain. However, the ADG range values observed in this study (34.11 to 46.56g/day) were within the range for the same breed of sheep-fed supplemented maize leaf diets (Fasae *et al.*, 2019).

The feed conversion ratio (FCR) varied ($P<0.05$) among the treatments and was enhanced by the supplemental effects of forage legumes. Animals supplemented with MSL had the best ($P<0.05$), which is statistically similar to sheep on MSE diets. This largely reflects the highest weight gain observed in animals on these treatments. Animals on the MSC treatment had the least ($P<0.05$) FCR, indicating that the feed was not efficiently utilized and converted to flesh by the animals. Although the differences in FCR among the treatments could be partly due to effects on the digestive utilization of feed, differences in the chemical composition and the live weight gain may also be involved.

The apparent nutrient digestibility of maize stover supplemented with various forage legumes in dwarf sheep (Table 4) elucidates the impact of different supplements on nutrient utilization. The significant improvement in the digestibility values with improved results across the forage legume-supplemented diets was an indication that all the rumen environments were favorable for the digestibility of the diets.

Table 4: Apparent Nutrient Digestibility (%) of forage legume-supplemented maize stover fed to West African Dwarf Sheep

Parameters (%)	MSC	MSG	MSE	MSL	Control	SEM
Dry Matter	61.12^{b}	66.05^{ab}	64.43^{b}	67.43^{a}	62.25^{b}	1.03
Crude Protein	51.88^{c}	59.56^{b}	57.29^{b}	63.95^{a}	53.10^{bc}	0.99
Ether Extract	57.00	51.96	45.45	58.88	51.88	0.87
Ash	67.61	63.40	64.60	61.22	64.00	1.01
Neutral detergent fibre	60.31^{b}	66.62^{a}	62.81^{b}	66.81^{a}	62.61^{b}	1.05
Acid detergent fibre	53.00^{b}	63.12^{a}	61.76^{a}	67.78^{a}	51.99^{b}	1.22
Acid detergent lignin	45.15^{c}	56.22^{a}	52.58^{b}	57.44^{a}	54.10^{ab}	1.14

^{abc} *means that the same superscripts within the same rows are significantly different (P<0.05)*

MSC – Maize stover concentrate, MSG–maize stover/*Gliricidia sepium*, MSE –Maize stover/*Enterolobium cyclocarpum*. MSL – maize stover supplemented with *Leucaena leucocephala,*

The best values observed in sheep-fed MSL emphasized its superior role in enhancing the nutritional value of *Leucaena leucocephala* for efficient utilization of maize stover by sheep. These findings aligned with previous research indicating that *Leucaena leucocephala* is rich in protein and beneficial for ruminant nutrition (Kaitho, *et al.,* 1998, Idan *et al.,* 2020). This is also concurrent with the findings of McDonald *et al.* (2010), stating that diet digestibility characteristics could be used as an essential parameter to determine its nutritional values and quality. Similarly, Kiomarzi *et al.* (2008) reported that diets with optimum protein levels would promote high microbial populations, which bout the crude fibre more vigorously and facilitate rumen fermentation.

Moreover, the low dry matter digestibility (DMD) value of sheep supplemented with MSC may be due to the non-supplementation effect of forage legume which probably reduced acceptability, and digestibility, while on the other hand, the high values of DMD of diets containing forage legumes might therefore be due to the high intake as a result of the higher protein contents. This is in consonant rhyme with the findings of Van Soest and Robertson (1985) that increased protein supplementation tends to improve intake by increasing nitrogen supply to the rumen microbes. This has a positive effect by increasing microbial population and also improves the rate of breakdown of digesta. Therefore, high DMD is evidence of high palatability and acceptability of the diet. Conversely, the least digestibility rates observed for MSC diets underscores the limitation of maize stover alone as an essential feed for sheep. Low digestibility values in poor nutritional diets have been attributed to the inadequate protein content and fibre digestibility in the absence of supplementary forage legumes, which has been previously documented (Mupangwa, *et al.,* 2000, Fasae *et al.,* 2014)

High dietary fibre has been implicated in low digestibility of diets. The results obtained in this study validates the reports of previous researchers who opined that forage legume diets have low dietary fibre contents with consequent high digestibility. Castro-Montoya and Dickhoefer (2020) reviewed that forage legume diets generally have lower dietary fibre content compared to grasses, and this has led to higher digestibility, which are attributed to the higher proportion of cell solubles, which are easily digested, and a lower proportion of fibre, which can be more difficult to break down.

Table 5 shows the supplemental effects of maize stover with forage legumes on nitrogen balance by West African Dwarf sheep. Nitrogen balance values of diets were positive and ranged from 2.87 - 4.03g/day across the dietary treatments.

These levels may be a result of the high digestibility of nutrients across forage legume diets. The positive nitrogen balance recorded in this study indicates animals gained weight or conserved nitrogen during the period of experimentation which suggests the potential of diets containing forage legume as adequate supplementary feed for sheep fed maize stover.

Table 5: Nitrogen Balance (g/day) by West African Dwarf sheep-fed maize stover supplemented with forage legumes

	Experimental concentrate diet					
Parameters	MSC	MSG	MSE	MSL	Control	SEM
Nitrogen intake	6.42^{c}	7.42^{a}	7.02^{b}	7.65^{a}	6.33^{c}	1.35
Faecal Nitrogen	2.59^{b}	3.41^{a}	2.90^{b}	3.37^{a}	3.11^{ab}	0.32
Urinary Nitrogen	0.21^{b}	0.24^{b}	0.28^{ab}	0.25^{b}	0.35^{a}	0.06
Total Nitrogen output	2.80^{b}	3.65^{a}	3.18^{ab}	3.62^{a}	3.46^{a}	0.12
Nitrogen balance	3.62^{ab}	3.77^{ab}	3.84^{a}	4.03^{a}	2.87^{b}	0.16

^{abc} *means with the same superscripts within the same rows are not significantly different (P>0.05)*

MSC – Maize stover concentrate, MSG–maize stover/*Gliricidia sepium*, MSE –Maize stover/*Enterolobium cyclocarpum*. MSL – maize stover supplemented with *Leucaena leucocephala,*

The higher nitrogen intakes recorded in the forage legume treatment groups may be related to the higher dry matter intake and crude protein content of these diets, which corroborate the observation of Mc-Donald *et al.* (2002) and Shuaibu *et al.* (2020) that dietary nitrogen intake is directly related to the proportion of nitrogen in the diet of animals. Meanwhile, the high (P<0.05) nitrogen intake and urinary nitrogen observed in MSL and MSE dietary treatments were similar to the trend in N-intake observed in sheep-fed sole ensiled maize stover (Amuda *et al.*, 2019). Van Soest (1994) also noted that increased nitrogen intake is associated with increased urea production in the liver and consequently its excretion in the urine. Nitrogen balance also depends on the intake of nitrogen and the number of fermentable carbohydrates in the diet (Sarwar *et al.*, 2003), hence the higher nitrogen observed in forage legume-supplemented treatments. However, all animals had a positive nitrogen balance, which implied that the animals utilized the diets offered effectively.

Conclusion

It was concluded that maize stover with forage legume supplementation enhanced the performance of West African Dwarf sheep, as they offer a range of essential nutrients that contribute to their overall productivity. The supplementation of maize stover with forage legume significantly improved the feed utilization, weight gain, and feed conversion ratio in West African dwarf sheep, with sheep fed *Leucaena leucocephala* supplementary diet having the best performance. With Nigeria producing tonnes of underutilized stover from maize every year, the use of maize stover in sheep feeding systems can be effectively exploited through forage legume supplementation to improve mutton output and save markedly the amount of feed grain used in livestock feeding.

Acknowledgments

The support of Tertiary Education Trust Fund (TETFUND) Institution Based Research 2023 Intervention Allocation is acknowledged for the project titled “Forage legume supplementation of maize stover in improving dry season feeding and

methane mitigation in sheep production systems".

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Date received: 8th February, 2025.

Date accepted: 29th July, 2025.