

NUTRITIONAL ASSESSMENT OF MAIZE STOVER RESIDUES ENSILED WITH SELECTED BROWSE FODDERS ON GROWTH PERFORMANCE OF WEST AFRICAN DWARF GOATS

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Abstract

The escalating price of protein concentrate supplements calls for the preservation of surplus crop residues and forage during the growing season as feed for ruminants at the time of feed shortage. Hence, a 90-day feeding trial was conducted to evaluate the effect of varying *Gliricidia sepium* (GS), *Ficus thonningii* (FT), and *Gmelina arborea* (GA) forages with maize stover residues (MSR) silage on the growth performance of West African dwarf (WAD) buck. A total of sixteen (16) growing WAD bucks, between 6 and 9 months of age, weighing an average body weight of 6.00-10.00 kg, were allocated randomly to four treatments, with 4 bucks per treatment and 2 bucks per replicate in a completely randomised design. The experimental diets (T₁-100%MSR, T₂-MSR70GS30, T₃-MSR70FT30, and T₄-MSR70GA30) were fed at 3% body weight of the individual animal, supplemented with 300g concentrate per day. A significant difference ($p < 0.05$) was observed across dietary treatments for the growth parameters. Bucks fed with T₄ diet had the highest daily feed intake (DFI) of 567.14 g/d with the lowest daily weight gain (DWG) of 21.11 g/d, while the highest DWG (23.33g/d) and lowest DFI (550.28 g/d) were recorded in bucks fed T₃ and T₁, respectively. The feed conversion ratio (FCR) of ranges between 24.09 – 26.86 was recorded with the bucks fed T₃ having the best feed utilisation value of 24.09. Our findings revealed that feeding maize stover residues with *Ficus thonningii* at a ratio of 70:30 with concentrates to growing bucks can enhance their weight gain and feed utilisation.

Keywords: *Tropical browse fodders, Maize stover residues, WAD bucks, Growth performance.*

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Introduction

Forage production in tropical regions is highly seasonal, leading to fluctuations in the availability and nutritional quality of pasture throughout the year. This variability undermines animal production systems that rely solely on pasture, resulting in surplus

output during the wet season and reduced productivity during the dry season (Rufino *et al.*, 2022). The decline in forage quality during dry periods adversely affects feed intake and animal performance (Barreto *et al.*, 2020). Given the critical role of nutrition in determining the productivity and

physiological characteristics of small ruminants, there is a compelling need to investigate dietary strategies that enhance animal quality (Gusha *et al.*, 2015; Pereira *et al.*, 2016).

Silage type has been shown to influence the quality of animal-derived products such as milk and meat (Milewski *et al.*, 2014). Incorporating legumes into silage formulations can improve the nutritional balance, enhance dry matter quality (Pereira *et al.*, 2019; Ligoski *et al.*, 2020), and increase nutrient yield per unit area (Oliveira *et al.*, 2020). Moreover, legume-based silages offer greater adaptability during periods of forage scarcity (Oliveira *et al.*, 2021). Compared to hay, silage is more suitable for arid and semi-arid environments due to its lower water requirements for ruminants.

Silages produced from forage species adapted to semi-arid conditions have demonstrated promising outcomes in improving the growth performance of small ruminants. Accordingly, this study was undertaken to evaluate the quality, nutritional value, and growth response of West African Dwarf goats fed diets comprising silages made from tropical browse species and maize stover residue mixtures.

Materials and Methods

Experimental site and animal management

The experiment was conducted at the Sheep and Goat Unit, Teaching and Research Farm, Oyo State College of Agriculture and Technology, Igboora. Sixteen (16) growing West African dwarf bucks weighing between 6.00 – 10.00 kg and of 6 – 9 months of age were used. All experimental animals were administered Albendazole[®] to control endoparasites. For prophylactic treatment, oxytetracycline and multivitamin injections were given intramuscularly at a dosage of 1 mL per 10 kg body weight. To prevent Peste des Petits Ruminants (PPR), a homologous vaccine was administered. The bucks were acclimatised for 28 days before the trial,

during which they were offered guinea grass and cassava peels. Clean drinking water was provided ad libitum throughout the study.

Collection of Maize stover residues and browse fodder plants.

The *Gliricidia sepium* (GS), *Ficus thonningii* (FT) and *Gmelina arborea* (GA) forages were obtained from mature woodlots at the college farm. The forages, which include leaves and twigs, were harvested by hand-cutting, while maize stover residues (MSR) were collected from maize production plots immediately after harvesting the green maize cobs at the College farms.

Silage production and experimental diets

The forages were chopped into bits using a sharp cutlass into lengths of 2 – 3 cm for ease of compaction, wilted for 6 hours to reduce the moisture content, and then thoroughly mixed with varied proportions of selected browse fodder plants, before ensiling. 200g of molasses were diluted in 4litres of water and sprinkled evenly on the chopped material. Mixture was packed, compacted and sealed in thick polythene bags to create an anaerobic condition for proper fermentation. The silage was ensiled for 21 days; after which they were opened for a feeding trial.

Experimental layout, design and feeding method

The animals were allocated by weight into four treatments of four bucks per treatment, and two bucks served as a replicate in a completely randomised design (CRD). The experimental diet was fed at 3% body weight of the individual animal, while maize stover residues (MSR) ensiled with browse fodders mixture were fed at varied proportions with the concentrate diet. The bucks were offered their respective experimental feeds (500g of silage) at 8.00 am and 300g of concentrate per buck per day at 2.00 pm, while 3 litres of fresh and clean water was also supplied daily. The compared experimental diets (ED) were: T₁

(100%MSR silage + 300g concentrate), T₂ (MSR70GS30 silage + 300g concentrate), T₃ (MSR70FT30 silage + 300g concentrate) and T₄ (MSR70GA30 silage + 300g concentrate)

and their proximate composition is shown in Table 2. Each group of animals was assigned to an experimental diet.

Table 1: Composition of formulated concentrate for experimental West African Dwarf growing bucks

INGREDIENTS	LEVEL (%)
Palm kernel cake	60.00
Wheat offal	20.00
Corn bran	9.75
Groundnut cake	8.00
Bone meal	2.00
Salt	0.25
TOTAL	100.00

Data Collection and Analysis

Feed Intake and Live Weight Gain:

A one-week adjustment period was observed before data collection. Bucks were weighed at the start of the experiment and subsequently weekly, always before morning feeding. Weight gain was calculated as the difference between initial and final live weights. Silage and concentrate feeds were weighed before feeding, and leftovers were measured the following morning to determine daily feed intake. These values were used to calculate dry matter intake (DMI), mean initial body weight, weekly body weight, feed intake, and feed conversion ratio (FCR).

Chemical Composition Analysis

After 21 days of fermentation, silage bags were opened, and representative samples were collected from each treatment silo. Samples were analysed for pH, then ground using a Willy hammer mill fitted with a 3 mm screen. Chemical analyses for dry matter (DM), crude protein (CP), ether extract (EE), and ash were conducted following AOAC (2000)

procedures. Neutral detergent fibre (NDF) was determined using the method described by Van Soest *et al.*, (1991), while additional analyses followed AOAC (2005) protocols.

Fermentative characteristics and Quality of silage determination

Following the termination of fermentation, silage samples were opened for quality assessment. As described by Ososanya and Olorunnisomo (2015), the evaluated parameters included colour, taste, aroma, temperature, and pH. Upon opening, a laboratory thermometer was immediately inserted to measure internal temperature, while pH was determined using a glass electrode pH meter. Colour was assessed visually using a standard colour chart. Sub-samples were collected from various depths and locations within each silo, thoroughly mixed, and oven-dried at 65 °C until a constant weight was achieved to determine dry matter content. The dried samples were subsequently milled and stored in airtight containers for chemical analysis.

Statistical analysis

All Data obtained were subjected to one-way analysis of variance (SAS, 2013). Mean value variance showing significant ($p < 0.05$) differences were separated using Duncan's Multiple Range Test (Duncan, 1955).

Results and Discussion

The chemical composition of silages produced by ensiling maize stover residues with selected browse tree species in equal proportions is presented in Table 2. The dry matter (DM) content ranged from 31.02% to 35.06%, exceeding values reported by Moran (2005) and Ashbell *et al.* (2002) for similar silages (23% and 21.2%, respectively), but slightly lower than the 37.02% reported by Elkholy *et al.*, (2009). These differences may be attributed to variations in the morphological composition of the forages, particularly the stem-to-leaf ratio.

Crude protein (CP) content in the mixed silages (14.89 – 16.50% DM) surpassed the minimum requirement for growth in ruminants (11.3% DM; ARC, 1984). The lowest CP value was observed in the T₁ diet (5.34%), which contained only maize stover residues, likely due to the maturity stage of the stover at ensiling. Diets T₂ (15.26%), T₃ (16.50%), and T₄ (14.89%) met or exceeded the minimum CP levels required for lactation (11–12%; ARC, 1984), efficient rumen microbial activity (6 –

7%; Minson, 1982), and general feed utilisation (7 – 12%; McDonald *et al.*, 1995; Gatenby, 2002).

The inclusion of browse legumes also increased ash content (8.96 – 10.12%), indicating a higher mineral concentration, consistent with findings by Kebede *et al.*, (2016), Nurhayu *et al.* (2021), and Tesfaye *et al.*, (2019). Ash levels in forage are influenced by factors such as plant maturity, morphological composition, climate, soil type, and fertilisation practices (Zewdu, 2007).

As expected, forage legumes contributed to reduced fibre content. Silages with legume inclusion showed lower neutral detergent fibre (NDF) and acid detergent fibre (ADF) values compared to maize stover alone, aligning with observations by Albayrak and Turk (2013). This reduction may result from the hydrolysis of NDF-bound nitrogen during fermentation (Jaakkola *et al.*, 2006), which enhances silage quality (Senjaya *et al.*, 2010).

These findings are consistent with studies by Xue *et al.*, (2020) and Nurhayu *et al.*, (2021), which demonstrated that increasing the proportion of browse legumes in maize stover-based silages reduces NDF, ADF, hemicellulose, and cellulose concentrations. Such improvements in nutritive value may reduce reliance on external protein supplements in ruminant diets.

Table 2: Proximate composition (%) of Maize stover residues ensiled with varying levels of selected browse fodder plants and concentrate diets fed to bucks

Parameters (%)	T1 100MSRS	T2 MSR70GS30	T3 MSR70FT30	T4 MSR70GA30	Concentrate
DM	35.06	31.72	31.02	31.57	94.48
CP	5.34	15.26	16.50	14.89	17.57
CF	37.82	16.30	14.38	18.40	8.75
EE	3.24	3.07	3.32	3.43	10.39
Ash	9.27	9.38	10.12	8.96	5.85
NFE	30.04	27.46	28.11	27.82	50.21
NDF	64.51	52.89	48.85	54.79	30.34
ADF	32.62	31.75	30.56	31.90	16.05
ADL	13.54	13.06	12.35	13.10	5.65
*ME(Kcal/Kg)	1529.03	1790.58	1879.99	1819.11	3282.45

DM= Dry Matter, CP= Crude Protein, CF= Crude Fibre, EE= Ether Extract, NFE= Nitrogen Free Extract, NDF= Neutral detergent fibre, ADF= Acid detergent fibre, ADL= Acid detergent lignin, *ME= Calculated Metabolizable energy, MSRS=Maize stover residue silage, GS= *Gliricidia sepium*, FT=*Ficus thonningii*, GA=*Gmelina arborea*

The physical features and fermentation quality of the silages are shown in Table 3. The observed colour differences between silages made solely from maize stover residues and those incorporating browse legumes can be attributed to the inclusion of leguminous species. The physical characteristics and temperature values of the silages (27.53 – 28.30 °C) fall within the acceptable range for high-quality silage (20.00 – 30.00 °C), as reported by Khota *et al.*, (2018) and Dongxia *et al.*, (2019).

Silage pH is a key indicator of preservation quality. In this study, maize stover residue silage recorded a pH of 4.30, while mixtures with browse legumes ranged from 4.40 - 4.60, all within the optimal threshold (<4.80) for stable silage (Jusoh *et al.*, 2016; Matlabe *et al.*, 2022). Slight increases in pH associated with

legume inclusion are likely due to their high buffering capacity, attributed to the presence of cations such as K⁺, Ca²⁺, and Mg²⁺, which neutralise organic acids formed during fermentation (Wang *et al.*, 2017; Da Silva Brito *et al.*, 2020).

Although elevated temperatures can impair fermentation by accelerating protein degradation and slowing pH reduction (Rahjerdi *et al.*, 2015), the temperatures recorded in this study (27.53 – 28.30 °C) were higher than those reported for maize stover silage from the Arganie variety (16.62 – 19.52 °C; Abebaye *et al.*, 2020), yet lower than the 29 – 40 °C range observed in other studies (Naeini *et al.*, 2014). These variations may be influenced by climatic conditions during ensiling.

Table 3: Fermentative characteristics, P^H and temperature of ensiled maize stover residues with selected browse fodder plants mixtures

Parameters	T1 100MSRS	T2 MSR70GS30	T3 MSR70FT30	T4 MSR70GA30
Colour	Pale yellow	Olive-green	Yellowish green	Yellowish green
Smell	Pleasant	Nice	Pleasant	Sweet-sour
Taste	Sour	Vinegar	Vinegar	Sour
pH	4.30	4.50	4.60	4.40
Temp (°C)	28.30	27.53	27.82	27.60

MSRS=Maize stover residue silage, GS= *Gliricidia sepium*, FT=*Ficus thonningii*, GA=*Gmelina arborea*, Temp=Temperature

The growth performance of West African Dwarf (WAD) bucks fed silages formulated with tropical browse fodder species and maize stover residues, supplemented with concentrate diets, is presented in Table 4. Significant differences ($p < 0.05$) were

observed in daily feed intake across treatments. Bucks on diet T₄ (MSR70GA30 + 300 g concentrate) recorded the highest intake (567.14 g/day), followed by those on T₃ (MSR70FT30 + 300 g concentrate; 562.08 g/day), while the lowest intake

(550.28 g/day) was observed in bucks fed solely maize stover residue silage (T₁).

This trend aligns with the inverse relationship between dry matter intake and fibre content reported by Reid and Klopfenstein (1983), although it contrasts with findings by Okah *et al.*, (2012) and Ahamefule *et al.*, (2006), who noted higher intake in high-fibre diets. The nature of fibre and its interaction with other nutrients, particularly protein, may influence intake. The inclusion of browse fodder species in diets T₂, T₃, and T₄ appeared to enhance palatability and nutrient availability, resulting in increased voluntary feed intake compared to T₁.

The elevated intake observed in T₄ may be attributed to improved rumen outflow and higher degradable organic matter (Yousuf *et al.*, 2007). However, the highest average weight gain (2.10 kg) was recorded in bucks fed T₃, likely due to its higher metabolizable energy content. This finding is consistent with Gemechu *et al.*, (2020), who reported improved growth in rams fed ensiled elephant grass with legume inclusion.

Growth rates in this study (21.11 – 23.33 g/day) exceeded those reported by Asaolu *et al.* (2012) for WAD goats supplemented with dried legume leaves but were lower than values (46 – 56 g/day)

reported by Babayemi *et al.*, (2006) for goats fed *Panicum maximum*-based diets with legume supplements. The variation in daily weight gain (DWG) may reflect differences in nutrient composition and digestibility across diets. Lower DWG compared to Fasae and Adelegan (2013) may also be attributed to breed differences.

Overall, growth performance mirrored nutrient utilisation, as supported by digestibility coefficients and total digestible nutrient (TDN) values. Similar observations were made by Okoruwa *et al.*, (2013) and Okoruwa and Bamigboye (2015), who emphasised the importance of balanced energy and protein intake for optimal growth. Adegun and Aye (2013) also reported a linear relationship between protein intake and feed-to-gain efficiency in WAD rams.

The lower feed intake in T₁ may be due to higher lignification, while the improved performance in T₃ and T₄ suggests better nutrient synergy. Feed conversion ratio (FCR) values ranged from 24.09 to 26.86, higher than those reported by Malisetty *et al.*, (2013) and Adebisi *et al.*, (2019), indicating moderate feed efficiency. Diets T₃ and T₂ showed superior feed utilisation, with T₃ yielding the best FCR (24.09), suggesting enhanced nutrient absorption and conversion efficiency.

Table 4: Growth performance of WAD growing bucks fed Maize stover residues ensiled with selected browse fodder plants and concentrate diets

Parameters	T1 100MSRS	T2 MSR70GS30	T3 MSR70FT30	T4 MSR70GA30	SEM (±)
Daily feed intake (g/d)	550.28 ^d	556.62 ^b	562.08 ^c	567.14 ^a	4.22
Average initial weight (kg)	9.46 ^c	9.45 ^b	9.47 ^a	9.30 ^d	0.19
Average final weight (kg)	11.40 ^c	11.44 ^b	11.57 ^a	11.20 ^d	0.80
Average weight gain (kg)	1.94 ^b	1.99 ^{ab}	2.10 ^a	1.90 ^c	0.03
Daily weight gain (g/d)	21.56 ^c	22.11 ^b	23.33 ^a	21.11 ^d	1.02
Feed conversion ratio (FCR)	25.52 ^b	25.18 ^b	24.09 ^c	26.86 ^a	1.10

^{abcd}mean on the same row with different superscripts are significantly different ($P < 0.05$). MSRS=Maize stover residue silage, GS= *Gliricidia sepium*, FT=*Ficus thonningii*, GA=*Gmelina arborea*, FCR = Feed conversion ratio

Conclusion

The study demonstrated that the T3 diet—comprising 70% maize stover residues and 30% *Ficus thonningii* silage supplemented with 300 g of concentrate—provided superior nutritional benefits for West African Dwarf (WAD) bucks. This diet, characterised by higher crude protein and lower crude fibre content, significantly improved silage quality, resulting in enhanced feed intake, digestibility, and growth performance.

Recommendation

Based on the findings, it is recommended that underutilised crop residues, such as maize stover, can be effectively supplemented with browse fodder species in silage production to improve the performance of growing bucks. The optimal mixing ratio may vary depending on the physiological status of the animals and the nutritional quality of both the maize stover and the selected browse species. Further research is warranted to determine the most effective maize stover-to-browse fodder ratio for silage formulation across different production stages and animal requirements.

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