Archiva Zootechnica 23:2, 23-35, 2020
DOI: 10.2478/azibna-2020-0010

Replacement value of white mulberry forage for elephant grass on nutrients digestibility, weight gain and blood profile of sheep

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ABSTRACT

A 63-day study that involved 20 growing West African Dwarf sheep with average live bodyweight of 7.44 ± 0.18 kgW$^{0.75}$ was carried out to evaluate nutrients intake, nitrogen metabolism, weight gain and blood profile of sheep fed *Pennisetum purpureum* (PP) substituted with white *morus alba* leaves (ML). The sheep were allotted to 5 treatments of 4 sheep per replicate in a Completely Randomized Design experiment. Five diets fed to the sheep were formulated designated as T1 (100 % PP), T2 (75 % PP: 25 % ML), T3 (50 % PP: 50 % ML), T4 (25 % PP: 75 % ML) and T5 (100 % ML). DM ranged 89.03 - 90.16 % and highest (21.05 %CP) was obtained in T5. Nutrients intake, DWG and FGR were significantly ($p<0.05$) influenced. Highest DMI (250.38 gW$^{0.75}$/day) and CPI (52.70 gW$^{0.75}$/day) were observed in sheep fed T5. Highest N-balance (5.75 gW$^{0.75}$) was obtained in sheep fed T5. Consequently, the best DWG (16.10 gW$^{0.75}$g/day) and least FCR (15.55). Haematological and serum biochemical indices were within normal range for WAD sheep. Thus, sole feeding of white mulberry leave could offer a reliable source of protein for sheep.

Keywords: blood markers, feed conversion, grass, nitrogen content, mulberry, WAD sheep

INTRODUCTION

In Nigeria, the grasslands in the savanna zones has the potential (feed resource) for the development of ruminant production sectors. Yet, the scarcity or seasonal fluctuation of these forages contributes significantly to the challenges of sheep production in Nigeria. Often times, natural pastures and or crop residues available for these animals are usually fibrous and devoid of most essential nutrients to adequately support the optimum performance of the host animal (Ahamefule et al., 2006). Hence, results in weight loss, impaired reproduction capacity and high mortality rate. Elephant grass (*Pennisetum purpureum*) has been widely used as tropical forage, because of its high dry matter (Hanna et al., 2004). The grass has been reported to be low in nitrogen but when combined with legumes and concentrate diet, could be suitable forage for dairy cattle (Nyambati et al., 2003). More so, the feeding of grass solely is being discouraged because it may not meet the nutrient requirement for optimum performance. These problems propelled the research focus on sourcing nutritious drought-resistant forages (like White Mulberry) since it's abundant and cheaply available year-round in Nigeria in order to sustain the livestock industry (Fajemisin, 2017). Mulberry (*Morus alba*) is a traditional shrub belonging to the order Urticales, the family *Moraceae* and the genus Morus. The most common species are: *Morus alba*, the White Mulberry, *Morus nigra*, the Black Mulberry, *Morus rubra* the Red berry and *Morus indica* (Prasad and Reddy, 1991). Mulberry has been reported to be an excellent feed for high yielding animals considering its nutritional values (Prasad and Reddy 1991). They can be offered fresh or dried or solely or mixed in compound ration (Fajemisin 2017).

However, White Mulberry has been used to supplement basal diets such as the grasses, the preferred feedstock for silkworms, and is also cut as food for livestock (cattle, goats, rams, etc.) in areas where dry seasons restrict the availability of quality vegetation. Thus, it is believing that the combination of *M. alba* leaves and elephant grass would result in better utilization and reduced enteric methane production. Maselema and Chigwa (2017) and Preston et al. (2019) reported higher *in vitro* rumen methane production in animals fed grasses than those fed leaves from trees and shrubs. Furthermore, blood analysis is very crucial as a diagnostic tool for various pathological, metabolic disorders, impact of environmental, nutritional and pathological stresses for assessing health status of animals (Aletor et al., 1998, Elagib and Ahmed, 2011). Hence, the crux of this study was to evaluate the nutrients intake, nitrogen metabolism, weight gain and blood profile of sheep fed *Pennisetum purpureum* substituted with white *morus alba* leaves.

MATERIALS AND METHODS

Description of the Study Area

The experiment was carried out at the Small Ruminant Unit of Teaching and Research Farm, laboratory analysis was done at Nutrition Laboratory Unit of the Department of Animal Production and Health, Federal University of Technology, Akure (FUTA), Ondo State, Nigeria.

Collection and Processing of the Forages

P. purpureum leaves were harvested from the pasture of the Teaching and Research Farm, FUTA, while White Mulberry was harvested from the pasture of Ondo State Sunshine Agro-based Empowerment Centre, Wealth Creation Agency, Ondo Road, Akure in the evenings on daily basis and allow to wilt (air dried) before use the next day.

Sheep Management, Experimental Design and Diet Formulation

Twenty (20) West African Dwarf (WAD) sheep aged 8 – 9 months and live weight of 7.44 ± 0.18 $kgW^{0.75}$ were selected from sheep of the Teaching and Research Farm. The experiment was laid on a Completely Randomized Design of five treatments replication four time, with each WAD sheep representing a replicate. Five diets were formulated such that *P. purpureum* was combined with white *M. alba* leaves designated as T1 (100 % *P. purpureum*), T2 (75 % *P. purpureum*: 25 % *M. alba* leaves), T3 (50 % *P. purpureum*: 50 % *M. alba* leaves), T4 (25 % *P. purpureum*: 75 % *M. alba* leaves) and T5 (100 % *M. alba* leaves). The forages were thoroughly mixed together, fed to the sheep and fresh clean water was offered ad libitum at 8.00 am every morning for a period of 63 days.

Digestibility Trial and Nitrogen Balance

Faecal and urine samples from the experimental sheep were collected in the morning before feeding and watering for digestibility trial during the last two weeks of the experiment. Faeces were weighed and oven dried at 105 °C for three hours for dry matter (DM) determination. The faecal samples for each experimental animal were thoroughly mixed, milled to pass a 0.2 mm sieve and sealed in polythene bags. These were stored in a cupboard at room temperature until required for chemical analysis. Total urine excreted by each animal was collected in a plaque bucket under each cage and to which 1 – 2 drops of 25 % H_2SO_4 was added daily to curtail ammonia volatilization of ammonia from the urine. The total volume of urine output per animal was measured and aliquots (10 %) of daily output per animal was saved in stopper plastics bottles, labeled and stored in a deep freezer. Apparent nutrient digestibility coefficient and nitrogen balance of the sheep were recorded and calculated at the end of the experiment according to the method of Ahamefule et al. (2006) as follows: Apparent digestibility = (Nutrients intake – nutrients in faeces)/(Nutrient intake) x 100

Nitrogen balance/retention = Nitrogen intake – (faecal nitrogen + Urinary nitrogen).

Blood Collection and Analysis

At the end of the feeding trial, blood samples were collected through the jugular vein from each sheep into a well labeled bijour bottle containing ethyl-diamine tetra-acetic acid (EDTA) as anticoagulant and to another without EDTA. The blood samples collected in the bottle with EDTA were used to assay haematological parameters such as red blood cell (RBC) count, white blood cell (WBC) count, packed cell volume (PCV) and haemoglobin (Hb) using the method by Dacie and Lewis (1991), while those without EDTA were used for the serum biochemistry analyses such as serum total protein, serum albumin, globulin, alkaline phosphatase (ALP), alanine aminotransferase (ALT) and aspartate aminotransferase (AST) using the method of Reitman and Frankel (1957).

Data Collection and Feed Analysis

Daily voluntary feed intake of sheep was calculated as the difference between daily feed given and orts. Weekly weight change was monitored using hanging scale before feeding the animals. Samples of feed, faeces and urine were analyzed for nutrient composition using the methods of AOAC (2002) and Van Soest et al. (1991) as appropriate.

Data Analysis

All data generated were subjected to one-way analysis of variance (ANOVA), and the treatment means were compared by the methods of Duncan's Multiple Range Test using SAS (2010) version 9.3. Significant difference was set at $p<0.05$.

RESULTS AND DISCUSSION

Nutrient composition

The result of chemical composition of *P. purpureum* substituted with mulberry leaves is shown in Table 1. The concentrations of nutrients determined were significantly ($p<0.05$) influenced by the dietary treatment except for dry matter. The following nutrient composition had been reported for White Mulberry leaf: (g/kg on dry matter basis): 262.2 dry matter, 101.8 ash, 231.9 crude protein, 384.2 crude fibre, 31.8 ether extracts, 250.3 nitrogen-free extracts (Prasad and Reddy, 1991; Bamikole et al., 2005). The reported high DM (89.03 – 96.01 %) might be traced to the age (maturity) of the forages, processing and period the forages were harvested as this might contribute to its high lignifications. The observed DM values compared favourably to dry matter values (68 – 92 %) observed by Bamikole et al. (2001) while evaluating nutritive properties of some forage leaves. The recorded CP contents (11.40 – 21.05 %) in the diets were above 8 % CP required by ruminants to enact the rumen microbe activities (Norton, 2003). It was observed that protein (13.72 - 21.05 % CP) contribution of Mulberry improved the protein quality of T2, T3, T4 and T5. Hence, mulberry could be an alternative source of protein feed ingredient during dry season. The fibre fractions' contents obtained in T1 was higher than other tested diets and this could be attributed to the crude fibre (36.91 – 45.58 %) contents in the *P. purpureum* (Widiyastuti et al., 2014).

Table 1. Chemical composition of diets

Parameters	**Chemical composition (%)**				
	Diets				
	T1	**T2**	**T3**	**T4**	**T5**
Dry matter	89.03±0.52	90.16±0.61	89.68±0.68	89.14±0.67	89.18±0.44
Crude protein	11.40±0.90^{c}	13.72±0.09^{bc}	16.39±1.09^{ab}	18.28±1.31^{ab}	21.05±1.19^{a}
Crude fibre	31.38±1.24^{a}	23.03±1.89^{b}	20.35±2.01^{b}	15.66±1.69^{c}	14.25±1.70^{c}
Ash	12.16±0.56^{a}	11.06±0.55^{ab}	10.63±0.48^{ab}	9.81±0.57^{ab}	7.94±0.48^{b}
Ether extract	1.61±0.09^{b}	2.14±0.10^{a}	1.66±0.08^{b}	1.51±0.14^{c}	1.71±0.07^{ab}
Nitrogen free extract	43.45±1.09^{c}	50.05±1.20^{b}	50.97±1.19^{b}	54.74±1.09^{a}	55.05±1.60^{a}
Neutral detergent fibre	70.17±5.31^{a}	66.41±4.91^{b}	51.20±5.11^{c}	45.80±5.28^{d}	38.88±4.63^{e}
Acid detergent fibre	58.11±2.91^{a}	45.71±3.00^{b}	37.23±2.75^{c}	34.86±2.78^{c}	27.95±2.61^{d}
Acid detergent lignin	44.46±2.56^{a}	30.59±2.45^{b}	25.42±2.20^{c}	25.09±1.09^{c}	20.16±3.09^{d}
Hemicellulose	12.06±0.90^{b}	20.70±1.35^{a}	13.93±1.08^{b}	10.94±1.00^{b}	10.93±1.07^{b}
Cellulose	13.65±0.79^{ab}	15.12±0.46^{a}	11.81±0.92^{abc}	9.77±1.02^{bc}	7.79±1.00^{c}

abcde = Means on the same row with different superscripts are significantly (P<0.05) different. n = 3. ***T1*** *- 100 % P. purpureum,* ***T2*** *- 75 % P. purpureum: 25 % mulberry leaves,* ***T3*** *- 50 % P. purpureum: 50 % mulberry leaves,* ***T4*** *- 25 % P. purpureum: 75 % mulberry leaves,* ***T5*** *- 100 % mulberry leaves.*

Nutrient intake

The nutrients intake by the sheep was positively influenced by the substitution of mulberry in the diets (Table 2). Sheep fed T5 (100% mulberry leaves) had the highest DMI. The high DM intake might be attributed to protein quality, acceptability and palatable diets hence, sources of energy and nitrogen that might enhance rumen microbial activity (McDonald et al., 1995). The crude protein intake was adequate for all the sheep, but those fed T5 had the highest crude protein intake. It could be said that quality of the dietary protein positively influenced this. The crude fibre intake decreased with increasing inclusion levels of mulberry in the diets. This observation might be attributed to the improved protein quality of the diets. It was also observed that crude fibre intake decreased as crude protein intake increases, this observation corroborates the report of Fajemisin et al. (2013) when varying levels of fresh *Tithonia diversifora* and *P. maximum* were fed to Yankasa sheep.

The fibre fractions intake in sheep fed T1 was high except hemicelluloses and cellulose compared to intake of other sheep indicating more lignin contents in *P. purpureum.*

Table 2. Nutrient Intake ($gW^{0.75}$/day) by WAD sheep fed experimental diets

Parameters	**Nutrient Intake ($gW^{0.75}$/day)**				
	Diets				
	T1	**T2**	**T3**	**T4**	**T5**
Dry matter	206.09±3.39^{e}	228.34±5.03^{d}	237.24±3.12^{c}	243.15±4.09^{b}	250.38±5.14^{a}
Crude protein	23.49±2.23^{e}	31.33±3.46^{d}	38.88±3.08^{c}	44.45±2.09^{b}	52.70±3.04^{a}
Crude fibre	64.67±3.06^{a}	52.59±2.99^{b}	48.28±2.64^{b}	38.08±3.37^{c}	35.68±2.17^{c}
Ether extract	25.06±0.63^{a}	25.25±0.63^{a}	25.22±0.78^{a}	23.85±0.87^{a}	19.88±0.57^{b}
Nitrogen free extract	89.55±5.01^{d}	114.28±4.67^{c}	120.92±2.36^{b}	133.98±4.69^{a}	137.83±6.04^{a}
NDF	144.61±6.00^{b}	151.64±5.03^{a}	121.47±4.48^{c}	111.36±6.10^{d}	97.35±5.56^{e}
Acid detergent fibre	119.76±5.68^{a}	104.37±4.49^{b}	88.32±4.78^{c}	84.76±3.49^{c}	69.98±4.67^{d}
Acid detergent lignin	91.63±3.76^{a}	69.85±4.90^{b}	60.31±3.67^{c}	61.01±2.80^{c}	50.48±3.56^{d}
Hemicellulose	24.85±2.29^{c}	47.27±3.01^{a}	33.05±2.46^{b}	26.60±2.01^{c}	27.37±1.47^{c}
Cellulose	28.13±1.08^{ab}	34.53±2.01^{a}	28.02±1.00^{ab}	23.76±1.57^{bc}	19.50±2.36^{c}

abcde = Means on the same row with different superscripts are significantly ($P<0.05$) different. n = 3. NDF - Neutral detergent fibre. ***T1*** *- 100 % P. purpureum,* ***T2*** *- 75 % P. purpureum : 25 % mulberry leaves,* ***T3*** *- 50 % P. purpureum : 50 % mulberry leaves,* ***T4*** *- 25 % P. purpureum : 75 % mulberry leaves,* ***T5*** *- 100 % mulberry leaves.*

Nutrient digestibility

The results of nutrients digestibility (%) of the sheep revealed that *P. purpureum* substituted with mulberry leaves enhanced the degradation activities of the rumen microbes significantly except dry matter (Table 3). McDonald et al. (1995) opined that digestibility of feed is influenced by dietary protein and its intake. Crude protein digestibility coefficient was higher than the range of 56.2 – 63.10 % reported by Olorunnisomo (2010) for lambs fed with sweet potatoes with mixture of the forage and root. Digestible crude fibre values were higher compared to the values (27 – 68 %) reported by Ahamefule et al. (2006).

Performance characteristics

The nitrogen metabolism, feed conversion ratio and weight gain of the sheep were significantly ($p<0.05$) influenced by the treatments (Table 4). The highest weight gain (16.10 $gW^{0.75}$) and nitrogen balance (5.75 $gW^{0.75}$) obtained in sheep fed T5 might be attributed to the palatability, high DMI, CPI and better digestibility of the diet as weight gain is dependent of these factors

(McDonald et al., 1995). The sheep fed T5 utilized their feed better compared to other sheep.

Table 3. Apparent Nutrient digestibility coefficients (%) by WAD sheep fed diets

Parameter	**Nutrient digestibility (%)**				
	Diets				
	T1	**T2**	**T3**	**T4**	**T5**
Dry matter	68.80±0.89	70.40±0.79	68.50±0.60	68.10±0.69	70.40±0.88
Crude protein	$68.40±0.71^{c}$	$68.90±0.90^{c}$	$72.50±0.28^{b}$	$73.30±0.78^{ab}$	$74.50±0.65^{a}$
Crude fibre	$67.19±1.58^{b}$	$75.07±1.39^{ab}$	$75.25±1.31^{ab}$	$79.43±1.79^{a}$	$79.54±1.73^{a}$
Ether extract	$55.90±2.09^{b}$	$59.30±3.03^{b}$	$61.10±2.31^{b}$	$69.40±2.07^{a}$	$77.20±1.00^{a}$
NDF	$66.40±1.03^{b}$	$74.30±1.19^{a}$	$76.60±1.13^{a}$	$76.70±1.11^{a}$	$76.60±1.56^{a}$
ADF	$66.60±1.93^{b}$	$73.90±1.89^{ab}$	$75.80±1.88^{a}$	$76.60±1.00^{a}$	$79.60±1.00^{a}$
ADL	$57.12±3.31^{c}$	$65.53±2.33^{b}$	$76.36±2.12^{ab}$	$76.96±2.09^{ab}$	$79.49±2.03^{a}$
Hemi cellulose	$59.18±1.13^{c}$	$64.65±1.85^{bc}$	$66.58±1.23^{b}$	$70.02±1.30^{ab}$	$75.07±2.36^{a}$
Cellulose	$60.76±1.23^{c}$	$70.74±1.93^{b}$	$73.15±1.14^{b}$	$78.13±3.00^{a}$	$80.41±2.31^{a}$

abcd = Means on the same row with different superscripts are statistically (P<0.05) different. n= 3. ***T1** - 100 % P. purpureum, **T2** - 75 % P. purpureum : 25 % mulberry leaves, **T3** - 50 % P. purpureum : 50 % mulberry leaves, **T4** - 25 % P. purpureum : 75 % mulberry leaves, **T5** - 100 % mulberry leaves.*

Table 4. Performance of WAD sheep fed experimental diets

Parameters ($g/dW^{0.75}$)	**Response Criteria**				
	Diets				
	T1	**T2**	**T3**	**T4**	**T5**
Nitrogen intake	$3.75±0.52^{c}$	$5.01±0.58^{bc}$	$6.22±0.42^{bc}$	$7.11±0.57^{ab}$	$8.43±0.48^{a}$
Faecal nitrogen	$0.24±0.12^{c}$	$1.05±0.15^{b}$	$1.36±0.20^{b}$	$1.32±0.13^{b}$	$2.08±0.19^{a}$
Urinary nitrogen	$0.15±0.05^{c}$	$0.32±0.07^{b}$	$0.58±0.06^{a}$	$0.58±0.07^{a}$	$0.57±0.02^{a}$
Nitrogen balance	$3.36±0.32^{c}$	$3.64±0.39^{c}$	$4.28±0.26^{bc}$	$5.21±0.28^{ab}$	$5.75±0.29^{a}$
Initial weight	7.37±0.17	7.48±0.18	7.49±0.19	7.40±0.17	7.47±0.18
Final weight	7.76±0.38	8.12±0.32	8.28±0.29	8.37±0.28	7.89±0.28
DM intake	$206.09±3.39^{e}$	$228.34±5.03^{d}$	$237.24±3.12^{c}$	$243.15±4.09^{b}$	$250.38±5.09^{a}$
Daily weight gain	$6.19±0.82^{d}$	$10.16±0.87^{c}$	$12.54±1.01^{b}$	$15.40±0.90^{a}$	$16.10±0.96^{cd}$
FCR	$33.29±1.72^{a}$	$22.47±2.11^{c}$	$18.92±1.86^{d}$	$15.79±2.09^{e}$	$15.55±1.49^{b}$

abcde = Means on the same row with different superscripts are significantly (P < 0.05) different. n = 3. ***T1** - 100 % P. purpureum, **T2** - 75 % P. purpureum : 25 % mulberry leaves, **T3** - 50 % P. purpureum : 50 % mulberry leaves, **T4** - 25 % P. purpureum : 75 % mulberry leaves, **T5** - 100 % mulberry leaves.* FCR – Feed conversion ratio, DWG – Daily weight gain.

From Figure 1 and 2, the linear progression in growth curve and nitrogen balance could be due to increased crude protein in the diets as a result of increasing level of mulberry leaves in the diet.

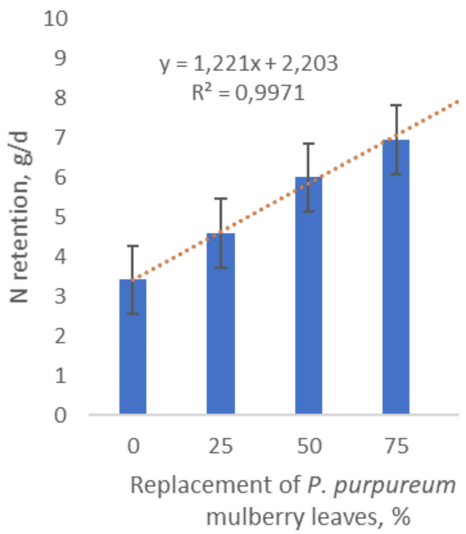

Figure 1. Nitrogen balance by sheep fed experimental diets

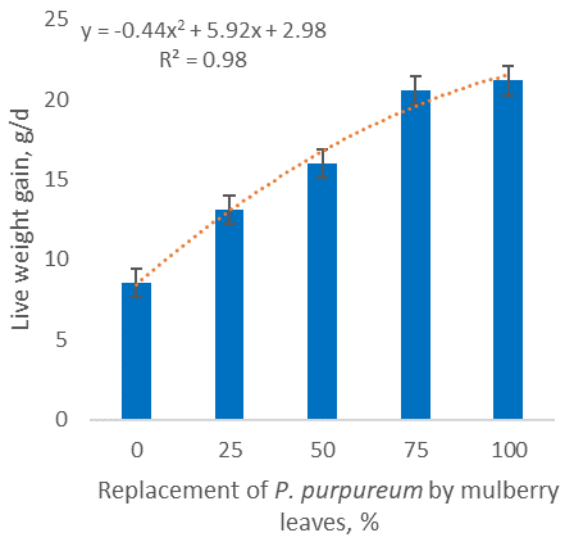

Figure 2. Growth curve by sheep fed experimental diets

Also, the nature of the protein could be said to be “true” protein which through its reaction with phenolic compounds (eg: condensed tannin) forms a complex and thus, protects it from rumen microbial activities (Barry and McNabb 1999), hence facilitating the rumen escape/bypass of the protein for more efficient enzymic digestion in the intestine.

Haematological and serum indices

Table 5 presents the haematological and serum biochemical indices of WAD sheep fed elephant grass substituted with white mulberry leaves. Parameters observed were significantly ($p<0.05$) influenced by mulberry leave except the mean cell haemoglobin concentration (MCHC), ALP and AST. Meanwhile, all results obtained were within the range for healthy sheep. Haematological assessment of animals is very key, for the diagnosis of pathological stresses, nutritional disorders, and environmental impact (Elagib and Ahmed, 2011). Packed Cell Volume (PCV) transports of oxygen in the blood and absorbed nutrients (Isaac et al., 2013). So, if PCV falls below normal range, it’s indicative of poor dietary protein quality and consequently anaemia (Awoniyi et al., 2004). From this present study, the obtained PCV values implied the good/quality dietary protein. Haemoglobin (Hb) is blood pigment that carries oxygen. Its high concentration is implied good carriage capacity of oxygen to various parts of the body. Red blood cell and Hb of sheep fed elephant grass and mulberry leaves had good blood oxygen carriage capacity since the values obtained for Hb and RBC were within normal range for healthy small ruminant (Daramola et al., 2005). White blood cell (WBC) and its differentials functions to fight foreign bodies/infections, defend the body through the process called phagocytocis. WBC of the sheep were influenced by dietary treatments; however, the obtained values were within normal range for healthy goats and sheep (Daramola et al., 2005; Plumb, 2018). Consequently, it could be said that the immune system of the sheep was not compromised by the substitution of mulberry leave.

Table 5. Haematological and Serum Biochemical indices of WAD sheep fed diets

Parameters	**Haematological and Serum Biochemical indices**				
	Diets				
	T1	**T2**	**T3**	**T4**	**T5**
Whole blood count					
White blood cell ($x10^3\mu l$)	7.26±0.22^c	8.59±0.30^b	8.87±0.45^b	10.50±0.25^a	11.69±0.58^a
Red blood cell ($x10^6\mu l$)	9.29±0.14^e	10.54±0.21^d	11.26±0.10^c	12.60±0.04^b	14.02±0.21^a
Haemoglobin (g/dl)	8.12±0.06^e	8.35±0.03^d	8.88±0.07^c	9.35±0.08^b	9.77±0.09^a
Packed cell volume (%)	26.46±0.66^b	27.14±1.09^b	28.69±0.43^b	32.42±1.16^a	34.20±1.57^a
Mean cell volume (μ^3)	28.47±0.37^a	25.82±1.57^{ab}	25.47±0.22^{ab}	25.73±1.01^{ab}	24.44±1.49^b
MCH (pg)	8.74±0.07^a	7.93±0.16^b	7.88±0.10^b	7.42±0.06^c	6.97±0.15^d
MCHC (g/dl)	30.70±0.55	30.86±1.19	30.92±0.67	28.91±1.04	28.65±1.11
Serum parameters					
Total protein (g/dl)	6.83±0.77	7.26±0.22	7.36±0.25	7.54±0.27	7.92±0.04
Albumin (g/dl)	3.60±0.04^a	2.29±0.14^c	3.34±0.32^b	3.26±0.10^b	3.54±0.16^a
Globulin (g/dl)	3.23±0.77^c	4.97±0.22^a	4.02±0.21^b	4.28±0.30^{ab}	4.39±0.33^{ab}
ALP (IU/l)	50.46±9.87	56.20±11.94	58.81±2.10	60.02±10.47	65.42±9.68
AST (IU/l)	60.83±2.65	62.50±3.77	66.83±1.17	68.83±2.17	72.67±6.09
ALT (IU/l)	9.80±1.10^b	12.84±0.54^{ab}	13.28±1.47^{ab}	13.33±1.27^{ab}	14.33±1.20^a

a,b,c, means on the same row with different superscripts are significantly ($P < 0.05$) different. n = 3. MCH - Mean Cell Haemoglobin, MCHC – Mean Cell Haemoglobin Concentration, ALP - Alkaline phosphatase, AST – Aspartate aminotransferase, ALT - Alanine aminotransferase. ***T1** - 100 % P. purpureum, **T2** - 75 % P. purpureum : 25 % mulberry leaves, **T3** - 50 % P. purpureum : 50 % mulberry leaves, **T4** - 25 % P. purpureum : 75 % mulberry leaves, **T5** - 100 % mulberry leaves.*

The serum total protein observed in this trial, ranged: 6.83 – 7.92 g/dl and fell within the normal range of 6.3 – 8.5 g/dl reported for WAD goats (Daramola et al. 2005). Serum total protein and albumin values in this study is an indication that protein in the diets is adequate (Aletor et al., 1998). Consequently, the blood had excellent clotting ability thereby could prevent haemorrhage (Daramola et al., 2005). Globulins concentrations ranged from 3.23 g/dL (T1) to 4.97 g/dL (T2), higher than 0.16 - 1.6 g/dL reported for WAD goats (Daramola et al. 2005). An indication that mulberry leave has the potential to boost immunity in the sheep. Hence, better defense line against infection.

The alkaline phosphatase (ALP) concentrations were within values reported for WAD goats reported by Daramola et al. (2005). Hence, local concentration of inorganic phosphate or to activate the collagen fibres in such a way that they cause deposition of calcium salts would increase according to Guyton and Hall (1998). Thus, high ALP values obtained implied mulberry leave substituted with elephant grass has the potentials to facilitate bone formation. The aspartate aminotransferase (AST) values were not statistically ($p>0.05$) influenced by the dietary treatment, however, obtained values were within the normal range reported for WAD sheep and goat by Daramola et al. (2005). Hence, no liver infarction and cellular dysfunction. The sheep were maintained in good health condition, improved cellular protein synthesis and general performance.

Conclusion

This study revealed that white mulberry had the nutritional potentials to improve nutrient intake, nitrogen balance and weight gain. From the result, the diets did not have any detrimental effect on the well-being (health status) of the WAD sheep, as AST levels were not elevated beyond normal to cause liver infarction. The study further established that mulberry leaves could furnish the required protein – energy for enhanced sheep production in the tropics without any deleterious effect(s) and is thereby recommended either as sole or supplementation in ruminant feeding.

Acknowledgments

The authors acknowledge the Departmental Technologists for the assistance rendered in the course of the laboratory analysis.

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