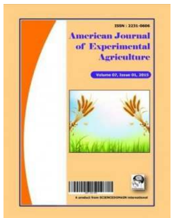

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Performance, Nutrient Intake and Digestibility of Uda Sheep with Graded Levels of *Xylopia aethiopica* (Ethiopian pepper)

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Authors' contributions

This work was carried out in collaboration between all authors. Author NM designed the study, wrote the protocol, analyse the data, provided PG training for author IM and finalized the manuscript. Author IM managed the experimental process and wrote the first draft of the manuscript. Author SAM critiqued the manuscript. Authors SB and KMA managed the literature searches and reviewed the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The effect of *Xylopia aethiopica* (Kimba) fruit on growth performance, nutrient intake and digestibility of Uda rams was investigated using 20 yearling Uda rams in eighty four days (feeding) and fourteen days (digestibility) trials.
Methodology: The animals were fed diets containing 0%, 2.5%, 5.0% and 7.5% (0, 2.5, 5.0 and 7.5 g/kg respectively) supplemented levels of *Xylopia aethiopica* fruit in a completely randomized experimental design replicated five times. Data were subjected to analysis of variance (ANOVA), where significant difference exist least significant differences (LSD) was used to separate the means
Results: Results indicated no significant difference in all the performance parameters (p=.05) except in feed intake as % body weight (which is significantly higher (p<0.01) for animals fed 5.0% *Xylopia aethiopica* per 100 kg diet). Total saponins intake, total tannin intake, saponins intake

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(kg/day) and tannins intake (kg/day) were significant across the treatments (p<0.01). Results showed no significant difference in all nutrients intake (p=.05) except ether extract and ash (p<0.01) with higher values for animals fed diets containing 7.5% *Xylopia aethiopica*. The digestibility of all nutrients except ether extract were significantly higher for animals fed diets containing 0 and 2.5% levels of *Xylopia aethiopica.*

Conclusion: It was concluded that increasing the level of *Xylopia aethiopica* in the diets of Uda rams more than 2.5% (2.5 g/kg) might significantly reduce performance.

Keywords: Performance; nutrient intake; digestibility; Uda sheep; Xylopia aethiopica; Ethiopian pepper.

1. INTRODUCTION

In an attempt to improve animal performance in an intensive system of animal production, farmers use to feed their animals with ration rich in starch and high quality protein, which are fermented rapidly. It is well known that the rapid degradation of starch leads to ruminal acidosis. The rapid breakdown of dietary protein to ammonia increase nitrogenous excretion rather than contributing directly to the animal's nutrient requirements. In order to delay ruminal protein degradation, dietary proteins were denatured by treatment with formaldehyde or controversially antibiotics were used to suppress the bacterial population responsible for the rapid protein fermentation. But the use of such compounds has been criticized, as they may leave harmful residues in the food chain and promote the spreading of resistance genes [1].

Recently, several researchers have used some plant extracts to manipulate rumen fermentation [2-4]. But obtaining these extracts from plants will be costly as the extraction process will require expensive instruments and the farmers from developing countries will not be able to afford such technology. Besides, only a small quantity of these plants will be available as extracts and the rest of such plants will be unused and wasted. Furthermore, the whole spices may contain some other useful components that can differ from their small amounts of extracts and these also can have more desirable impacts on degradability and fermentation.

The demand for animal protein is increasing as a result of increased human population and economic growth [5]. The challenge in the millennium is to sustain the livestock industry amidst shortage so as to boost animal protein intake worldwide. There has been a growing trend in developing countries to exploit natural bioactive extract or products of plant origin as an alternative to chemical feed supplements.

Feed supplementation with spices such as *Xylopia aethiopica* (Ethiopia pepper, Negro pepper, West African pepper) [6] (with growth promoting activity increase stability of feed and beneficially influence gastrointestinal ecosystem mostly through growth inhibition of pathogenic microorganism, thus consequently helps to increase the animal's resistance to stress and increase the absorption of essential nutrients [7].

Furthermore, the inclusion of *Xylopia aethiopica* fruits might represent safe and low cost alternatives to synthetic compounds such as antioxidant, antibiotics and other growth promoters use to improved animal performance, more especially by small holder farmers. Despite the potentials, there is little information on the utilization of the plant in ruminant nutrition. The study evaluated the effect of *xylopia aethiopica* on growth performance, nutrient intake and digestibility of Uda rams.

2. MATERIALS AND METHODS

2.1 Location of Experiment

The experiment was conducted at the Livestock Teaching and Research Farm of the Department of Animal science, Faculty of Agriculture, located at the main campus of the Usmanu Danfodiyo University Sokoto. Sokoto state is located in the north-western part of Nigeria between longitude 4°8' and 6°54'E and latitudes 12°0'N and 13°58'N and at altitude of 350 m above sea level [8]. The state has a semi-arid climate which is characterized with low rainfall ranging from 500-1300mm with seasonal variation. Heat is more severe in the state in March and April, but the weather in the state is always cold in the morning and hot in the afternoon except during the harmattan period [9]. The minimum temperature of 13°C has been recorded in January and maximum of 44°C in April [10]. The low humidity of the state makes the heat bearable. Sokoto has two main seasons, the dry, season which starts from October and last up to April, in some part and may extend to May or June in other part. And the wet season begins in most part of the state in May and last up to September or October [9]. Sokoto state has abundant of livestock resources, because the climate is more suitable for livestock production, due to the absence of tsetse - fly on the open grassland. There are numerous species of animals in both wild and domesticated forms in the state. Sokoto ranks second in livestock production in the country with livestock population of over 8 million [10].

2.2 Experimental Feed Sourcing, Preparation and Diet Formulation

The *Xylopia aethiopica* fruit was purchased from Sokoto central market together with other feed ingredients which included maize, cowpea husk, cotton seed cake, rice bran, cowpea hay, salt, bone meal and premix. The *Xylopia aethiopica* was properly sorted from any possible debris or foreign matter, sun dried and ground by grinding machine. One experimental diet was formulated with the following ingredients maize (38.65%), cowpea husk (15.70%), cotton seed cake (14.70%), Rice bran (0.95%), Cowpea hay (26.50%), Salt (0.50%), Bone meal (2.50%) and Premix (0.50%). The Ethiopian pepper was added at the rate of 0, 2.5, 5.0, and 7.5 kg/100 kg diet for died 1, 2, 3 and 4 respectively. The experimental design is a completely randomized design (CRD). The gross compositions of the experimental diets are shown in Table 1.

2.3 Experimental Animals and their Management

Twenty (20) Uda rams (yearlings) with an average live weight of 35 kg was purchased from village markets around Sokoto and used in the experiment. The animals were quarantined in the teaching and research farm of the Usmanu Danfodiyo University. Treated against ecto and endo parasites with ivemectin (1 ml per 10 kg live body weight) and treated with oxytetracycline Hcl (a broad spectrum antibiotic) at dosage rate of 2 ml/10 kg live weight against possible bacterial infection. Faeces and urine of the animals were removed every day from the feeding pens to ensure adequate hygiene and minimal ammonia accumulation. Feed and water troughs were cleaned every morning before feeding. Before the commencement of the experiment, the animals were managed intensively and group fed with cowpea hay and wheat offal.

2.4 Feeding Procedure

Four animals were allocated as treatment in the feeding trials. Each animal is housed in a pen measuring 2 m×1 m, each group was assigned to one of the experimental diets and fed *ad libitum* in the morning and evening for 12 weeks (84 days). Water and salt lick was offered *ad libitum*.

Table 1. Composition of the experimental diets

Ingredients	**Treatments (inclusion levels of *Xylopia aethiopica)* (%)(g/kg)**			
	1 (0)	**2 (2.5)**	**3 (5.0)**	**4 (7.5)**
Maize	38.65	38.65	38.65	38.65
Cowpea husk	15.70	15.70	15.70	15.70
Cotton seed cake	14.70	14.70	14.70	14.70
Rice bran	0.95	0.95	0.95	0.95
Cowpea hay	26.50	26.50	26.50	26.50
Salt	0.50	0.50	0.50	0.50
Bone meal	2.50	2.50	2.50	2.50
Premix	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Calculated values:				
Calculated energy (ME/Kg)	2600	2600	2600	2600
Calculated protein (%)	12.00	12.00	12.00	12.00
Calculated fiber (%)	19.80	19.80	19.80	19.80
Added level of *Xylopia aethiopica*:	0%	2.5%	5.0%	7.5%

2.5 Data Collection

The animals are weighed at the beginning of the experiment and subsequently every week on the same day of the week between 8:00-9:00 am after withdrawing feed for 14-16 hours to avoid error due to gut-fill. Daily record of feed intake and weekly body weight was taken throughout the 12 weeks of the feeding trial.

2.6 Proximate and Fibre Analysis of the Experimental Diet and the Test Ingredient

Thoroughly mixed representative sample of the experimental diet and test ingredient was analyzed for proximate composition according to A.O.A.C procedure [11] to determine the moisture content, crude protein (CP), crude fibre (CF), ether extract (EE) and Ash, while fibre fraction was analyze according to procedure described [12].

2.7 Phytochemical Analysis of *Xylopia aethiopica*

Grounded sample of *Xylopia aethiopica* fruits was used to determine the total phenolic by method described by [13], Saponins by the spectrophometric method of Brunner as described by [13] and alkaloids by gravimetric method of Harbone [14]. Tannins was determined by the method of Maga as described by [14]) and phytate by Lucus and Markakas method as described by [15].

2.8 Digestibility Trial

At the end of feeding trial, digestibility trial was conducted using three animals from each treatment. The animals are fed the same experimental diets used in the feeding trial. The trial lasted for 14 days with 7 days for adaptation to harness bag and 7 days for faecal samples collection. Total faecal output from each animal was recorded daily and 5% of it was oven- dried at 80℃ for dry matter determination and then stored for subsequent analysis.

2.9 Statistical Analysis

The data generated from the experiment are subjected to analysis of variance (ANOVA) using completely randomized design using stat view statistical package [16]. Where significance difference exists Least Significant Difference (LSD) was used to separate the means.

3. RESULTS AND DISCUSSION

3.1 Proximate and Fibre Components of the Experimental Diet and Test Ingredient (*Xylopia aethiopica*)

Proximate composition of the experimental diet contained 94.8% DM, 12% CP, 15.8% CF, 3% EE and 53% NFE.NFE and EE content of *Xylopia aethiopica* were higher than in the formulated diet (Table 6) while DM, CP and Ash were higher in the test ingredient. Neutral detergent fibre (NDF) was observed to be higher in the fibre fraction followed by Hemi cellulose, Acid detergent fibre (ADF), Cellulose and Lignin in that order (Table 2).

The crude protein content of the diet obtained in this study is above 8% required to satisfy requirement of ruminant animal [17] necessary to provide minimum ammonia level required by rumen microorganisms to support optimum activity [18,19]. The crude fibre content obtained in this study is within the range of 15-20% recommended for improved intake and production in finishing ruminants [20]. The ether extract content of the diet is below the recommended range of 4-10% as reported by [21,22]. Nitrogen free extract obtained in this study is higher than 20.34% obtained by [23]. The fibre fraction (ADF, NDF, cellulose and hemicellulose) obtained are higher in diets that may affect DM intake as reported by [24].

The crude protein content of *Xylopia aethiopica* obtained in the present study is higher than 2.10% obtained by [25] but similar to 11.90% obtained by [26]. The lipid content of *Xylopia aethiopica* is lower than 14.51% obtained by [26] while ash content is higher than 2.31% and 4.37 obtained by [27,25] respectively. The crude fibre content of *Xylopia aethiopica* obtained in the present study is lower than 14.5%, 12.14% and 38.60% as obtained by [26,24,25] respectively. The nitrogen free extract of *Xylopia aethipica* obtained is comparable to 63.41% obtained by [27] but higher than 30.18% obtained by [26]. This variation could be attributed to soil and climatic conditions, plant nutrient status and varieties as observed by [28].

3.2 Phytochemical Components of *Xylopia aethiopica*

Qualitative analysis of the test ingredient indicated presence of steroids, volatile oils and antraquinones. There was moderate presence of

Table 2. Proximate and fibre components of the experimental diet and *Xylopia aethiopica*

Parameters	Experimental diet	*Xylopia aethiopica*
Proximate composition		
Dry matter (DM) (%)	94.79	93.83
Crude protein (CP) (%)	12.12	10.59
Crude fibre (CF) (%)	15.77	3.33
Ether extract (EE) (%)	3.00	12.17
Nitrogen free extract (NFE) (%)	53.00	63.08
Ash (%)	11.11	3.83
Fibre components		
NDF	65.77	
ADF	18.78	
Cellulose	18.42	
Hemicellulose	46.99	
Lignin	0.9	

ADF- Acid detergent fibre, NDF- Neutral detergent fibre

alkaloids and tannins. Adequate presence of saponins was found in the fruits of *Xylopia aethiopica*. However, quantitative analysis indicated a higher presence of Saponins and Tannins compared to other phytochemicals (Table 3).

Table 3. Quantitative and qualitative phyto-chemical composition of *Xylopia aethiopica*

Parameter	Inference
Tannnins	++
Saponins	+++
Alkaloids	++
Glycosides	+
Cardiac glycoside	-
Saponin glycoside	+
Steroids	+
Volatile oils	+
Antraquinone	+
Balsam	+
Alkaloids	1.29%
Saponins	3.45%
Tannins	2.33%

Key: + (present), ++ (moderately present), +++ (adequately present) and – (absent)

The quantitative value of saponin obtained in this study is higher than 2.93% obtained by [27]. The tannin content also falls below 4.96% obtained by [27] but above 0.24% obtained by [25]. Alkaloids values obtained in the present study is similar to 1.24% reported by [27]. These variations may be due to genetic factors, climatic condition, soil and cultivation techniques [29,30,31,32].

3.3 Performance Characteristics of Uda Ram Fed Graded Levels of *Xylopia aethiopica*

The Results (Table 4) indicated no significant difference in initial weight, final weight, feed intake, live weight gain, average daily gain and feed conversion ratio (p=.05). There was no significant difference between treatments 1, 2 and 4 in feed intake as % body weight (p=.05). Feed intake as % body weight was significantly higher (p<0.01) for animals fed diet containing 5.0% *Xylopia aethiopica*. There is high significant difference in STSI, STTI, SSI and STI between all the treatments (p<0.01).

The relationship between average daily gain and saponins intake showed decreased weight gain (g/day) with increased saponin intake (g/day) (Fig. 1). The same observation was also made for tannin intake (Fig. 2).

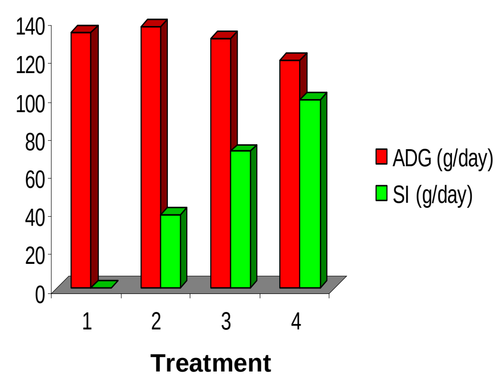

Fig. 1. Average daily gain of Uda rams in relation to saponins intake

Table 4. Performance characteristics of Uda rams fed graded levels of *Xylopia aethiopica*

Parameters	Treatments (inclusion of *Xylopia aethiopica*) (%) (g/kg)				SEM
	1 (0)	2 (2.5)	3 (5.0)	4 (7.5)	
Initial weight (kg)	35.50	35.88	35.67	35.75	4.88
Final weight (kg)	46.50	47.75	44.33	47.50	5.52
Weight gain (kg)	11.25	11.50	11.00	10.00	1.88
ADG (g/day)	133.93	136.91	130.95	119.05	22.36
STSI (Kg)	0.00^{d}	8.92^{c}	16.87^{b}	27.05^{a}	1.45
STTI (Kg)	0.00^{d}	6.03^{c}	11.39^{b}	18.28^{a}	0.98
SSI (kg/day)	0.00^{d}	0.13^{c}	0.24^{b}	0.39^{a}	0.02
STI (kg/day)	0.00^{d}	0.09^{c}	0.16^{b}	0.26^{a}	0.01
FCR	8.16	9.03	9.35	9.49	0.45
Feed intake as % body weight	3.79^{b}	3.67^{b}	3.61^{b}	4.54^{a}	0.23
Average feed intake (kg/day)	1.43	1.48	1.39	1.49	0.17

a, b, c means values with different superscripts in a row denotes significant (p<0.05) difference between means within the same rows. ADG- Average daily gain, STSI- Supplemented total saponins intake, STTI- Supplemented total tannin intake, SSI- Supplemented saponins intake, STI- Supplemented tannins intake, FCR- Feed conversion ratio

The relationship between feed conversion ratio and saponin intake showed increased feed conversion ratio with increased saponin intake (g/day) (Fig. 3). The same observation was also made for tannin intake (Fig. 4).

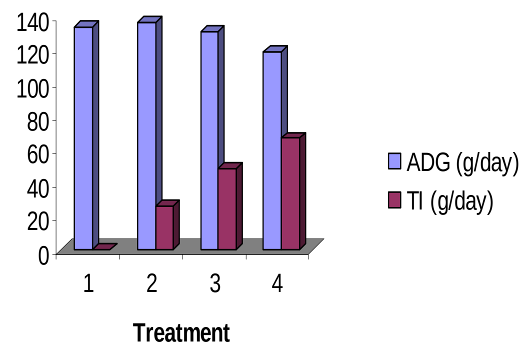

Fig. 2. Average daily gain of Uda rams in relation to tannin intake

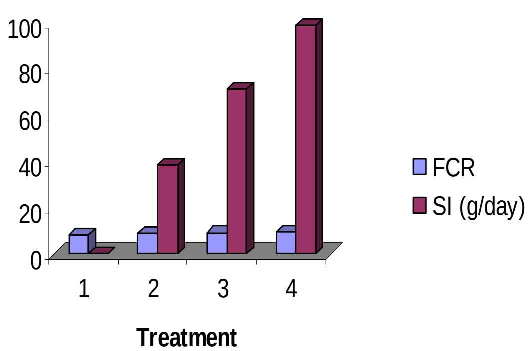

Fig. 3. Feed conversion ratio (FCR) of Uda rams in relation to saponin (SI) intake

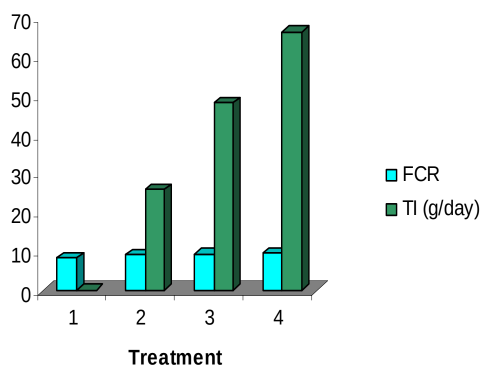

Fig. 4. Feed conversion ratio (FCR) of Uda rams in relation to tannin intake (TI)

The weight gain obtained in this study fall within the range 3.40 – 13.70 kg reported by [33]. The protection of dietary protein from degradation in the rumen as a result of presence of tannin in the test ingredient as observed by [34] might be responsible for increased weight gain even at 7.5% inclusion level of *Xylopia aethiopica*. Similarly ADG obtained in the present study is lower than 217 – 254 g reported by [35] when sheep was fed with cinnamaldehyde or juniper berry essential oil added to barley based diet at similar concentration. Decreased in body weight from 5% to 7.5% inclusion level of *Xylopia aethiopica* is an indication of poor response of the animals. No change in Average Daily Gain (ADG) was observed when sheep were fed diets supplemented with oregano leaves (*Origanum vulgare* L.) providing 144 or 288 mg of oregano oil (850 mg g^{-1} of carvacrol) per kilogram of diet DM [36]. These variations may be as a result of difference in nature and the amount of the bioactive compounds consumed by the animals as reported by [37].

The feed conversion ratio obtained in the present study increased with increase in the level of test ingredient coupled with increased intake of saponins and tannins, suggesting decreased efficiency of feed conversion which was equally observed in LWG. Improvement in average daily gain and feed conversion ratio on supplementation of 1.5% level tannin in lambs was also reported [38]. The lower level tannins might be responsible for higher ADG as opposed to the ADG obtained in the present study. This would explain the reason why increased saponin, tannin intake from treatment 2 to treatment 4 brought about decreased LWG although insignificant.

3.4 Nutrients Intake of Uda Ram Fed Graded Levels of *Xylopia aethiopica*

The results (Table 5) showed no significant difference in DM, CP, CF, NFE and Ash intakes (p=.05). There was no significant difference between treatment 2 and 3 in EE intake (p=.05). EE intake was significantly higher (P<0.01) for animals fed diets containing 7.5% *Xylopia aethiopica* and significantly lowers for animals in the control diet.

The non-significant difference in CF intake could be brought partly by non-significant difference in DMI and partly by the lower CF composition of the test ingredient (*Xylopia aethiopica*) even with increased supplementation from diet 1 to diet 4.The same reason could be attributed to Ash intake. Although the DM and NFE decreased slightly with increase in the supplemented level of *Xylopia aethiopica,* CP and EE intake increased. Increase in CP intake from treatment 1 to treatment 4 might be brought by increased level of *Xylopia aethiopica* which has been shown to contain active compound that might reduce protein degradation in the rumen as observed by [39]. This contradicts the report of [40] which observed a direct relationship between Dry matter intake and Crude protein intake. It also contradicts observation made by [41] which showed increased DMI and CPI when sheep were fed diets containing fenugreek seed. EE intake increased with increased supplementation of *Xylopia aethiopica* because of increased level of fat in the test ingredient with increased supplementation.

3.5 Nutrients Digestibility of Uda Ram Fed Graded Levels of *Xylopia aethiopica*

The result (Table 6) indicates no significant difference between treatments 1, 2 and 3 in dry matter, crude protein and crude fibre digestibility (p<0.01). Nitrogen free extract and ether extract digestibility were significantly higher for animals fed diets containing 0 and 2.5% *Xylopia aethiopica.*

Table 5. Nutrients intake of Uda ram fed graded levels of *Xylopia aethiopica*

Parameter	Treatments (inclusion of *Xylopia aethiopica*) (%)(g/kg)				SEM
	1 (0)	2 (2.5)	3 (5.0)	4 (7.5)	
DM intake (g/day)	1404.26	1432.45	1412.61	1348.50	161.16
CP intake (g/day)	194.11	196.90	216.06	252.81	24.24
CF intake (g/day)	142.19	146.79	138.87	148.52	16.57
EE intake (g/day)	26.18^c	44.30^b	48.62^b	81.58^a	5.51
NFE intake (g/day)	891.87	800.59	782.68	746.62	93.26
Ash intake (g/day)	176.09	164.07	164.15	165.39	17.18

a, b, c means values with different superscripts in a row denotes significant (p<0.05) difference between means within the same rows

Table 6. Nutrients digestibility of Uda ram fed graded levels of *Xylopia aethiopica*

Parameter (%)	Treatments (inclusion of *Xylopia aethiopica*) (%)(g/kg)				SEM
	1 (0)	2 (2.5)	3 (5.0)	4 (7.5)	
DM digestibility	76.81^a	73.81^a	70.83^a	66.81^b	1.39
CP digestibility	78.15^a	75.15^{ab}	74.59^{ab}	70.15^b	1.94
CF digestibility	76.76^a	75.76^a	75.13^a	63.76^b	1.69
NFE digestibility	72.14^a	69.14^a	66.44^b	63.70^b	2.31
EE digestibility	73.76^a	64.76^b	63.41^b	54.76^c	1.69

a, b means values with different superscripts in a row denotes significant (p<0.05) difference between means within the same rows

The significant decrease in DM, CP and CF digestibility for animals fed higher level of *Xylopia aethiopica* could explain the reduced LWG and ADG from treatment 1 to treatment 4. Animals fed diets containing 2.5 and 5.0% level of *Xylopia aethiopica* were however not significant in terms of DM, CP and CF digestibility. This could explain the reason why animals in these groups are not significant in terms of their LWG and ADG. This contradicts the finding of [42] who reported increased dry matter digestibility in animals fed diets supplemented with saponins. On the other hand the crude fibre digestibility of the animals is similar to the finding of [42] who reported reduction of the crude fibre digestibility by increased saponin intake. This could be due to the fact that saponin decreases cellulotic bacteria rather than amylolytic bacteria as observed by [43,44]. It was further reported that the beneficial and the adverse effect of the bioactive compounds depend upon the nature and the amount of feed consumed [45]. This could explain the fact that high concentrations of tannins and saponins could reduce voluntary feed intake and nutrient digestibility, whereas low to moderate concentrations may improve the digestive utilization of feed mainly due to a reduction in protein degradation in the rumen and a subsequent increase in amino acid flow to the small intestine [46].

4. CONCLUSION

It was concluded that high level supplementation of *Xylopia aethiopica* could depress feed intake and LWG. Lower level supplementation of not more than 2.5 g/kg of diet can be incorporated in the diets of Uda sheep.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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