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Dry matter intake, nutrient digestibility and nitrogen balance of WAD sheep fed ensiled maize stover and concentrate supplement

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Abstract

A study on effect of ensiled maize stover (EMS) and protein concentrate supplement (CS) on nutrient digestibility and nitrogen balance of ensiled maize stover (EMS) and concentrate supplement (CS) by West African Dwarf ewe was carried out. Fifteen West African dwarf ewe with body weight of 14-16 kg were allotted to individual metabolic cage in completely randomized design after preliminary feeding trial. The treatments were: A (75% EMS + 25% CS), B (50% EMS + 50% CS), C (25% EMS + 75% CS), D (100%EMS) and E (100% CS). The digestibility study lasted for seven days to determine dry matter digestibility, nutrients digestibility and nitrogen retention of WAD ewe fed ensiled maize stover and concentrate supplement. Results showed that dry matter intake (DMI), digestible crude protein (DCP), digestible crude fibre (DCF), digestible nitrogen free extract (DNFE), and total digestible nutrients (TDN) ranged from 321.65- 694.41gDM/day, 3.99 - 12.30%, 7.32 - 17.23%, 33.35 – 38.85% and 63.65 – 70.92%, respectively. Dry matter intake of ewe fed sole ensiled maize stover (diet D) was lowest (321.65gDM/day) while animals on diet C (25% EMS+75%CS) had the highest (694.41gDM/d). Apparent digestibility of CP was lowest (3.99%) in ewe fed sole EMS and highest (12.20%) in ewe fed diet C (25% EMS + 75% CS). Positive N-balance was observed for all the five diets, but it was highest (P< 0.05) in diet B (50%+50%) and lowest in diet D (100% EMS). Similarly, N-retention was highest (67.15%) in diet B and lowest (27.61%) in diet D. Therefore, diet made up of 50% ensiled maize stover and 50% concentrate is recommended for sheep production.

Keywords: concentrate supplement, digestibility, nitrogen balance, maize stover, sheep.

Introduction

Traditional ruminant livestock production in Africa is based predominantly on animals grazing natural pastures which are often of low nutritive value especially during the dry season. In Nigeria, ruminant production is limited by the low quality and quantity of native grasses and straws which often leads to incessant clash between herdsmen and farmers (Amuda *et al.,* 2018). Despite the naturally endowed vegetations, there are still inadequate feeds and feedstuffs for livestock in Nigeria (Babayemi, 2007). Ruminants in the tropics are raised predominantly on grasses which are inherently poor in digestibility, nutritive value and unavailable in the off-season (Babayemi *et al*., 2009). The concept of ruminant animal production requires feeding animals on rich diet so that they can attain slaughter weight within short time usually 70 – 120 days (Madziga *et al*., 2012). Good nutrition is a prerequisite for good health, good reproduction, high milk yield, fast growth rate and a successful rearing system (Ochepo *et al*., 2009). Recent trends in animal nutrition have focused attention on the use of crop residues and agro-industrial by-products but these are low in protein, high in fibre and low in digestibility. Expensive concentrates and milling by-products are forcing farmers to rely more on crop by-products as sources of energy. However, sheep and goats can play an active role in converting crop residues of no human dietary value to meat and milk of high nutritive value for man (Fajemisin *et al.*, 2010).

The search for alternative and locally available sources of energy and protein to enhance productivity of sheep and goats during the period of scarcity and dry season has placed attention on the use of post-harvest crop residues (Sodeinde *et al.*, 2007). There is usually an abundance of crop residues especially cereal straws and stovers, which have potentials to be used as feed. These can be used to improve the nutrition of ruminant during the dry season through the strategic supplementation of animals with crop residues. In Nigeria, very few crop residues are utilised as ruminants feed by small holder farmers. Maize crop residue (stover) can be an inexpensive source of forage, and it may be grazed, stacked or ensiled. Preservation of maize stover as silage makes it possible to preserve plant nutrients that otherwise would be lost by physiological activity or leaching, offering the possibility of using stover in rations for growing animals. To achieve efficient utilisation of the crop residues especially ensiled maize stover as a potential feed for ruminants; it has to be supplemented with concentrate. Sustainability of sheep production could come through the feeding of ensiled maize stover and concentrate supplements.

This study was therefore undertaken to assess the dietary effect of ensiled maize stover and concentrate supplements mix on dry matter intake, nutrient digestibility and nitrogen balance of West African dwarf sheep.

Materials and methods

Experimental site

The study was carried out at the Sheep and Goat Unit of the Teaching and Research Farm, University of Ibadan, Ibadan, Oyo –State, Nigeria. It is situated in derived savannah vegetation zone (Latitude $7^0$27'N and $3^0$45'E) at an altitude between 200m and 300m above sea level. The mean is temperature 25-29^{0}C with an average annual rainfall of about 1250mm. The soils are much drained and belong to the afisol (Rhodic Kandiustalf) (Babayemi *et. al.*, 2003).

Experimental diet

The experimental diets were Diet A = 75% EMS + 25% Concentrate supplement, Diet B = 50% EMS + 50% Concentrate supplement, Diet C = 25% EMS + 75% Concentrate supplement,

Diet D = 100% EMS (Silage only), Diet E = 100% Concentrate supplement only

The concentrate supplement of the diet contained 60% wheat bran, 25% palm kernel cake (PKC), 10% corn bran, 3% oyster shell, 1% salt and 1% ruminants premix

Pre-experimental management of sheep

Fifteen post weaned female West African dwarf sheep aged 8 – 10 months weighing 16 – 20kg were purchased from Iwo town, in Osun state, Nigeria. On arrival, the sheep were given prophylactic intramuscular treatment of oxytetracycline and vitamin B complex at the dosage of 1mL/10kg body weight of the animal. They were also drenched with albendazole to control endoparasites and treated for mange and other ectoparastes using Ivomec(R).

Experimental design and management of experimental animals

The pens, feeding and drinking troughs were thoroughly cleaned. The floor was thoroughly swept, washed and disinfected before the commencement of the experiment. The animals were then transferred into individual metal metabolic cages and allotted to the five experimental diets with three ewe per treatment. Each metabolic cage consists of a netted slab i.e faecal and urinary board for faecal and urine sample collections. The metabolic cages enabled complete separation and easy collection of urine and faeces. The experiment lasted for seven days (7 days) sequel to the preliminary feeding trial. Water and salt lick were provided to the animals *ad libitum* throughout the metabolic trial. The silage and concentrate supplement were mixed and served at 5% body weight of the animals. Leftover feed was weighed at 0800 hours every morning and deducted from the total feed offered for feed intake determination prior to serving fresh feed daily. During the seven days of collection period, total faeces and urine were collected and weighed daily. Ten percent aliquot of the total faeces and urine were collected quantitatively and bulked for each animal. Two drops of concentrated sulphuric acid (H_2SO_4) was added to each container daily after collection of each sample to prevent microbial growth, organic matter decay and loss of nitrogen/nitrogen volatilization (Chenn and Gomez, 1992).

Chemical analysis

All feed, faecal and urine samples were analysed according to AOAC (1995). The neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to Van Soest *et al*. (1991). Hemicellulose was calculated as the difference between NDF and ADF and cellulose as the difference between ADL and ADF (Rinne *et al*., 1997). Samples were analysed for nitrogen by macro-kjeldah method. The data collected were computed and subjected to a one-way analysis of variance using the procedure of SAS (1999). Significant treatment means were separated using Duncan (1955) option of the same software.

Results

Chemical composition of ensiled maize stover and concentrate supplements

Chemical composition of ensiled maize stover and concentrate supplements is presented in Table 1. The amounts of DM content was lowest (31.6%) in diet D followed by that of diet A (46.1%) and were both appreciably lower than the DM contents in concentrate supplements (89.5%), diets B (60.5%) and C (75.0%). The CP content of diet D (8.4%) was lower than those of diets A, B and C. Ash content in D (8.8%) was comparable those of other diets with varied silage-concentrate mix. The NFE content of diet D was relatively the same with other diets with concentrate supplements. Fibre content and ADL contents in maize stover silage were higher than the rest diets with concentrate. The NDF (i.e. cell walls) contents (46.8%) was slightly higher than in concentrate supplements but lower than contents in diets A, B and C. The lignin content in diet D was slightly higher than those of other diets and concentrate supplements but lower in hemicelluloses and cellulose contents than other dietary treatments.

Table 1: Chemical composition (%) of ensiled maize stover and concentrate supplement

	Diet composition				
Parameters	A	B	C	D	E
Dry matter	46.08	60.54	74.99	31.62	89.45
Organic matter	92.11	91.03	89.21	91.20	86.06
Crude protein	12.60	14.35	16.45	8.40	15.05
Ether extract	8.86	7.84	8.50	6.77	7.88
Ash	7.89	8.97	10.79	8.80	13.94
Nitrogen free extract	45.76	46.09	43.39	46.25	43.30
Crude fibre	24.89	22.75	20.87	29.78	19.83
Neutral detergent fibre	54.60	49.69	52.80	46.83	44.74
Acid detergent fibre	32.76	28.82	27.84	26.86	29.69
Acid detergent lignin	11.92	10.91	10.81	12.81	9.50
Hemicellulose	21.84	20.87	24.96	19.97	15.05
Cellulose	20.84	17.91	17.03	14.05	20.19

Diet A = 75% Maize Stover Silage + 25%, Concentrate supplement, B = 50% Maize Stover Silage + 50% Concentrate supplement, C = 25% Maize Stover Silage + 75% Concentrate supplement, D = 100% Maize Stover Silage and E = 100% Concentrate supplement.

Dry matter and nutrient digestibility (%) of ensiled maize stover and concentrate supplements by West African dwarf sheep

Presented in Table 2 is the dry matter and nutrient digestibility (%) of ensiled maize stover and concentrate supplement by sheep. Dry matter digestibility (DMD) was similar (P > 0.05) across the treatment. The digestibility of crude protein (CP), crude fibre (CF), ether extract (EE), nitrogen free extract (NFE) and total digestible nutrient (TDN) are presented in Table 2 and ranged from 3.99 – 12.20%, 7.32 – 17.23%, 7.96 – 13.95%, 33.35 – 38.85% and 63.65 – 70.92%, respectively. Significant (P < 0.05) differences were observed for all the parameters.

Table 2: Dry matter and nutrient digestibility (%) of ensiled maize stover and concentra te supplements by West African d warf sheep

	Experimental Diets					
Nutrient	**A**	**B**	**C**	**D**	**E**	**SEM**
DMD	62.32	66.32	67.44	62.18	62.18	3.29
CPD	8.36^{c}	10.53^{b}	12.20^{a}	3.99^{d}	10.04^{b}	0.17
CFD	11.34^{b}	9.96^{b}	7.32^{c}	17.23^{a}	8.63^{b}	0.47
EED	13.95^{a}	11.90^{b}	13.13^{a}	7.96^{c}	11.67^{b}	0.19
NFED	35.22^{b}	38.85^{a}	33.35^{b}	$34.46b^{c}$	33.06^{c}	0.31
TDND	68.87^{ab}	70.92^{a}	65.70^{ab}	63.65^{b}	65.15^{ab}	1.15

abc = Means on the same row differently superscripted are significantly different (P < 0.05)
DMD = Dry Matter Digestibility; CPD = Crude Protein Digestibility, CFD = Crude Fibre Digestibility, EED = Ether Extract Digestibility, NFE = Nitrogen Free Extract Digestibility, TDN= Total Digestible Nutrient Digestibility
Diet A = 75% EMS + 25% Concentrate supplements, B = 50% EMS + 50% Concentrate supplements, C = 25% EMS + 75% Concentrate supplements, D = 100% EMS (Silage only)
E = 100% Concentrate supplements, SEM = Standard Error of Means, EMS = Ensiled Maize Stover.

Nitrogen utilisation by WAD Sheep fed ensiled maize stover and concentrates supplements

Table 3 shows the nitrogen utilisation by the experimental sheep. N-intake, feacal-N, urinary-N, N-total excreta, N-balance, N-balance per metabolic weight and N-retention were significantly (P<0.05) influenced by dietary treatments. The N-intake was significantly (P < 0.05) highest in animals fed 25% ensiled maize stover and 75% concentrate and lowest in animals that received whole ensiled maize stover. Non-significant (P>0.05) difference was observed for faecal-N in all the treatments. For urinary-N, there were significant (P < 0.05) differences among the treatments such that it was lowest in diet D (100% EMS) and highest in diet E (100% CS). The N-excreted was significantly (P < 0.05) higher in animals on diet E than animals on diet D (Ensiled maize stover only) but similar to those on diets A, B and C. Positive N-balance was observed for all the five diets. However, there was significant (P < 0.05) variation between the treatments means, diet B (50%C + 50%CS) gave the highest value while diet D (100% EMS) gave the least. N-balance per metabolic weight was significantly (P < 0.05) different such that it was highest in diet B and lowest in diet D. Similarly, significant (P < 0.05) variation was observed between the dietary treatments for N-retention (%). It was highest (67.15) in diet B and lowest (27.61) in diet D.

Table 3: Nitrogen utilisation by WAD sheep fed ensiled maize stover and concentrate supplements

	Experimental diets					
Parameters	**A**	**B**	**C**	**D**	**E**	**SEM**
Dry Matter intake	437.5^{b}	681.79^{a}	694.41^{a}	321.65^{c}	612.22^{a}	17.13
Nitrogen intake (g/d)	8.82^{c}	15.65^{b}	18.28^{a}	4.32^{d}	14.74^{b}	0.40
Nitrogen (faeces) (g/d)	2.96^{a}	4.17^{a}	3.34^{a}	2.23^{a}	4.98^{a}	0.70
N – urine (g/d)	2.57^{a}	0.98^{b}	3.19^{a}	0.93^{b}	3.23^{a}	0.04
N – total excreta (g/d)	5.54^{ab}	5.14^{ab}	6.52^{ab}	3.16^{b}	8.21^{a}	0.60
N – balance (g/d)	3.28^{c}	10.51^{a}	11.75^{a}	1.16^{c}	6.54^{b}	0.47
N – balance $W^{0.75}$ (g/d)	0.436^{c}	1.089^{ab}	1.217^{a}	0.190^{c}	0.836^{b}	0.06
N – retention (%)	37.23^{bc}	67.13^{a}	64.99^{ab}	26.46^{c}	44.23^{b}	2.95

abc = Means on the same row differently superscripted are significantly different (P < 0.05), Diet A = 75% EMS + 25% Concentrate supplements, B = 50% EMS + 50% Concentrate supplements, C = 25% EMS + 75% Concentrate supplements, D =100% EMS (Silage only). E = 100% Concentrate supplements, SEM = Standard Error of Means, EMS = Ensiled Maize Stover. N = Nitrogen.

Discussion

Dry matter intake, digestibility and nitrogen balance

The dry matter content of ensiled maize stover only (diet D) 31.6% in Table 1 compare well with other forage grasses such as Guinea grass, (*Panicum maximum*) 26.0 – 35.1%, elephant grass (*Pennisetum purpureum)* (37.7%) and Gamba grass (*Andropogon gayanus*) (21.7%) reported by Babayemi (2007) and Odedire and Babayemi (2008). Similarly, the organic matter content of diet D (91.20%) which compared well with diets A, B, C and E, is similar to the 91.5 and 93.0% reported by Elkholy *et al*. (2009) and Nour *et al*. (1987), respectively. This observation suggests that the silages could furnish nutrients to small and large ruminants. Dry matter content obtained in this study was higher than 23% and 21.2% reported in similar MS-silages by Moran (2005) and Ashbell *et al.* (2002) but lower than 37.02% reported by Elkholy *et al*. (2009). The obvious differences in the various values may be in the differential proportions of morphological parts i.e stem to leaf ratio. The crude protein obtained in silages used in this study (8.4%) exceeds that of Guinea grass (7.9%) and the 6 – 7% minimum CP required to provide the minimum ammonia level for efficient rumen microbial activities (Minson, 1982). However, diets A (12.60% CP), B (14.35% CP) and C (16.45% CP) seemed to satisfy the minimum requirement of 11 - 12% CP proposed for lactation in ruminant animals by (ARC, 1984). McDonald *et al*. (1995) suggested threshold of about 7- 8% CP to guarantee sufficient utilization of feed. Gatenby (2002) indicated 10- 12%CP as moderate level for ruminant production. Therefore, it thus appears that the ensiled maize stover could supplement or replace poor quality grasses especially during the dry season.

The NDF level of maize stover silage only (diet D) was 46.83% while the other silages with concentrate ranged from 49.7 for diet B (50%C + 50CS) to 54.60% for diet A (75%C + 25% CS). For maize stover silage based diet, Elkholy *et al*. (2009) reported 48.0% level of NDF for sheep diet. Consequently, the range value 46.83 – 54.60% of NDF obtained in this study for maize stover silage and concentrate supplements was not detrimental to the intake and digestibility of the feed. It was lower than the 55.0 – 60.0% reported by Bamikole *et al.* (2004) as capable of limiting the intake of forage. However, the relative higher NDF content of the diets suggested that the feed will have low digestibility because lower NDF content has been associated with increase in digestibility and hence feed intake (Van Soest, *et al.* 1991 and McDonald *et al*., 2002). The level of dry matter intake (DMI) increased as the level of concentrate supplements increased. This indicates that the feeding of protein supplements with silage diets increases intake of silage. The range value of 437.50 to 694.41 gDM/day from the current study is relatively close to the range values of 617.20 to 759.10 gDM/day reported by Babayemi (2009) for Guinea grass silage fed to WAD sheep. A possible mechanism for a direct effect of nitrogen (N) on intake is that low N supply reduces digestibilty of the fibre component of the diet which in turn leads to decreased intake due to rumen fill effects (Rook and Gill, 1990). Alternatively inadequate N supply to the animal's tissues may create an effective energy surplus leading to decreased intake (Egan, 1965). Furthermore, the high dry matter intake (DMI) of sheep on silages with different levels of concentrate supplements could be due to high CP content. The level of DMI is influenced by several factors, such as body composition of animals (composition of body fat), environmental conditions especially climate, genetic factors, weight of animals, type of management, feed composition and quality (ARC, 1980). Dry matter intake was high. However, it has been observed that DMI can be favourably influenced by CP level (Karim *et al*., 2001; Karim and Santra, 2003). Overall, DMI of sheep were within 310 to 870g/day values reported by ARC (1980) and McDonald *et al*. (1987) as adequate for sheep with body weight of 20 to 35 kg. However, NRC (1985) reported that DMI could go up to 1000 to 1300g/day for growing sheep. Some factors, e.g low pH (Shaver *et al*., 1985) as well as high contents of acetic acids (Wilkins *et al*.,1971) and lactic acids (McLeod *et al*.,1970) have been attributed to the reduced intake of silage. Values of DMD obtained in the present study suggest that dry matter digestibility is not limiting factor and that when maize stover silage is used in ruminants ration with concentrate supplement, it could be of benefit to the ruminants. Similar suggestions have been given by Nour *et al*. (1987), Siulapwa and Simukoko (2000), Preston and Leng (1987), Syomiti *et al*. (2009) and Jianxin (2002). As a further support, the total digestible nutrient (TDN) values ranged from 63.65 to 70.92 (Table 2) and varied significantly among the treatments. The silage diets with concentrate supplements were consistently superior to the maize stover silage only (diet D). This further supports the need for the inclusion of maize stover silage as a potential feed resource in Nigeria and could form an important feed base for smallholder farmers, especially during the dry season when there is scarcity of forages. Digestibility of CP often increases as CP intake decreases because metabolic faecal N usually makes up a larger part of faecal N at low intake than at high intake (Wheeler *et al.*, 1995). This indicates that concentrate supplements had significant effect on CP digestibility of the maize stover silage. Utilization of digestible crude protein (DCP) of ensiled maize stover diets supplemented with concentrate by WAD sheep is of significant value except for diet D (100% Ensiled Maize Stover) which was poorly digested and utilized by animals under dietary treatment due to low level and poor quality of protein contents of the diet. Moreover, lower crude protein digestibility in 100% EMS agrees with D'Mello, (1992) that untreated cereal stover cannot maintain an animal when fed alone. However, higher level (17.23%) of digestible crude fibre (DCF) observed for WAD sheep on diet D (100% Ensiled Maize Stover) suggests that animals on treatment D had adapted to the diet. Furthermore, fungi and fibrolytic bacteria might be the major dominant microbes in the rumen of sheep that fed sole ensiled maize stover and this could be the major factor that enhanced the digestibility and utilization of fibre component of the feed. The highest CF digestibility (DCF) in

100% EMS also agrees with Abdulrazak (1995) who reported that in the utilization of high fibre forages as 100% EMS, ruminant animal is found better. FAO (1995) classified digestibility of feed as high when >60%, medium: 40-60% and low when < 40%. Consequently, apart from the DMD, the apparent digestibility of all the nutrients were low. This agrees with the findings of ARC (1980) and Ndlov (1992) for nutrients digestibility of crop residues.

Presented in Table 3 is nitrogen utilisation by WAD sheep fed ensiled maize stover (EMS) with graded levels of concentrate supplements. Apart from energy, nitrogen (N) is also one of the most limiting nutrient for ruminant animal production. Therefore, the incorporation of this nutrient in a feeding system based on low-nitrogen fibrous diet is of paramount importance. The trend in N-intake observed in sheep fed sole ensiled maize stover (EMS) and EMS with concentrate supplements (CS) was in accordance with the findings of Lamidi (2009) who reported that N-intake is proportional to the CP content of the feed. Sowande *et.al*. (2008) reported that faecal nitrogen excreted largely originated from endogenous sources and microbial CP. Moreover, inefficient ruminal utilisation of NH_3 would have been reflected in the urinary nitrogen excretion as observed in sheep fed diets A, C and E. A fraction of excess ammonia absorbed through the rumen wall is converted into urea and excreted in the urine and would not be efficiently utilised by microbes (Bonsi *et al*., 1995). The metabolic nitrogen balance (N-balance $W^{0.75}$) of diets ranged from 0.190 – 1.217g/day in the order C >B > E > A > D, all positive N-balance. The N-retention followed a similar trend ranging from 26.46 to 67.15%. The levels of N-retention may be as a result of the high digestibility of nutrients in all the diets containing maize stover silage. N-balance and retention values were high and this shows the potentiality of the diets to enhance N-utilisation. The positive N-balance and retention recorded in this study are indicative of animals gaining weight or conserving nitrogen during the period of experimentation. This therefore suggests that the diets A, B and C (i.e. all silage diets) except diet D which is 100% silage with lowest level of N-balance and N-retention could be deemed adequate. However, the high level of faecal and urine nitrogen recorded for animals on diets B, C, E and A, C, E may be due to poor utilisation of dietary nitrogen as well as absorbed excess NH_3 excreted as urea. Moreover, when animals are not fasted, the excreted nitrogen in faeces are derived from structural nitrogen of dietary sources while those in urine are mostly derived from broken down microbial protein not utilised by the animals as well as absorbed excess NH_3 excreted as urea (Van Soest,1982). The relatively high proportion of nitrogen intake excreted in faeces and urine for diets A, B, C and E is an indication of the poor utilisation of the protein, since it was not properly digested (those in the faeces) or it was wasteful broken down and excreted in the urine (Fraser *et al.,*2000).

Conclusion

The study showed that ensiled maize stover cannot be fed as sole diet to sheep because the dry matter intake and nutrient composition can neither maintain nor support the growth of sheep. Therefore, maize stover silage should be fed with concentrate supplements in order to give a balance diet before being fed to West African Dwarf sheep to improve their performance with respect to dry matter intake, nutrients digestibility and nitrogen utilisation.

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