Digestibility, Nitrogen balance and haematological profile of West African dwarf sheep fed dietary levels of *Moringa oleifera* as supplement to *Panicum maximum*

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Abstract: The effect of inclusion level on nutrient intake, digestibility, nitrogen balance and haematological parameters of West African Dwarf (WAD) sheep fed *Moringa oleifera* as supplements to *Panicum maximum* was investigated in a completely randomized design experiment using twenty WAD rams with average initial weight of 16.1kg. There were five treatments 1 – 5 with 0, 25, 50, 75 and 100 % *M. oleifera* inclusion levels respectively. *M. oleifera* had better nutrient profile with 29.68% CP and 16.98% CF contents than *P. maximum* with 9.17% CP and 40.37% CF. Inclusion of *M. oleifera* as supplement to *P. maximum* in the diets of WAD sheep significantly lowered ($P<0.05$) DM intake especially at higher (>50%) inclusion rates. OM, EE and NFE intakes were similar but CP intake increased while CF intake decreased ($P<0.05$) as inclusion level increases. The best DM, organic matter (OM), CP and Nitrogen-free extract (NFE) digestibility were obtained at 100 % *Moringa* inclusion while CF and ether extract (EE) digestibility were highest at 25 % inclusion level which also gave similar DM and CP digestibility with 100 % inclusion. N balance and retention were best under 25 % *M. oleifera* and least under 75 % *M. oleifera*. Packed cell volume (PCV), Haemoglobin (Hb), red blood cell (RBC) and white blood cell (WBC) counts for animals on browse supplementation were within the normal physiological range for healthy sheep, in contrast with those without supplementation which were below the range. The blood profile was best for animals on 25 % *Moringa* inclusion. [Journal of American Science 2010;6(10):634-643]. (ISSN: 1545-1003).

Key words: Digestibility, haematological profile, WAD sheep, *Moringa*

1. Introduction

One of the major factors limiting the productivity of small ruminants in developing countries is the over-dependence on low digestibility feeds which at certain periods of the year cannot meet even the maintenance requirements of these animals. Jayasuriya (2002) categorized these feed resources as high fibre low protein feeds having organic matter digestibility between 30 – 45 % and they include native grasses, crop residues and fibrous agro-industrial waste products. They form the bulk of feed consumed by small ruminants in tropical countries because they are produced in large quantities and are relatively cheap since they are not competed for by man or monogastric animals.

According to Leng (1997), the poor condition of livestock in the tropics is more likely as a result of inefficient digestion in the rumen and inefficient utilization of the nutrients absorbed from low quality feeds. Several attempts which have been made to improve the nutritive quality of this class of livestock feeds include physical, chemical and biological treatments, use of feed additives as well as supplementation with non-protein nitrogen sources such as urea and molasses (Adegbola 2002). Alkali treatment of fibrous crop residues have been well researched and proven to increase the potential feeding value of crop residues (Preston and Leng 1987). Moreover, the possibility of using urea as a cheap readily available source of nitrogen in ruminant diets led to the expectation of rapid improvement in ruminant productivity in developing countries. However for various reasons these technologies have not been widely adopted as expected and animal productivity is still poor (Owen and Jayasuriya 1989).

In recent years there has been a growing interest in many tropical countries to identify potentially important feed sources among shrubs and

trees for inclusion in the ruminant diet to provide green fodder that is high in protein to supplement the available low protein forage. This has been recognized as one of the most effective means of improving animal performance in smallholder livestock production (Blair 1989). *Moringa oleifera* is a well known tree in West Africa especially in semi-arid areas where it is often cultivated as a living fence around people's gardens and consumed in various forms as food. Leaves of the tree are noted for high content of crude protein, essential vitamins, minerals and amino acids (Makkar and Becker 1997; Gidamis et al. 2003). However, according to Akinbamijo et al. (2004), the value of the tree and its benefits as a high-quality supplement to low-quality roughages in ruminant feeding systems have not been fully known nor widely exploited.

Evaluation of the blood profile of animals may give some insight as to the potentials of a dietary treatment to meet the metabolic needs of the animal since according to Church et al. (1984), dietary components have measurable effects on blood constituents such that significant changes in their values can be used to draw inference on the nutritive value of feeds offered to the animals. The assertion of Ikhimoya and Imasuen (2007) that most of the available information on haematological parameters of goats in the humid tropics is based on disease prognosis is also applicable to sheep from the region. Thus, data on blood profile of West African dwarf (WAD) sheep offered foliages from non-conventional fodder sources are scanty. The objective of this study therefore was to evaluate the nutrient digestibility, nitrogen balance and haematological profile of WAD sheep as affected by dietary inclusions of *Moringa oleifera* as supplement to *Panicum maximum.*

2. Materials and Methods

The experiment was carried out at the Teaching and Research Farm of the Federal University of Technology, Akure, Nigeria. Matured WAD rams (n=20) averagely weighing 16.08kg were used in a completely randomized design experiment. The animals were housed in individual metabolic cages. They were divided into five groups of four animals each after balancing for weight and each group randomly assigned to one of five treatments namely:

Treatment 1: 100 % *Panicum maximum* (control)
Treatment 2: 75 % *Panicum maximum* + 25 % *Moringa oleifera;*
Treatment 3: 50 % *Panicum maximum* + 50 % *Moringa oleifera;*
Treatment 4: 25 % *Panicum maximum* + 75 % *Moringa oleifera;*
Treatment 5: 100 % *Moringa oleifera.*

Fresh *Moringa* foliage was harvested from established plantation in the Federal College of Agriculture, Akure while fresh *Panicum* were sourced from the pasture within FUTA campus. Both were allowed to wilt overnight before feeding to the animals. Measured quantities of the leaves were offered to the animals each day and the quantity left over was weighed the following morning to determine daily feed intake. Water was provided *ad-libitum*. The experiment lasted for 6 weeks.

Digestibility Trial

In the last week of the experiment, total faecal and urinary outputs were collected from each animal daily and weighed. 10% of daily faecal output were dried, bulked together and stored until needed for proximate analysis while 10% of the daily urine output preserved with 50% sulphuric acid was frozen till it was required for nitrogen analysis.

Chemical Analysis

Feed and faecal samples were oven-dried, ground to pass through 1mm screen and analyzed for proximate compositions (AOAC 1995). Nitrogen in urine was determined by microkjedahl methods. Results obtained were used to calculate the nutrients intake, digestibility, N balance and retention.

Haematological Studies

Blood was collected from the jugular vein of the experimental animals at the termination of the experiment in a vial containing ethylene diamine tetra-acetic acid (EDTA). The bottles were immediately capped and the content mixed gently for about a minute by repeated inversion or rocking. Blood samples were analyzed immediately after collection for packed cell volume (PCV) and haemoglobin (Hb) concentration as described by Benson et al. (1989) and Jain (1993). Red blood cells (RBC), white blood cell (WBC) as well as the differential WBC counts were determined using the Neubauer haemocytometer after appropriate dilution (Lamb, 1981). Values for the constants: mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV) were calculated from RBC, Hb and PCV values as described by Jain (1993).

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of MINITAB (2000) and where significant F-values for treatment effect were found, means were compared by Least Significant Difference (LSD). Linear correlation and regression analyses were carried out according to SAS (1999).

3. Results and Discussion

Nutrient composition

The proximate composition of *Moringa* and *Panicum* depicted in Table 1 show that both plants had comparable dry matter (DM) contents (21.48% and 24.27% respectively). The crude protein (CP) content of *Moringa* at 29.68% is higher than that for *Panicum* (9.17%) and it exceed by far the minimum protein requirements for ruminants recommended by ARC (1985). Odee (1998) reported a CP content of 29% for *M. oleifera*, similar to what was obtained in this study. However, the CP values obtained in this experiment differ from values reported by other authors. For example, Makkar and Becker (1996) and Manh et al. (2005) obtained CP values of 25.1 and 26.4 % respectively for *Moringa* while Aganga and Tshwenyane (2004) and Arigbede et al. (2005) obtained 7.8 – 20.5 and 8.5 % CP respectively for *Panicum*. Variability in the nutrient content of browses has been attributed to within species differences, plant parts, season, harvesting regime, location, soil type and age (Norton 1994).

Table 1: Proximate composition (%) of *Moringa oleifera* and *Panicum maximum*

Composition	*M. oleifera*	*P. maximum*	SEM
DM*	21.48	24.27	1.40
OM	92.46	88.08	2.19
CP	29.68	9.17	5.76
CF	16.98	40.37	7.20
EE	5.78	4.07	0.86
ASH	7.54	11.92	2.19
NFE	40.11	34.47	2.82

* DM, % in fresh sample, others % in DM.

Crude fiber (CF) content in *Panicum* was similar to 33.4 % reported by Aganga and Tshwenyane (2004) and was higher than the value obtained for *Moringa*, which compares very well with the average of 19.8 % CF for selected multipurpose trees (Fadiyimu 2000). This is consistent with the observation of Okoli et al. (2003) that CF content of tropical grasses is usually higher than that for browse shrubs and trees.

Nutrient Intake

Table 2 shows the nutrient intake by WAD sheep fed dietary inclusions of *Moringa* and *Panicum*. DM intake was highest ($P<0.05$) in treatment 1 but it is comparable with values for treatments 2 and 3 while lower values were recorded in treatments 4 and 5. The higher DM intake for treatment 1 could be due to the fact that small ruminants have affinity for guinea grass and since it was offered as sole feed, the animals have no choice than to eat what was served (Babayemi and Bamikole 2006). Mean DM intake in this study is low compared with 428.5 g/day obtained by Manh et al. (2005) and this could be due to the method of offering the forage as it has been shown that small ruminants have difficulty in picking up isolated leaves from the feed trough as compared with 'plucking' them from intact branches, resulting in lower DM intakes for the former (Toum et al. 2004). According to Theng et al. (2003), it appears that small ruminants find it easier to bite the leaves when they are attached to stems offering some resistance to the action of eating compared with the foliage placed in the feed trough.

The average CP intake obtained in this study at 58.0 g day^{-1} is comparable to the 57.1 g day^{-1} obtained by Osakwe et al. (2004) for *Daniella oliveri*. Table 2 also shows that as *Moringa* inclusion increases, CP intake increased and CF intake reduced. This suggest that high levels of *Moringa* supplementation may probably lead to a lower microbial protein turn-over in the rumen since according to Leng (1997), the rate of microbial growth on protein is approximately half that of carbohydrates and that protein: energy (P/E) ratios are lower when protein is degraded in the rumen in comparison to carbohydrates. Therefore supplementation of *P. maximum* with *M. oleifera* is probably better at the lower (25-50 %) than at the higher (75-100 %) inclusion levels.

Table 3 shows that there was significant ($P<0.05$) indirect relationship between DM intake and level of *Moringa* inclusion. This contradicts the findings of Arigbede et al. (2005) and Odeyinka and Ademosun (1995) who reported increasing DM intake with increasing level of browse supplementation. It however agrees with Fasae et al. (2005) who reported a decreasing DM consumption with increasing level of *Leucaena* supplementation in Yankasa sheep diets. On

the other hand, CP intake had a significant (P<0.05) direct relationship with the level of *Moringa* inclusion in the diets. This agrees with the observation of McDonalds et al. (1988) that ruminant animals show higher N intake with feed high in crude protein contents. Also, the significant (P<0.05) positive relationship between *Moringa* inclusion and both CP and NFE intakes is probably a reflection of the increasing quality of the diets with increasing level of *Moringa* supplementation since according to Ventura et al. (1975), forage quality increases as nutrient intake increase.

Nutrient Digestibility

Table 4 shows the DM and nutrient digestibility in WAD sheep fed dietary inclusions of *Moringa*. Values recorded for DM and OM digestibilities in the control treatment are comparable with 52.2 and 55.4 % respectively obtained by Arigbede et al. (2005) in WAD goats fed 100 % *Panicum*. With the exception of CF, nutrient digestibilities were significantly higher (P<0.05) in supplemented diets than in the control. Among the *Moringa*-supplemented diets, DM, OM and NFE digestibility were highest in treatment 5 while CF and EE digestibility were best in treatment 2. Conversely, the least DM, OM, CF and EE digestibilities were obtained in treatment 4 while the poorest NFE digestibility was recorded in treatment 3.

CP digestibilities in treatments with dietary levels of *Moringa* were statistically similar and were all significantly higher (P<0.05) than in the control. This is probably because *Moringa* fodder consists of more degradable components especially crude protein than *Panicum* and thus could serve as supplement to the former in ruminant diets. The higher CF digestibility in treatments 2 and 3 equally suggests an increase in the activities of fibrolytic bacteria in the rumen probably as a result of the availability of essential nutrients especially protein, energy and minerals in balanced proportions to enhance microbial growth and multiplication.

In Table 5, level of *Moringa* supplementation was directly correlated with each of DM, OM, CP and NFE digestibilities and indirectly related to CF and EE digestibilities. However, the correlation coefficient was significant (P<0.05) for only NFE digestibility suggesting that up to 100 % inclusion, increasing level of *Moringa* supplementation will probably enhance the utilization of the soluble carbohydrate components of the dietary organic matter.

Nitrogen Balance

Table 6 depicts the nitrogen (N) balance when graded *Moringa* leaves were fed to WAD sheep. N intake increased progressively from treatment 1 to treatment 5 hence it has significant (P<0.05) direct relationship with dietary level of *Moringa* (Table 7). This is probably due to increased CP intake with increasing level of *Moringa* inclusion in the experimental diets as reported above. The average N intake is similar to 9.2 g day^{-1} obtained by Alli-Balogun et al. (2003) for Yankasa/WAD sheep crosses fed grass supplemented with cassava foliage or groundnut hay.

Faecal N did not differ (P>0.05) among the diets in agreement with Black et al. (1978) that faecal N was not significantly affected by N intake. On the other hand, urinary N increased progressively from diets 2 to 5, a result which tally with Ahamefule et al. (2006). Table 7 also show that N digestion is directly correlated with level of *Moringa* inclusion hence values of N digestion recorded for the supplemented diets were significantly higher (P<0.05) than the control. This suggests that additional N consumed by the animals on *Moringa* supplementation was well digested and absorbed. Total N output followed the same pattern as urinary N, with treatments 1 and 2 having the least values in both parameters, and from treatment 3 the values increased (P<0.05) steadily up to treatment 5. This is probably because the protein moiety of the *Moringa*-supplemented diets was more soluble than that of the control.

According to Brooker *et al.* (1995), when feed is high in soluble plant protein, N metabolism occur mainly in the rumen rather than in the lower digestive tracts leading to the production of large quantities of ammonia N in excess of the requirements of rumen microorganisms. The ammonia N not utilized by the bacteria is converted to urea by the animal and excreted in urine. This means that more rumen ammonia would be produced with the *Moringa*-supplemented diets which would have increased as N intake increases from treatments 2 to 5. This perhaps explain why significantly higher (P<0.05) values of urinary N and total N output were recorded as the level of *Moringa* supplementation increased in this study.

All the treatments gave positive N balance and N retention values, an indication that the protein requirement for maintenance in the experimental animals was adequately met by the dietary treatments. Treatment 2 had the highest (P<0.05) N balance and N

retention, and the values were similar to that obtained by Lamidi et al. (1998) for WAD sheep fed *Ficus thonningi* at the same (25 %) level of supplementation. The implications of treatment 2 having the best N balance and N retention in this study is that the optimum level of replacement of *P. maximum* with *M. oleifera* is probably at about 25 % and that at higher inclusion levels efficiency of protein utilization decreases.

Haematological Studies

The data presented in Table 8 show that except for packed cell volume (PCV) and mean cell volume (MCV) which were significantly different ($P<0.05$), other erythrocyte indices were apparently similar across the treatments. Even though the red blood cell (RBC) counts did not differ significantly ($P>0.05$), only values obtained for treatments 2, 3 and 5 were within the normal physiological range of 9.0-15.0x10^6 mm^{-3} for healthy sheep (Jain 1993). RBC count aid in the characterization of anemia (Ikhimioya and Imasuen 2007). Thus the abnormally low values recorded for treatments A and D is an indication of a likely high susceptibility to anemia-related disease conditions by these animals. This is corroborated by the fact that animals in these treatments also recorded MCV values that were comparatively at the high end of the normal physiological range of 28.0 – 40.0 µm (Jain 1993) which according to MERCK (1979) increases the probability of the release of immature red blood cells into the circulatory system.

Mean PCV was highest in treatment 2 and lowest in the control diet. However, only the control recorded PCV value outside the physiological range of 27.0 – 45.0 % given by Jain (1993). Similarly, haemoglobin (Hb) concentration was least numerically in the control diet which together with treatment 5 also had values outside the physiological range (9.0-15.0 g/100ml) as reported by Jain (1993). Aikhuomobhogbe and Orheruata (2006) asserted that low PCV results in anemia which causes reduced oxygen carrying-capacity of blood, increased pulse rate and consequently heart failure. Therefore, the abnormally low ($P<0.05$) PCV and Hb values recorded for treatment 1 (control) is an indication that feeding *P. maximum* alone to small ruminants could predispose the animals to pernicious anemia while supplementation with *M. oleifera* especially up to 50% level of inclusion could probably alleviate it.

The fact that only the sheep on treatment 2 had PCV level above 32 % which is stated to be normal for circulatory system in sheep (Frandson 1986) means that it is probably only at the 25 % level of *Moringa* supplementation that small ruminants could have a high probability of a return of PCV to normal level following an infection through compensatory accelerated production (Dargie and Allonby 1975). This is in tandem with the findings of Ikhimioya and Imasuen (2007) who recorded the best PCV level in WAD goats at 25% level of *Newbouldia laevis* supplementation.

Table 8 also presents the total and differential leucocytes counts of WAD sheep when offered *M. oleifera* as replacement to *P. maximum*. Mean white blood cell (WBC) count for the supplemented diets at 7.8x10^3 mm^{-3} is comparable with 8.0x10^3 mm^{-3} stated as ideal for clinically healthy sheep (Heath and Olusanya 1988) whereas the value obtained for the control diet is outside the physiological range of 4.0 – 12.0x10^3 mm^{-3} (Jain1993). The abnormally high WBC count of the control animals could be in response to poor health status as a result of under-nourishment and this can probably be reversed by supplementation with *M. oleifera* by ensuring intake of balanced nutrients.

Out of all the differential leucocyte parameters, only lymphocyte and neutrophil counts showed significant differences ($P<0.05$). Aikhuomobhogbe and Orheruata (2006) pointed out that varying lymphocyte values indicate different levels of immune status of farm animals and Lazzaro (2001) further expatiated that depressed levels of lymphocytes might indicate either a depleted immune system or elevated neutrophil level in an active infection. However, lymphocyte and neutrophil counts obtained in this study fall within the physiological range of 40 – 75 % and 10 – 50 % respectively for healthy sheep (Jain 1993).

The trend of the result as set out in Table 8 also showed that treatments 2 and 3 with significantly low ($P<0.05$) lymphocyte counts had significantly high ($P<0.05$) neutrophil counts while the reverse was the case for treatments 1, 4 and 5. Further statistical analysis revealed that neutrophil and lymphocyte counts had significant ($P<0.05$) negative correlation ($r = –0.96$). This is in agreement with the observation of Osueni (2001), Lazzaro (2001) and Aikhuomobhogbe and Orheruata (2006) that an increase in neutrophils is associated with a decrease in lymphocytes and vice versa. However, as shown in Table 9, all the haematological parameters had variable but non-significant correlations ($P>0.05$) with *Moringa* inclusions, suggesting that the probability of

predicting haematological profile of WAD sheep from levels of dietary inclusion of *M. oleifera* is low.

4. Conclusion

This study revealed that *M. oleifera* had significantly higher crude protein and lower crude fibre contents than *Panicum maximum* and its inclusion in the diets of West African Dwarf (WAD) sheep as supplement to the grass resulted in significantly higher crude protein intake, higher dry matter and nutrient digestibilities, higher nitrogen retention and better haematological profile in the supplemented than non-supplemented animals. It was found out that *Moringa* can satisfactorily supplement *P. maximum* up to 100 % inclusion but the optimum inclusion level at which the best nitrogen balance, nitrogen retention and haematological profile was recorded was at 25 % *Moringa* inclusion.

Table 2: Nutrient intake (g day^{-1}) of WAD sheep fed dietary inclusions of *Moringa oleifera* and *Panicum maximum*

Parameters	Treatments					Mean±SEM
	1	2	3	4	5	
DM intake	236.59^{a}	232.92^{a}	226.43^{ab}	215.12^{b}	212.05^{b}	222.62±12.11
OM intake	208.39	207.49	204.12	197.00	196.04	200.61±8.08
CP intake	47.65^{c}	53.70^{bc}	59.22^{b}	59.72^{b}	69.71^{a}	58.00±7.31
CF intake	82.24^{a}	72.42^{b}	61.55^{c}	48.10^{d}	39.67^{e}	60.80±15.51
EE intake	33.62	33.68	33.69	31.33	33.46	33.16±0.92
NFE intake	43.72	46.35	48.48	46.88	52.35	47.56±2.48

$^{a, b, c, d, e}$ Means along the same row with different superscripts are significantly different (P<0.05); SEM = standard error of the means

Table 3: Linear correlation and regression analyses between *Moringa oleifera* inclusions (*X*) and nutrient intake (*Y*)

Moringa inclusions vs.	Correlation Coefficient	Regression Equation
DM intake	-0.90*	$Y = 238.0 – 0.31X$
OM intake	-0.79NS	$Y = 209.65 – 0.81X$
CP intake	+0.97*	$Y = 47\ 97 + 0.20X$
CF intake	-1.00*	$Y = 82.69 – 0.44X$
EE intake	-0.41NS	$Y = 33.69 – 0.01X$
NFE intake	+0.88*	$Y = 44.0 + 0.07X$

*(P<0.05); NS = Not significant

Table 4: Nutrient digestibility (%) of WAD sheep fed dietary inclusions of *Moringa oleifera* and *Panicum maximum*

Parameters	Treatments					Mean±SEM
	1	2	3	4	5	
DM digestibility	55.74^{c}	70.80^{a}	66.51^{ab}	63.02^{b}	71.57^{a}	65.53±5.79
OM digestibility	49.63^{c}	64.80^{ab}	62.38^{b}	60.24^{b}	70.16^{a}	61.44±6.67
CP digestibility	64.69^{b}	79.64^{a}	77.04^{a}	79.54^{a}	84.96^{a}	77.17±6.76
CF digestibility	70.57^{a}	76.93^{a}	76.14^{a}	72.53^{a}	68.04^{b}	69.08±8.38
EE digestibility	64.33^{b}	74.69^{a}	69.56^{ab}	64.77^{b}	65.98^{ab}	67.87±3.98
NFE digestibility	12.93^{c}	56.03^{b}	49.80^{b}	61.94^{ab}	75.82^{a}	51.30±21.03

$^{a, b, c, d, e}$ Means along the same row with different superscripts are significantly different (P<0.05); SEM = Standard error of the mean

Table 5: Linear correlation and regression analyses between *M. oleifera* inclusions (*X*) and nutrient digestibility (*Y*)

Moringa inclusions vs.	Correlation Coefficient	Regression Equation
DM digestibility	+0.58 NS	$Y = 60.75 + 0.10X$
OM digestibility	+0.76 NS	$Y = 54.14 + 0.15X$
CP digestibility	+0.85 NS	$Y = 69.09 + 0.16X$
CF digestibility	-0.48 NS	$Y = 74.73 – 0.11X$
EE digestibility	-0.24 NS	$Y = 69.19 – 0.03X$
NFE digestibility	+0.89*	$Y = 24.97 + 0.53X$

*Significant (P<0.05); NS = Not significant

Table 6: Nitrogen balance in WAD sheep fed *Moringa oleifera* as replacement for *Panicum maximum*

Parameters	TREATMENTS					Mean±SEM
	1	2	3	4	5	
N intake, g day^{-1}	7.62^{c}	8.59^{bc}	9.47^{b}	9.55^{b}	11.15^{a}	9.28±1.17
Faecal N, g day^{-1}	2.69	1.75	2.18	1.92	1.69	2.05±0.36
N digestion, g day^{-1}	4.93^{c}	6.84^{b}	7.29^{ab}	7.63^{ab}	9.46^{a}	7.23±1.45
Urinary N, g day^{-1}	3.98^{b}	3.85^{b}	5.28^{ab}	6.20^{ab}	8.08^{a}	5.48±1.56
Total N output, g day^{-1}	6.67^{b}	5.60^{b}	7.46^{ab}	8.12^{a}	9.77^{a}	7.52±1.40
N balance, g day^{-1}	0.95^{bc}	2.99^{a}	2.01^{a}	1.43^{c}	1.38^{ab}	1.75±0.70
N retention, % intake	12.50^{ab}	34.85^{a}	21.22^{ab}	14.97^{ab}	12.35^{ab}	19.17±8.47
N retention, % digestion	19.27^{bc}	43.71^{a}	27.57^{b}	18.74^{bc}	14.59^{c}	24.78±10.36

$^{a, b, c, d,}$ Means along the same row with different superscripts are significantly different (P<0.05); SEM = Standard error of the mean

Table 7: Linear correlation and regression analyses between *M. oleifera* inclusions (*X*) and nitrogen balance parameters (*Y*)

Moringa inclusions vs.	Correlation Coefficient	Regression Equation
N intake	+0.97*	$Y = 7.67 + 0.03X$
Faecal N	-0.71 NS	$Y = 2.41 - 0.007X$
N digestion	+0.96*	$Y = 5.26 + 0.04X$
Urinary N	+0.96*	$Y = 3.37 + 0.05X$
N output	+0.89*	$Y = 5.78 + 0.04X$
N balance	-0.27 NS	$Y = 1.89 - 0.007X$
N retention	-0.43 NS	$Y = 23.21 – 0.13X$

*Significant (P<0.05); NS = Not significant

Table 8: Effect of different levels of *Panicum maximum* replacement with *Moringa oleifera* on the haematological indices of WAD sheep

PARAMETER	TREATMENT					MEAN±S.E
	1	2	3	4	5	
RBC count ($\times10^6$ mm^{-3})	7.87	11.29	11.03	8.21	10.06	9.69±1.41
Haemoglobin (g 100ml^{-1})	8.15	10.75	10.43	9.02	8.22	9.31±1.09
PCV (%)	25.33 ^{c}	32.33 ^{a}	31.33 ^{ab}	28.00 ^{bc}	29.83 ^{ab}	29.36±2.49
ESR (mm hr^{-1})	0.67	0.53	0.52	0.60	0.70	0.60±0.07
MCHC (%)	32.22	33.29	33.28	32.17	30.08	32.21±1.17
MCH (pg)	11.93	9.66	10.87	11.22	8.25	10.39±1.30
MCV (µm^3)	36.77 ^{a}	29.11 ^{ab}	32.77 ^{a}	35.07 ^{a}	26.85 ^{b}	32.11±3.68
WBC count ($\times10^3$ mm^{-3})	12.66 ^{a}	5.39 ^{c}	6.93 ^{bc}	8.26 ^{bc}	10.44 ^{ab}	8.73±2.57
Monocytes (%)	8.33	9.00	7.50	8.33	7.83	8.20±0.51
Lymphocytes (%)	56.50 ^{a}	50.33 ^{b}	51.50^{b}	54.83^{a}	55.67^{a}	53.77±2.42
Neutrophils (%)	31.17^{b}	36.83^{a}	37.83^{a}	33.17^{b}	32.67^{b}	34.33±2.55
Eosinophils (%)	2.50	2.67	2.33	2.67	2.67	2.57±0.14
Basophils (%)	1.50	1.17	0.83	1.00	1.00	1.10±0.23

$^{a, b, c,}$ Means along the same row with different superscripts are significantly different (P<0.05); S.E = standard error of the means

Table 9: Linear correlation and regression analyses between *M. oleifera* inclusions (*X*) and haematological parameters (*Y*)

Moringa inclusions vs.	Correlation Coefficient	Regression Equation
RBC count	+0.13NS	$Y = 9.43 + 0.005X$
Haemoglobin	–0.21NS	$Y = 9.63 – 0.006X$
PCV	+0.27 NS	$Y = 28.43 + 0.02X$
ESR	+0.25 NS	$Y = 0.58 + 0.0005X$
MCHC	–0.65NS	$Y = 33.29 – 0.02X$
MCH	–0.63 NS	$Y = 11.55 – 0.02X$
MCV	–0.53 NS	$Y = 34.89 – 0.06X$
WBC count	–0.09 NS	$Y = 9.05 – 0.006X$
Lymphocyte	+0.17 NS	$Y = 53.20 + 0.01X$
Monocyte	–0.46 NS	$Y = 8.53 – 0.007X$
Neutrophils	–0.04 NS	$Y = 34.47 – 0.003X$
Eosinophils	+0.35 NS	$Y = 2.50 + 0.001X$
Basophils	–0.73 NS	$Y = 1.33 – 0.005X$

NS = Not significant

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