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Original article

Nutrient and cell wall fraction digestibility of growing WAD ewe fed Mexican sunflower leaf meal (MSLM) based diets

A.H. Ekeocha[a,*], P.O. Fakolade[b]
[1]*Department of Animal Science, University of Ibadan, Ibadan, Nigeria.*
[2]*Department of Animal Science, Osun State University, Osogbo, Nigeria.*

[*]Corresponding author; Department of Animal Science, University of Ibadan, Ibadan, Nigeria.

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ABSTRACT

After a previous 84-d performance phase on growing WAD ewe, Studies was conducted using sixteen West African dwarf (WAD) ewe-lambs weighing between 17.50 and 17.88kg on a basal diet of *Panicum maximum* were allotted into 4 treatment groups A, B, C and D of 4 replicates each. The MSL replaced Wheat bran (WB) gravimetrically at 0, 15, 30 and 45%. Treatment A served as control. The experiment lasted for one week. Digestibility was determined using a 6-d total fecal collection. Ewes were given *ad libitum* access to feed and water. Parameters measured were voluntary dry matter intake (VDMI), which comprised concentrate dry matter intake (CDMI) and grass dry matter intake (GDMI), Apparent Digestibility Coefficients of DM, CP, NDF, ADF, ADL, Organic matter (OM) and Energy . Data were analyzed using descriptive statistics and ANOVA .The VDMI (g/d) varied from 392.30 - 695.00, CDMI (g/d) varied from 181.80 - 536.80 and GDMI (g/d) varied from 130.65 - 215.95 for ewe-lambs. Apparent Digestibility Coefficients of NDF, ADF, ADL, organic matter (OM) and Energy were similar. Approximately 75.5 ±1.1% of the VDMI came from the supplement. Diets containing 15% MSLM was superior to others for CDMI (181.80 – 536.80 g/day), CP intake (17.72 – 32.40 g/day/kgW$^{0.75}$), Digestible DMI (49.45 - 80.68 g/day/kgW$^{0.75}$) and Digestible CPI (13.68 - 27.16 g/day/kgW$^{0.75}$) while GDMI (130.65 – 215.95 g/day) for diets containing 30% and 45% MSLM were significant ($p < 0.05$). Inclusion of up to 45% Mexican Sunflower Leaf in the diets of growing ewe to replace Wheat bran was adequate.

1. Introduction

Scarcity of pasture during the dry season is a major problem in ruminant livestock production. Mexican Sunflower (MS) *Tithonia diversifolia* grows in the wild and is available all the year round in humid south of Nigeria. In Nigeria it grows wild in hedges, road sides, farm boundaries and wastelands in the forest savannah zone (Akinola *et al*., 1999, Ekeocha, 2009). Mahecha and Rosales (2005) showed that this specie have many qualities which gave it a high potential for animal production in the tropics. Important features are its high biomass yield and rapid rate of re-growth after cutting which has proven to be valuable in improving soil fertility for crop production in areas constrained by soil N, P, and K deficiencies (Lijzenga, 1998). According to Barrios (2004), the *in vitro* DM digestibility of *Tithonia diversifolia* leaves is 52.8% to 61.7%. The content of secondary plant compounds, especially tannins, appears to be low (Wambui *et al* 2006). Planted as a hedge *Tithonia* has great potential to supply plants with essential nutrients (Abednego, 2003). There is paucity of information on its value as a fodder for sheep. The performance of West African Dwarf (WAD) sheep fed Mexican Sunflower Leaf Meal (MSLM) was investigated.

2. Materials and methods

2.1. Plant materials (Mexican sunflower)

Mexican sunflower "*Tithonia diversifolia*" leaf obtained at the Teaching and research farm, University of Ibadan was harvested at approximately 6 weeks by slashing and carrying after the onset of rains. The stems were cut 50cm above the ground and sorted into leaves (Tarawali *et al*., 1995). The stems were sun-dried on a clean cemented platform until crisp. The leaves were partially ground and packed into sacks, weighed and stored in a silo. The samples were bulked together and manually mixed to obtain as uniform a product as possible. A representative sample was collected from it for proximate analysis. The MSL sample was air dried and later oven dried at 105^0C for 24 hours (to constant weight), milled and stored in air tight, sealed polythene bags prior to chemical analysis.

2.2. Pen management

The pen and metabolic cages were swept and dusted. They were later fumigated with Izal (Saponated cresol) at the ratio of 1:200 water (1litre:200litres of water) and also with diazintol (diazinon) at the rate of 2ml/litre of water (diazintol a strong and broad spectrum insecticide, acaricide and larvicide). Wood shavings were later spread on the floor of individual pens including the adaptation and spare pens; the wood shaving was changed fortnightly till the end of the trial.

2.3. Experimental design and treatments

Sixteen WAD sheep were divided into four groups of four animals each based on dentition. Each group was randomly assigned to one of 4 treatments and individual animals were completely randomized within the experimental pens in the unit.

The statistical model was: $\gamma_{ij} = \mu + \alpha_i + e_{ij}$

where γ_{ij} = individual observation

μ = general mean of population

α_i = treatment effect due to diets

e_{ij} = error effect

2.4. Animal feeding

The WAD sheep were fed Mexican sunflower wheat bran blended ration (Table 1). *Panicum maximum* leaves were harvested from pasture and range management unit of Animal Science Department at the Teaching and Research farm of the University of Ibadan. Leaves were allowed to wilt over-night before feeding and this was chopped manually with cutlass into 3-5cm pieces just before feeding.

Panicum maximum was given to all the treatments as basal diets. Feeding was done daily at 08:00 and 16:00 hrs (GMT). Fresh water was provided for each animal *ad libitum* daily. The animals were fed at 5% of body weight calculated from the diets on dry matter basis.

2.5. Digestibility study

Digestibility was carried out by the total faecal and urine collection method (McDonald *et al*., 1995). Animals were weighed and each animal was penned in an individual cage for 14 days, with a 7 day adjustment and another 7days collection period. Faeces and urine voided were collected. Individual total urine was collected and a 10% aliquot were kept in a refrigerator (0-4 ^{0}C) for analysis. Faecal samples were dried at 65 ^{0}C for 48hrs to a constant weight wrapped in aluminium foil, milled and stored in air-tight bottles until analyzed.

Apparent Digestibilities (AD) of dry matter (DM), organic matter (OM), energy, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) of experimental diets (Treatments) were calculated using the formula:

$$\frac{\text{Nutrient consumed (as feed)} - \text{Nutrient in feaces} \quad \text{x}}{\text{Nutrient consume}} \quad 100$$

OR

$$\frac{\text{Nutrient} \quad [\text{Input} - \text{Output}]}{\text{Input}} \quad \text{x} \quad 100$$

2.6. Laboratory analysis

Samples of dried MSLM and *Panicum maximum* were oven dried at 105 ^{0}C to constant weight, milled and stored in air tight, sealed polythene bags prior to chemical analysis. The nutrient composition of dried milled sample of MSLM, *Panicum maximum* leaves or branchlets and faeces were determined according to the procedure of AOAC (1990). Nitrogen content of feeds, faeces and urine were determined by the micro-kjeldahl technique using the Markham's distillation apparatus.

Results obtained were used for the calculation of DM, nutrient digestibilities by the WAD sheep. Neutral Detergent Fiber (NDF): NDF was determined by the Van Soest and McQueen (1973) methods as the residue after the reflux with 0.5m H_2SO_4 (TetraoxosulphateVI acid) and acety/trimethy/ammonium bromide. Acid Detergent Fiber (ADF): ADF was determined by the Van Soest (1963) method as the residue after extraction with boiling neutral solutions of sodium lauryl sulphate and EDTA. The percentage hemicellulose was obtained by deducting the ADF from the NDF. The percentage cellulose was obtained by deducting the percentage lignin from the ADF. ADF residue is primarily lignocellulose. The cellulose is dissolved by using 72% H_2SO_4 (TetraoxosulphateVI acid) solution. The remaining residue consists of lignin and acid soluble ash.

Table 1
Ingredient composition of experimental ration.

Ingredients %	**Rations**			
	A	**B**	**C**	**D**
MSLM[1]	0.00	15.00	30.00	45.00
Wheat bran	45.00	30.00	15.00	0.00
Cassava peel	33.20	33.20	33.20	33.20
Palm kernel meal	10.00	10.00	10.00	10.00
Ground nut cake	10.00	10.00	10.00	10.00
Oyster shell	0.50	0.50	0.50	0.50
Bone meal	0.50	0.50	0.50	0.50
Mineral/Vit. Premix	0.30	0.30	0.30	0.30
Common salt	0.50	0.50	0.50	0.50

[1]MSLM = Mexican Sunflower Leaf Meal, A = 0% MSLM, B = 15% MSLM, C = 30% MSLM, D = 45% MSLM

Table 2
Proximate composition of experimental diet.

Constituents %	Rations			
	A	B	C	D
Dry matter	92.00	91.00	90.00	89.00
Crude protein	17.10	16.90	16.50	16.20
Crude fiber	15.70	16.40	17.00	17.50
Ether extract	3.47	3.63	3.70	3.75
Ash	8.60	9.40	10.10	11.30
NFE[1]	55.13	53.67	52.70	51.25
ADF[2]	22.54	26.70	30.85	35.01
NDF[3]	43.15	44.50	45.85	47.20
ADLs[4]	7.92	8.41	9.03	9.85
Gross energy(kcal/kg)	3829.5	3805.5	3781.0	3735.5

[1]NFE= Nitrogen free extract
[2]ADF= Acid detergent fiber
[3]NDF= Neutral detergent fiber
[4]ADL= Acid detergent lignin

Table 3
Chemical Composition of Dried Mexican Sunflower Leaf Meal (MSLM), Wheat bran and *Panicum maximum.*

Components	MSLM	Wheat bran	*Panicum maximum*
Dry matter	89.00	89.00	26.00
Crude protein (CP)	16.33	17.00	7.95
Crude fiber (CF)	21.80	8.50	31.00
Ether extract (EE)	2.81	3.50	4.00
Ash	14.68	13.01	8.90
NFE[1]	44.38	57.99	48.15
ADF[2]	42.63	25.00	42.70
NDF[3]	60.00	51.00	74.30
Hemi cellulose	17.37	26.00	31.60
ADL[4]	9.96	8.60	13.87

[1]NFE= Nitrogen free extract
[2]ADF= Acid detergent fiber
[3]NDF= Neutral detergent fiber
[4]ADL= Acid detergent lignin

Table 4
Anti nutritional factors in MSLM.

Component	Quantity (mg/100g)
Total Alkaloid	6.32
Saponin	1.05
Oxalate	5.25
Phytate	8.81
Tannin	5.19
Glycosides	0.42
Phenol	0.53

Source: Ekeocha (2009)

2.7. Statistical analysis

The experimental design was completely randomized and the Data obtained were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) of SAS software (SAS, 1999). Treatment means were compared by Duncan test of the software.

3. Results and discussion

3.1. Nutrient digestibility of WAD ewe fed MSLM based diets

3.1.1. Crude protein

As shown in Table 5 Treatment effects on observed values of crude protein (CP) was significant ($P<0.05$) for CP intake and absorbed. From the result, ewes on treatment B(32.40 g/day/kgW$^{0.75}$) had the highest CP intake and this was numerically higher than ewes on treatments A(22.75g/day/kgW$^{0.75}$) and C(22.63g/day/kgW$^{0.75}$) but significantly ($P<0.05$) higher than ewes on treatment D(17.72g/day/kgW$^{0.75}$). No significant difference ($P>0.05$) was observed in the values obtained among ewes on treatments A, C and D respectively. The same trend followed for CP absorbed or digestible CP intake.

The high intake, absorbed and digestibility observed in the ewes on treatment B with respect to crude protein is in accordance with earlier reports (Reid *et al*., 1987; Robertson *et al*., 1996) that higher intake lead to higher absorbed and digestibility.

The digestibility coefficient of crude protein of growing West African Dwarf ewe fed MSLM based rations (77 - 84%) was higher which is an indication that the crude protein in the rations was well utilized.

3.1.2. Energy

Values obtained for energy intake, digestible energy and digestibility coefficient were shown in Table 5. Treatment effects on observed values of energy profile were not significant although ewes on diet B had the highest energy intake (364.73 Mcal/kg W$^{0.75}$) and the highest digestible energy (210.65Mcal/kgW$^{0..75}$), but these values were only numerically higher ($P>0.05$) than the rest of the diets. Ewes on diet D had the least energy profile across the diets and this could be due to the low feed or dry matter intake. The increase in energy intake (364.73g/day/kgW$^{0.75}$) and digestible energy (210.65g/day/kgW$^{0.75}$) observed in treatment B did not give a corresponding linear increase in energy digestibility; rather animals on treatment C (59.0%) had the highest energy digestibility which is a pointer to the fact that digestibility is indicative of the nutritive potential of the diet but that appropriate supplementation to improve protein flow to the intestine is the real determinant of performance.

3.1.3. Dry matter

Dry Matter Intake (DMI) at the digestibility phase is presented in Table 5. Dietary effects on Total DMI were not significant ($p > 0.05$) throughout the digestibility phase of the experiment. Concentrate DM consumption was 316.20, 536.80, 285.40, and 181.80 g/day for diets A, B, C and D respectively. Ewe on diet B recorded the highest Concentrate Dry matter Intake (CDMI) (536.80 g/day) and this was numerically higher than observed values for ewes on diets A (316.20 g/day) and C(285.40 g/day) but significantly ($p < 0.05$) higher than for ewes on diet D(181.80 g/day) which recorded the lowest CDMI. Ewes on diets A and C were only numerically higher in CDMI than ewes on diet D. An increase in the inclusion level of Mexican sunflower leaves in the concentrate diet brought about a reduction in CDM Intake of ewes on diet D, suggesting a substitution effect. There are several possible explanations for the relatively lower voluntary CDM Intake of ewes on diet D. First, drying might have increased neutral detergent fiber and lignin contents of the forage (Papchristous and Nastis, 1994), resulting in longer rumen retention times, slower rates of passage and consequently reduced voluntary DM intake of the dried leaves. Secondly, chemical reactions during the drying process might have rendered the dry leaves more bitter, and consequently less acceptable to the sheep on diet D. On the contrary, ewes on diets C (215.95 g/day) and D (210.49 g/day) had the highest Grass DMI and these were significantly ($p < 0.05$) higher than Grass Dry Matter Intake (GDMI) consumption for ewes on diets A (130.65 g/day) and B (158.26 g/day) (Table 5). Digestible dry matter intake (DDMI) was significant ($p < 0.05$). Animals on treatment B (80.68g/day/kgW$^{0.75}$) had the highest DDMI and this was significantly higher ($p < 0.05$) than what was obtained for animals on treatment D (49.45g/day/kgW$^{0.75}$).

Table 5

Nutrient apparent digestibility and body weight changes of growing WAD ewe fed MSLM based diets.

Parameters	Treatment				
	A(0%MSLM)	B(15%MSLM)	C(30%MSLM)	D(45%MSLM)	SEM
Dry Matter Intake Concentrate g/day	316.20[ab]	536.80[a]	285.40[ab]	181.80[b]	189.83
Dry Matter Intake Grass g/day	130.65[b]	158.26[b]	215.95[a]	210.49[a]	31.25
Total Dry Matter Intake g/day	446.85	695.00	500.10	392.30	200.08
Total Dry Matter Intake g/day/kgW$^{0.75}$	97.19	135.36	105.75	88.15	32.56
Organic matter intake g/day/kgW$^{0.75}$	90.78	125.82	98.06	81.44	28.06
Crude Protein Intake g/day/kgW$^{0.75}$	22.75[ab]	32.40[a]	22.63[ab]	17.72[b]	8.05
Energy Intake Mcal/kgW$^{0.75}$	259.49	364.73	284.73	236.57	81.53
Digestible nutrient (g/day/kgW$^{0.75}$)					
Digestible dry matter intake	57.44[a]	80.68[a]	64.61[a]	49.45[b]	24.53
Digestible organic matter intake	52.97	73.72	58.79	44.69	22.45
Digestible crude protein intake	18.98[ab]	27.16[a]	18.33[ab]	13.68[b]	7.52
Digestible energy intake	148.60	210.65	168.88	128.18	63.98
Digestibility coefficients (%)					
Dry matter	59.0	60.0	61.0	56.0	6.0
Organic matter	58.0	59.0	60.0	55.0	6.0
Crude protein	83.0	84.0	81.0	77.0	4.0
Energy	57.0	58.0	59.0	54.0	7.0

[ab]means on the same row with different superscripts differ significantly (*P<0.05*) . S.E.M: Standard error of mean.

Table 6
Cell wall fraction digestibility of growing WAD ewe fed MSLM based diets.

Parameters	Treatment				
	A(0%MSLM)	B(15%MSLM)	C(30%MSLM)	D(45%MSLM)	SEM
ADF Intake (g/day)	127.06	188.57	156.54	130.86	60.81
ADF Output (g/day)	35.52[b]	51.36[a]	37.14[b]	34.71[b]	7.67
ADF Absorbed (g/day)	91.54	137.21	119.40	96.15	56.53
ADF Apparent Digestibility (%)	72.04	72.76	76.27	73.48	4.51
NDF Intake (g/day)	233.51	349.22	283.60	234.84	94.12
NDF Output (g/day)	48.41[b]	68.06[a]	51.76[ab]	47.59[b]	11.59
NDF Absorbed (g/day)	185.10	281.16	231.84	187.25	86.43
NDF Apparent Digestibility (%)	79.27	80.51	81.75	79.74	3.12
ADL Intake (g/day)	43.16	67.09	55.54	47.10	18.51
ADL Output (g/day)	43.09[b]	66.67[a]	47.92[ab]	44.85[b]	13.32
ADL Absorbed (g/day)	0.07	0.43	7.63	2.25	11.43
ADL Apparent Digestibility (%)	1.15	1.23	3.62	4.20	14.85

[ab]means on the same row with different superscripts differ significantly (*P<0.05*) . S.E.M: Standard error of mean.

3.1.4. Organic matter

Observed variations were not significant for organic matter although animals on treatment B had the highest organic matter intake (125.82g/day/kgW$^{0.75}$), digestible organic matter intake (73.72g/day/kgW$^{0.75}$) while animals on treatment C had the best organic matter digestibility coefficient (60.0%).

3.1.5. Acid detergent fiber (ADF)

Treatment effect on observed value of acid detergent fiber (ADF) was significant (*P<0.05*) for faecal ADF. Ewes on treatment B (51.36g) had the highest faecal ADF and this was significantly (*P<0.05*) higher than ewes on treatments C (37.14g), A (35.52g) and D (34.71g).

There were no statistical significance (*P>0.05*) among the values obtained for treatments C, A and D respectively. The higher increase in values witnessed in ewes on treatment B across all parameters measured is in accordance with records of previous scholars (Reid *et al*, 1987; Robertson *et al*, 1996) that higher intake leads to higher faecal and digestibility coefficients.

3.1.6. Neutral detergent fiber (NDF)

Treatment effect on observed values of neutral detergent fiber (NDF) was significant (*P<0.05*) for faecal NDF. Ewes on treatment B (68.06g) had the highest faecal NDF and this was numerically higher than ewes on treatment C (51.76g) but significantly (*P<0.05*) higher than ewes on treatments A (48.41g) and D(47.59g).

There were no significant difference in the values (*P>0.05*) observed for ewes on treatments C, A and D. Dietary characteristics that promote relatively high numbers of protozoa may indirectly yield high ruminal fibrolytic activity by causing opposite bacterial shift (Mackie *et al*., 1987) through a process known as defaunation. Consequently, high and fast digestibility leads to higher feed intake. Factors that can also affect intake and utilization of forage nutrients include breed, mature size, age, bodyweight, previous plane of nutrition, disease incidence like bloat, tetany and environmental factors like heat or cold stress, presence of alkaloids, taste and smell (Galyean and Goetsch, 1993).

3.1.7. Acid detergent lignin (ADL)

Treatment effect on observed value of acid detergent lignin (ADL) was significant (*P<0.05*) for faecal ADL. Ewes on treatment B (66.67g) had the highest faecal ADL and this was numerically higher than ewes on treatment C (47.92g) but significantly (*P<0.05*) higher than ewes on treatments A (43.09g) and D (44.85g).

There were no statistical significance (*P>0.05*) among values obtained in ewes on treatments C, A and D respectively. The high increase in values witnessed in ewes on treatment B across all parameters measured is in accordance with records of previous reports (Reid *et al*, 1987; Robertson *et al*, 1996) that higher intake leads to higher faecal and digestibility coefficients.

3.2. Body weight change

Treatment effects on observed values for body weight change were not significant although animals on treatment B had the highest daily weight gain while animals on treatment D had the least daily weight gain.

4. Conclusion

Mexican Sunflower Leaf Meal incorporation in the diets of growing ewes improved nutrient intake and nutrient digestibility. Inclusion of up to 45% MSLM based-diets enhanced the performance of ewe-lambs in terms of intake and weight gain.

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