Feed additive effect of *Chromolaena odorata* on performance of West African dwarf bucks

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Abstract

Efficient rumen fermentation is necessary for improved feed utilization and animal production. The use of feed additives to improve rumen fermentation is promising. Twenty-four West African Dwarf (WAD) bucks with an average weight of 10 ± 2 kg were randomly allocated on weight equalization to four treatment diets with 0, 2, 4 and 6% *C. odorata* inclusion for a period of three months. Six animals per treatment were used for the study with each animal served as a replicate. Weight changes were taken weekly and digestibility study was carried out. At the end of the study blood samples were also collected for haematological and serum assay. Results showed that the addition of *C. odorata* to the diets influenced ($p < 0.05$) weight gain of experimental goats with goats on diets (4% inclusion) having the highest value (6.20 kg). Nutrient intake, apparent digestibility of nutrients, and nitrogen utilization by WAD goats fed experimental diets were not ($p > 0.05$) affected by dietary inclusion of *C. odorata*. Haematological parameters were not differed ($p > 0.05$) across the dietary treatments. However, serum glucose and aspartate aminotransferase increased ($p < 0.05$) with increase in inclusion of *C. odorata*. It can be concluded that the use of *C. odorata* as an additive at 4% inclusion increased weight gain of goats with normal blood ranges indicating no negative effect of goats' health.

Keywords: *Chromolaena odorata*, performance, blood profile goats

Introduction

Small ruminants, sheep and goats are increasingly becoming a major source of animal protein among the small holder settlement in Nigeria, contributing over 30 % to total meat consumption in the country (Lebbie, 2004). Goats are found in all agro-ecological zones from hyper-arid to super-humid and over the whole range of production systems from intensive smallholder production to very extensive nomadic pastoralism (Payne and Wilson, 1999). With the realization that small ruminants, especially goats are an under-used and poorly understood resource, there is a need for a greater understanding of their role, capabilities and outputs that will contribute to the overall productivity of tropical farming systems.

One of the major concerns of ruminant keepers in the tropics is the strategic provision of feed to meet the nutritional

requirements of the livestock. In the traditional settings, this demand by the animals is presumptuously met through the basal supply of natural pasture grass which are characterized by low yield and nutrients (Babayemi *et al.*, 2006) as they grow on infertile and erosion degraded soils. The use of field waste or leftovers such as maize stover to feed goats when the available forages are senesced has been a promising option as most agricultural wastes can effectively be put into livestock feeding. However, their availability (in terms of quantity and quality) are of major concerns coupled with high fibre content of these agricultural waste. Moreover, it has been demonstrated that tropical plants (*Luecena leucocephala*, *Chromolaena odorata*, *Moringa oleifera*, *Eichhornia crassipes* etc) containing certain phytochemicals are possible source of feed to ruminants in the tropics (Puchala *et al.*, 2005). They are

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available all year round with high nutritional profile, hence, a good option for the scarce and fibrous forage resource and maize residue. *Chromolaena odorata* are of high nutritive profile, it contains phytochemicals and it is fairly high in protein. Due to the ubiquitous nature of this plant, there have been numerous researches into its use for livestock nutrition. However, there has been general apathy towards the use of *Chromolaena odorata* in ruminant nutrition following the reports of its toxicity (Sajise *et al.*, 1974) and the death of some cattle in the Philippines after its ingestion. This was later invalidated by Fadiyimu *et al.* (2005), who fed six species of weed (*Tridax procumbens*, *Chromolaena odorata*, *Aspilia africana*, *Boerhavia diffusa*, *Ageratum conyzoides* and *Sida acuta*) to a group of West African dwarf goats and reported improved acceptability of *Chromolaena odorata*. Additionally, Aro *et al.* (2009) stated that *Chromolaena odorata* can also be used in the diet of ruminants at a limited quantity and if dried to reduce the presence of anti-nutritional factors. Due to the ubiquitous nature of this plant and its rich protein content with the controversies around it, it is imperative to delve into its possible use in ruminant, hence, this study.

Materials and methods

Experimental location

The study was carried out at the Goat Unit of the Institute for Food Security,

Environmental Resource and Agricultural Research (IFSERAR), Federal University of Agriculture, Abeokuta which falls within 7° 10' N and 3° 2' E and altitude 76 m above sea level. It lies in South-Western part of Nigeria with a prevailing tropical climate, a mean annual rainfall of 1,037 mm and average temperature of 34.7 °C.

Collection of *Chromolaena odorata*

Fresh *Chromolaena odorata* leaves were sourced from the College of Animal Science and Livestock production of Federal University of Agriculture, Abeokuta Farm and within the University environment before inflorescence so as to harvest more leaf. The leaves were air dried until crispy and milled to pass through a 1mm sieve and bulked for subsequent analysis and further use.

Animal and management

Twenty (24) WAD goat bucks averaged 10±2kg were used for the experiment. The animals were reared under intensive management system and maintained under a uniform and constant nutritional regimen with concentrate feed at 300g/body weight while maize stover was given *ad libitum*.

Experimental diets

Maize stover was harvested 20cm above ground level and chopped into small sizes. A complete concentrate diet was formulated to contain 17% crude protein (Table 1) and *Chromolaena odorata* leaf meal was included as additive at four (4) levels of 0, 2, 4 and 6%/ 100kg concentrate feed.

Table 1: Gross composition (%) of experimental concentrate diet

Feed Ingredients	%
Maize	16.00
Soybean	6.00
Wheat offal	52.00
Palm kernel cake	24.00
Bone meal	1.00
Salt	1.00
Total	100
Calculated Nutrient	
Crude protein	17.44
Crude fat	4.39
Crude fibre	9.98
Ash	4.79

*Calculated nutrient did not consider *C. odorata*

Experimental design and data collection

The animals were divided into four groups of six animals each, which was randomly assigned one of the experimental concentrate diets containing 0, 2, 4 and 6 % *C. odorata* addition. The animals were fed the experimental diets for a period of 12 weeks.

Digestibility trial

At the 10th through 12th week of the feeding trial, four goats were taken from each treatment to the metabolic cage for digestibility trial. The first seven days of the digestibility trial was for the adaptation of the goats to the metabolic cages and the next seven days was for the collection of faecal and urine samples. The samples were bulked together and 10% aliquot was collected. The bottles for urine collection were rinsed with 10% sulphuric acid to prevent ammonia volatilization. The quantity of nitrogen retained by the goats was also studied.

Data collection

Chemical analysis

Samples taken from the concentrate diet and *Chromolaena odorata* leaf meal were used for proximate analysis following standard procedure of AOAC (2005) and fibre fraction according to the method of Van Soest *et al.* (1991). Samples taken from the diets were after the inclusion of the test ingredient

Weight change determination

Weight change = final weight – initial weight

Feed Conversion Ratio

Feed conversion ratio = feed intake /weight gain

Blood sample collection and analysis

Blood samples (10 mL) were collected at end of the experiments via jugular vein punctured with new hypodermic needle fitted on a new 10ml calibrated syringe in the morning before feeding and transported in EDTA bottles for heamatological assays and plain bottles for serum studies and then taken to the Veterinary Physiology and

Pharmacology Laboratory, Federal University of Agriculture, Abeokuta for analysis. Haematological parameters such as white blood cell (WBC), lymphocyte, monocyte, neutrophils, eosinophil, basophils, red blood cell (RBC), haemoglobin, pack cell volume, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration were determined.

Serum parameters analysed were; blood glucose, serum total protein, serum albumin, serum globulin, alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP). Total protein was determined spectrophotometrically according to the method of Tietz (1995), serum albumin was measured spectrophotometrically according to the method of Donmas *et al.* (1971) while serum globulin was determined by deducting serum albumin values from total protein values. Serum glucose was assayed with the aid of a photospectrometer according to the method of Barham and Trinder (1972). ALT, AST and ALP were determined following the procedure described by Randox (2012).

Phytochemical screening

The phytochemical screening of *Chromolaena odorata* leaf meal for tannin, saponnin, flavonoids, alkaloids and phytates was carried out using the method described by Sofowora (2008).

Statistical analysis

Data collected during the experimental period were subjected to one-way analysis of variance (ANOVA) in a Completely Randomised Design using SAS (1999) and the means separated using Duncan Multiple Range Test of the same software at 5% level of significance. The model for the experiment is given below;

$$Y_{ijk} = \mu + T_j + \epsilon_{ij}$$

Where, Y_{ijk} individual observation

μ = population mean

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Tj the effect of *Chromolaena odorata*

Σij random residual error

Results

Chemical properties of C. odorata

The chemical properties of *C. odorata* are presented in Table 2. The values for chemical composition were dry matter (DM) 96.90%, crude protein (CP) 17.51%, crude fibre (CF) 20.43%, ether extract (EE)

1.39%, ash 8.52%, nitrogen free extract (NFE) 52.16%, organic matter (OM) 91.48%, neutral detergent fibre (NDF) 62.65%, acid detergent fibre (ADF) 37.77%, acid detergent lignin (ADL) 10.72%, hemicellulose 24.88% and cellulose 27.05%. For the phytochemicals investigated, the values obtained were saponin 1.99%, tannin 2.57%, flavonoid 1.08% and alkaloid 1.26%. All parameters were on dry matter basis.

Table 2: Chemical composition of *Chromolaena odorata* (%DM)

Parameters	(%)
Dry Matter	96.9
Crude Protein	17.5
Crude Fibre	20.4
Ether Extract	1.39
Ash	8.52
Nitrogen Free Extract	52.2
Organic Matter	91.5
Neutral Detergent Fibre	62.7
Acid Detergent Fibre	37.8
Acid Detergent Lignin	10.7
Hemicellulose	24.9
Cellulose	27.1
Saponin	1.99
Tannin	2.57
Flavonoid	1.08
Alkaloid	1.26
Phytate	1.33

Chemical composition of experimental concentrate diet and maize stover

The chemical composition of the experimental diets is presented in Table 3. The four experimental diets varied ($P<0.05$) in all the proximate parameters and fibre fractions. Diet containing 0% inclusion of *Chromolaena odorata* had the highest ($P<0.05$) dry matter (DM) content (93.32%) while the lowest (92.05%) was obtained in the diet with 6% *C. odorata* inclusion. The highest ($P<0.05$) crude protein (CP) value (14.97%) was observed in the diet with 6% *C. odorata* inclusion while the lowest (13.35%) was recorded in the diet with 0% *C. odorata* inclusion. The highest ($P<0.05$) values (5.00% and 9.44%) for ash and ether extract (EE), respectively, were observed in the diets with 4% *C.*

odorata and 6% *C. odorata* inclusion while the least values 3.85 and 8.13% were recorded for EE and ash in diets with 2% and 0% *C. odorata* inclusion for ash and ether extract respectively. For crude fibre, there was difference ($P<0.05$) in the percentage, values ranged from 6.21%-6.52% with increase in *C. odorata* inclusion. The values for NFE and OM decreased significantly progressively ($P<0.05$) from 61.00% to 56.73% and 91.87% to 90.56% from 0% to 6% *C. odorata* inclusion, respectively. There were significant differences ($P<0.05$) in the means for NDF and Hemicellulose. Values ranged from 58.14% - 66.14% for NDF and 18.57% - 33.38% for hemicellulose. The values decreased from 0% to 6% level of *C. odorata* inclusion. ADF and cellulose

increased significantly ($P>0.05$), their values ranged from 32.23% - 31.69% for ADF and 28.40% - 35.23% for cellulose. The highest ($P<0.05$) value (4.38%) for ADL was recorded in the diet with 6% *C. odorata* inclusion while the lowest value (3.58%) was recorded in the diet with 4% *C.*

odorata inclusion. The proximate composition of maize stover determined in this study was; DM 92.95%, CP 4.38%, CF 30.80%, EE 0.70%, ash 10.02%, NFE 54.21%, OM 89.99%, NDF 79.61%, ADF 19.95%, ADL 5.53%, hemicellulose 59.66% and cellulose 14.42%.

Table 3: Nutritional composition of experimental concentrate diet and maize stover fed to West African dwarf bucks

Parameters (%)	M S	Treatment diets				SEM	P-value
		T ₁	T ₂	T ₃	T ₄		
Dry matter	93.0	93.3 ^a	93.0 ^b	93.0 ^b	92.1 ^c	0.10	0.01
Crude protein	4.28	13.6 ^d	14.0 ^c	14.1 ^b	15.0 ^a	0.13	0.01
Crude fibre	30.8	6.21 ^b	6.30 ^b	6.45 ^a	6.52 ^a	0.03	0.05
Ether extract	0.70	4.63 ^b	3.85 ^d	5.00 ^a	4.39 ^c	0.10	0.01
Ash	10.0	8.13 ^d	9.13 ^c	9.30 ^b	9.44 ^a	0.12	0.01
Nitrogen free extract	54.2	61.0 ^a	59.5 ^b	57.8 ^c	56.7 ^d	0.33	0.01
Organic matter	90.0	91.9 ^a	90.9 ^b	90.7 ^b	90.6 ^c	0.12	0.01
Neutral detergent fibre	76.6	66.1 ^a	62.5 ^b	59.2 ^c	58.1 ^d	0.72	0.01
Acid detergent fibre	18.0	32.7 ^a	35.6 ^b	38.8 ^c	39.6 ^d	0.62	0.01
Acid detergent lignin	5.53	4.36 ^a	3.66 ^b	3.58 ^c	4.38 ^a	0.86	0.01
Hemicelluloses	59.7	33.4 ^a	26.9 ^b	20.4 ^c	18.5 ^d	1.34	0.01
Cellulose	14.4	28.4 ^c	32.0 ^b	35.2 ^a	35.2 ^a	0.65	0.01
*ME (MJ/Kg DM)	14.1	14.1 ^a	13.7 ^c	14.0 ^b	13.7 ^c	0.04	0.01

^{abcd} Means on the same row having different superscripts are significantly different ($p<0.05$)

* Calculated using MAFF 1984 equation; M.S: Maize stover. T₁: 0% *C. odorata*, T₂: 2% *C. odorata*, T₃: 4% *C. odorata*, T₄: 6% *C. odorata*

Performance characteristics of West African dwarf bucks fed *C. odorata* as additive

Table 4 shows the performance characteristics of WAD bucks fed diets with increasing levels of *Chromolaena odorata* leaf meal additive. The initial weight, final weight, daily concentrate intake, daily maize stover intake, total feed intake and feed conversion ratio were not significantly ($p>0.05$) different across the dietary treatments. However, parameters such as weight gain (kg) and daily weight gain (g) were significantly ($p<0.05$) differed. The highest value (6.20kg) for weight gain was observed in the treatment with 4% *C. odorata* inclusion while the least value (4.50kg) was observed in the diet with 6% *C. odorata* inclusion. Likewise, the highest ($p>0.05$) value (73.81g) for daily weight gain was recorded in the treatment with 4% *C. odorata* inclusion with the lowest value

(53.87g) was observed in the diet with 6% *C. odorata* inclusion.

Apparent nutrient digestibility of West African dwarf bucks fed diet with *Chromolaena odorata* leaf meal additive

Table 5 shows the apparent nutrient digestibility of WAD bucks fed diets with *C. odorata* additive. Increasing levels of *C. odorata* had no effect on DM, CP, EE, CF, ash, NFE and OM digestibility.

Nitrogen utilization of West African dwarf bucks fed *Chromolaena odorata* leaf meal as additive

The result for nitrogen utilization of WAD bucks fed diet with *C. odorata* additive is shown in Table 6. The values for nitrogen intake from concentrate and maize stover, total nitrogen intake, faecal and urinary nitrogen, total nitrogen excreted, nitrogen absorbed and nitrogen retention were similar ($p>0.05$) across the dietary treatments.

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Table 4: Effect of *Chromolaena odorata* additive on growth performance characteristics of West African dwarf bucks

Parameters	Treatment Diets				SEM	P-value
	T ₁	T ₂	T ₃	T ₄		
Initial weight (kg)	10.0	10.0	9.90	10.0	1.00	0.62
Final weight (kg)	14.8	15.1	16.1	14.5	0.53	0.76
Weight gain (kg)	4.80 ^b	5.00 ^{ab}	6.20 ^a	4.50 ^b	0.24	0.05
Daily weight gain (gday ⁻¹)	57.1 ^b	59.5 ^{ab}	73.8 ^a	53.6 ^b	2.86	0.05
Concentrate intake (gday ⁻¹)	348	334	346	330	13.9	0.97
Maize intake (gday ⁻¹)	188	188	212	193	17.9	0.97
Total feed intake (gday ⁻¹)	535	522	558	523	30.6	0.98
Feed conversion ratio	9.37	8.77	7.56	9.76	0.74	0.80

^{ab} Means on the same row having different superscripts are significantly different (p<0.05)

T₁: 0% *C. odorata*, T₂: 2% *C. odorata*, T₃: 4% *C. odorata*, T₄: 6% *C. odorata*

Table 5: Effect of *Chromolaena odorata* addition on apparent nutrient digestibility of West African dwarf bucks

Parameters (%)	Treatment Diets				SEM	P-value
	T ₁	T ₂	T ₃	T ₄		
Dry matter	74.9	73.7	73.9	72.9	2.39	0.99
Crude protein	83.7	83.6	84.1	83.4	0.98	0.52
Ether extract	90.8	88.8	89.7	88.2	0.75	0.86
Ash	89.6	10.0	89.1	91.3	0.68	0.92
Nitrogen free extract	70.5	68.9	71.2	68.7	1.74	0.95
Organic matter	66.6	63.7	65.8	63.3	3.21	0.98
Crude fibre	84.3	83.5	83.4	79.9	1.92	0.88

T₁: 0% *C. odorata*, T₂: 2% *C. odorata*, T₃: 4% *C. odorata*, T₄: 6% *C. odorata*

Table 6: Effect of *C. odorata* addition on nitrogen utilization of West African Dwarf bucks

Parameters (%)	Treatment Diets				SEM	P-value
	T ₁	T ₂	T ₃	T ₄		
<i>Nitrogen Intake (g/day)</i>						
Concentrate	7.43	7.46	7.82	7.90	0.31	0.94
Maize stover	1.28	1.28	1.45	1.32	0.12	0.94
Total nitrogen intake (g/day)	8.71	8.74	9.27	9.22	0.42	0.95
<i>Nitrogen excretion (g/day)</i>						
Faecal nitrogen	1.30	1.02	1.35	1.40	0.02	0.48
Urinary nitrogen	0.23	0.26	0.25	0.23	0.01	1.00
Total nitrogen excreted (g/day)	1.53	1.28	1.60	1.63	0.02	0.80
Nitrogen absorbed (g/day)	7.41	7.72	7.92	7.82	0.43	0.97
Nitrogen balance (g/day)	7.18	7.46	7.67	7.59	0.44	0.97
Nitrogen retention %	82.4	82.3	82.7	82.3	0.62	0.99

T₁: 0% *C. odorata*, T₂: 2% *C. odorata*, T₃: 4% *C. odorata*, T₄: 6% *C. odorata*

Blood parameters of West African dwarf bucks fed *C. odorata* as additive

Table 7 shows the blood parameters at the culmination of the experiment of WAD bucks fed *C. odorata* as additive. Glucose and AST were influenced (p<0.05) by incremental levels of *C. odorata*. Bucks that received 6% *C. odorata* addition had the highest glucose value (99.00%) while the lowest value (68.00%) was obtained from bucks fed 4% *C. odorata* additive. The

values for AST increased (p>0.05) with increase in *C. odorata* inclusion. The values ranged from 59.67% for bucks on 0% *C. odorata* inclusion to 75.33% for bucks on 6% *C. odorata* inclusion. Other parameters such as red blood cell, white blood cell, haemoglobin, packed cell volume, lymphocyte, eosinophil, basophil, monocyte, neutrophil, total protein, albumin, globulin, ALT and ALP were comparable (p>0.05) across the dietary treatments.

Table 7: Effect of *C. odorata* additive on blood parameters of West African dwarf bucks

Parameters	NV	Treatment Diets				SEM	P-value
		T ₁	T ₂	T ₃	T ₄		
Packed cell volume (%)	22-38	31.00	29.33	29.33	29.00	0.99	0.92
White blood cell (x10 ⁹ /L)	5-12	5.00	5.23	5.77	5.83	0.20	0.92
Red blood cell (x10 ¹² /L)	8-18	9.43	9.97	9.97	10.01	0.18	0.64
Haemoglobin (g/dL)	8-12	8.83	9.27	9.67	9.80	0.38	0.85
Lymphocyte (%)	50-70	68.0	68.3	68.0	71.0	0.90	0.65
Eosinophil (%)	1-8	0.33	0.33	1.00	1.33	0.25	0.44
Basophil (%)	0-1	0.67	1.00	1.33	0.67	0.19	0.63
Neutrophil (%)	25-48	29.0	29.3	27.3	25.0	1.06	0.51
Monocyte (%)	0-4.0	1.67	1.00	2.33	2.00	0.33	0.59
Total protein (g/dL)	6.4-7.0	6.27	6.50	6.80	6.53	0.11	0.44
Albumin (g/dL)	2.7-3.9	3.27	3.07	3.63	3.70	0.13	0.31
Globulin (g/dL)	2.7-5.7	3.00	3.43	3.17	2.83	0.10	0.18
Glucose (mg/dL)	60-100	90.3 ^a	75.3 ^b	68.0 ^{bc}	99.0 ^{ab}	4.37	0.02
AST (u/l)	60-167	59.7 ^b	60.0 ^b	65.3 ^{ab}	75.3 ^a	2.60	0.01
ALT (u/l)	15-52	20.3	33.7	23.3	25.3	2.34	0.22
ALP (u/l)	93-287	42.7	46.3	37.3	48.3	2.17	0.32

^{abc} Means on the same row having different superscripts are significantly different (p<0.05)

T₁: 0% *C. odorata*, T₂: 2% *C. odorata*, T₃: 4% *C. odorata*, T₄: 6% *C. odorata*, ALT: Alanine aminotransferase,

AST: Aspartate aminotransferase, ALP: Alkaline phosphatase, NV: Normal values. Normal values were according to Veterinary manual (2016).

Discussion

The percentage dry matter recorded for (Siam weed) *C. odorata* leaf meal in this study was slightly higher than that reported by Aro *et al.* (2009); Ekeyem *et al.* (2010); Kawed (2016) who recorded values of 87.40%, 91.44% and 90.49%, respectively. This disparity in dry matter percentages may be due to the varying growth stages of the leaf, seasonal variations in the study areas as influenced by weather condition. Flowering and matured plants tend to have less moisture and more fibre compared to emerging plants, dry matter percentage is always higher during the dry season compared to the rainy season. The crude protein values of *C. odorata* leaf meal in the present study was similar to those reported by Igboh *et al.* (2009) which was 16.17%, Aro *et al.* (2009) with 18.67% and Ekeyem *et al.* (2010) who reported 16.67% CP. The value of saponins and tannins in *C. odorata* in this study was lower than that reported by Agaba and Fawole (2016) which were 3.48% and 4.10%, respectively. However, the value of tannin was higher and that of

saponins similar to the report of Igboh *et al.* (2009) which were 0.37% and 1.98%, respectively. The percentage of flavonoid and alkaloid were higher than that reported by Agaba and Fawole (2010) and the value of phytate was also higher than the report of Igboh *et al.* (2009) which were 0.77%, 1.55% and 0.54% for flavonoid, alkaloid and phytate, respectively. These slight variations can be attributed to agronomic factor such as stage of maturity of leaf at harvest while the presence of tannin, alkaloid and flavonoid may influence the performance of the experimental animals. The dry matter percentage of maize stover in this study is similar to the reports of Biwi (1986), Tolera and Sundstol (1999), Fabian (2011) who had 93.40%, 92.50% and 93.50% DM, respectively. However, Fabian (2011) reported a higher crude protein (CP) percentage of 5.60% compared to that reported in this study. Tolera and Sundstol (1999) had a similar CP percentage of 4.8% to the one reported in this study. The CP of experimental diets was above 80 g/kg DM¹, the reported

minimum required in diet for adequate digestive activities of rumen microbes (Orskov 1982). The high CP content in the experimental diet is an advantage to rumen microbes that depend on dietary source of nitrogen to build up their body proteins. The increase in crude protein and ash contents of diets with *C. odorata* leaf additive justifies the possible feeding value of the leaf as protein and minerals supplement to feeds with lower level of protein and minerals. Goats fed diet supplemented with 4% *C. odorata* leaf meal were most superior in terms of performance characteristics. The improved performance characteristics could be attributed to the high CP percentage of the diet, higher feed intake, higher CP intake and higher CP digestibility compared to other treatments. This suggest that *C. odorata* is a good protein source as it improved feed intake, CP digestibility and CP intake up to 4% level of inclusion. This result is supported by the observations of Apori *et al.* (2000) and Kawed (2016) who experimented on WAD and small East African (SEA) goats, respectively, and reported positive performance characteristics of goats fed *C. odorata* supplemented diets. The similar DM, CP, EE, CF, ash and NFE digestibility reported in this study is in line with the reports of Apori (2000) and Kawed (2012) who documented similar DM, CP, EE, CF, ash and NFE digestibility for rabbits and goats fed *C. odorata* supplemented diets, respectively. Silvong (2012) also observe comparable effect on nutrient digestibility of goats fed mulberry supplemented diets. Also, Park *et al.* (2014) did not observe any effect of *Forsythia suspense* supplementation on nutrient digestibility of native Korean goats. This is an indication that *C. odorata* inclusion in the concentrate ration of WAD bucks does not have any negative effect on nutrient digestibility and utilization. On the other hand, high fiber and lignin contents have been reported to

decrease nutrient digestibility (Mekasha *et al.*, 2002). In this study however, the fibre levels of the diets were not high (6.21 – 6.52%) of fibre reported by Mekasha *et al.* (2002), which is another plausible reason for the non-significance observed in apparent nutrient digestibility. The report of Park *et al.* (2014) who did not observe any effect of *Forsythia suspense* supplementation on nitrogen utilization of native Korean goats is in accordance with the observation of the current study. *C. odorata* containing saponins did not affect nitrogen retention in this study, indicating that *C. odorata* does not have the ability to alter nitrogen metabolism in the rumen at 2, 4 and 6% levels of inclusion. According to Ahamefule *et al.* (2005) packed cell volume (PCV) is an index of toxicity and its range varies with breeds. In the present study, PCV values were within the physiological range of 22 – 38% reported by Krammer (2000) for goats. Aikhuomobhogbe and Orheruata (2006) opined that low PCV results in anaemia, which is associated to reduced oxygen carrying capacity of the blood. The normal PCV values observed in this study is an indication that the treatment diets were nourishing, non-toxic and influenced adequate blood production and supply. The red blood cell (RBC) and white blood cell value (WBC) values were similarly within the normal range for WAD goats reported by Daramola *et al.* (2005). The RBC values in this study suggests that the diets support good health status of the goats. High WBC count is usually associated with microbial infection or the presence of foreign body or antigen in the circulating medium (Ahamefule *et al.*, 2005). In relation to this study, similar results were reported for haematology of indigenous Pedit goats fed *Vachellia karroo* leaf meal supplemented diets (Brown *et al.*, 2006). Serum values such as total protein, albumin, globulin, Alanine aminotransferase (ALT) and alkaline phosphatase (ALP) were within normal

range for goats reported by (Merck manual 2016). However, aspartate aminotransferase (AST) though within the normal range reported in Merck manual (2016) for goats increased with increasing level of *C. odorata* inclusion. This could be a pointer that *C. odorata* could be toxic to the liver of goats at higher inclusion levels (than those employed in this study) and longer duration of feeding.

Conclusion

The study showed that addition of 4% *C. odorata* had the best performance in terms of weight gain and daily weight gain with a similar apparent nutrient digestibility and nitrogen utilization and normal health status in terms of the similar haematological indices. Inclusion of 4% *C. odorata* to the bucks' diets will improve their immune response as reflected in highest serum protein and albumin values.

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