# THE ECONOMIC BENEFITS OF FEEDING RUMEN WASTE AND IN THE DIETS OF WEST AFRICAN DWARF GOATS

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**ABSTRACT**
*The cost of conventional feeds has over the years posed a challenged to ruminant production. There is a need for affordable/cheap nonconventional feed materials. This study was undertaken to determine the economic benefit of feeding Rumen Waste and in the diets of West African dwarf goats. Twenty five West African Dwarf goats were fed five treatment diets containing Cattle Rumen waste (CRW) and Goat Rumen waste (GRW) at 0, 20 and 40% inclusion levels, respectively, using a completely randomized design. Daily feed intake and weekly weight gain were measured. Metabolism cages were used for total collection of faeces and urine. There was no significance difference (P>0.05) in Dry Matter Intake, Organic Matter Intake, weight gain, Dry Matter and Organic Matter digestibility for all the treatments, while diet 5 (40% GRC) had the least Dry Matter and Organic Matter digestibility. Cost of feed decreased from N268.88 for 0% RW to N188.87 and N151.63 for 20% CRW and 40% GRW respectively. Also, feed cost/kg live weight gain decline from N344 at 0% RW to N160.85 for 40% CRW. Cattle and goat rumen wastes will therefore be of immense economic benefit in reducing cost of production when used in the diets of goats.*
**Keywords: Feed Cost, Feed Intake, Rumen Waste, Weight Gain, Digestibility**

## INTRODUCTION

A major constraint to small ruminant production in Nigeria is adequate feeding; feeding has been reported to constitute 65-80% of the total cost of livestock production (Aruwayo and Garba, 2015). This has been accentuated by the high cost of conventional feeds which are majorly protein and energy concentrates and seasonality of pasture. Also, by products like Palm kernel meal from industrial processing of palm kernel, which was relatively, cheap has seen an upsurge in demands and by consequence an increase in selling price. Consequently, livestock farmers are encumbered with a high cost of feeding thereby limiting productivity especially in most rural and peri-urban areas. A major challenge facing the livestock industry is how to reduce feeding cost globally (Agolisi *et al*., 2020). Rumen waste is undigested or partially digested feed materials obtained from the rumen after slaughtering of cattle or goats in abattoirs. These wastes are rich in protein and it contains numerous amount of microbes found in the rumen. RW contain considerable amount of nutrients that can enhance animal performance (Usman *et al*., 2008). These rumen wastes are readily available and abundant in supply in most abattoirs in Nigeria, constituting an environmental pollution and possible threat to human health if not properly disposed. Harnessing them as feed material in ruminant diets has been promising as observed by Dairo *et al*. (2005), Usman *et al*. (2008), Inweh *et al*. (2013), etc. This research was undergone to ascertain the economic benefits of feeding Rumen Waste in the diets of West African dwarf goats in replacement for conventional concentrate diets.

## MATERIALS AND METHODS

This study was carried out at Ruminant Unit of the University of Benin Farm Project in Benin City, Edo State, Nigeria, located on latitude $6^0$ and $30^0$ N and longitude $5^0$ 40′ and $6^0$ E in the rainforest zone. It has o an average temperature of 27.6 C; annual rainfall of 2162mm and mean relative humidity of 72.5% (Orheruata *et al*., 2010). Rumen wastes were collected fresh after slaughtering from abattoirs in the city. Rumens of Cattles and goats were disemboweled into clean plastics, convened to the University Farm Project site and sun-dried on concrete slabs for 4-5 days. After which they were milled in a 2mm hammer mill. Four experimental diets were formulated to contain 20% and 40% CRC and GRC respectively as shown in Table 1 and a fifth diet without RC (0% RC) served as control diet. All diets were isonitrogenous and isocaloric. Twenty weaned WAD goats of similar age and weights were balanced for weight and randomly allotted to the five dietary treatments with four goats per treatment in a completely randomized design (CRD). Goats were fed twice daily at 0800hr and 1600hr over a period of 84 days. Feed intake was recorded daily by subtracting left over feed from feed offered. The goats were weighed at commencement of the experiment and on weekly basis subsequently. After 70 days, goats were moved into metabolism cages for total collection of faeces and urine separately for a period of 7 days, which was preceded by 7 days of adaptation in a digestibility trial. Quantity of faeces and urine collected were measured and recorded and daily aliquots taken and preserved in a freezer for chemical analysis. Urine was collected in plastic containers acidified with few drops of 25% sulphuric acid. Feed Samples were weighed, oven dried at $65^0$C for a period of 24 hours to a constant weight for determination of dry matter, ash, organic matter and crude protein (AOAC, 2000). Neutral detergent fibre (NDF) and Acid detergent fibre (ADF) were analyzed as described by Van Soest *et al*. (1991). Data collected was subjected to analysis of variance (SAS, 2008). Observed variations among treatment means that are significant were determined using Duncan Multiple Range Test (1955).

**Table 1: Composition of the experimental diets**

| Ingredients | Control | 20%CRW | 40%CRW | 20%GRW | 40%GRW |
|---|---|---|---|---|---|
| Cattle rumen content | - | 20.00 | 40.00 | - | - |
| Goat rumen content | - | - | - | 20.00 | 40.00 |
| Palm kernel meal | 48.00 | 40.00 | 20.00 | 40.00 | 20.00 |
| Wheat Offals | 5.04 | 19.04 | 17.39 | 19.04 | 17.39 |
| Maize | 22.73 | 7.50 | 5.00 | 7.50 | 5.00 |
| Soyabean meal | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Groundnut cake | 13.19 | 7.46 | 11.61 | 7.45 | 11.61 |
| Bone meal | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Lime stone | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Common Salt | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Vit/Min Premix | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Cost/kg feed (₦/kg) | 268.88 | 188.87 | 157.63 | 188.87 | 157.63 |
| ME Kcal/kg | 2452.64 | 2324.28 | 2471.85 | 2324.28 | 2471.85 |

CRW – cattle rumen waste, GRW – goat rumen waste

## RESULTS AND DISCUSSION

Values obtained for crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and cellulose in this study, were lower in comparison to values (14.4% CP, 63.3% NDF, 41.1% ADF and 27.0% cellulose) reported by El-Yassin *et al*. (2010) for cattle and goat rumen wastes. Observed differences in these nutrients can be due to the variety of feed consumed by cattle and goats before slaughtering (Basher *et al*., 2002). Also, the time interval between feeding and slaughtering can have an effect on nutrient composition of rumen waste collected (Adeniji and Balogun, 2001).

Dry matter and organic matter digestibility

Dry matter and organic matter digestibility were similar for all diets except goats fed diet 5 (40% GRC), which had values of 53.05% and 58.58% for DMD and OMD respectively. However, the least OM digestibility of 58.58% is still capable of supporting growth (Anigbogu and Okocha, 2003). Farinu *et al*. (2005) attributed a lowered digestibility to increased amount of fibre in diets. The cost of feed reduced gradually from #268.88.45 at 0% rumen waste to #188.87 and #157.63 at 20% and 40% cattle rumen waste and goat rumen waste respectively. Diet 5 (40% goat rumen waste) had an in increased cost to #274.39 for cost/kg live weight gain obviously due to the reduced digestibility on the diet culminating in an increase in feed intake in an attempt to meet goats nutrient requirement.

**Table 2: Proximate Composition (g/100gDM) of rumen wastes**

| COMPOSITION | CRW | GRW |
|---|---|---|
| Dry matter | 87.57 | 88.89 |
| Organic matter | 92.58 | 72.44 |
| Crude protein | 10.94 | 6.13 |
| Neutral Detergent Fibre | 62.81 | 67.50 |
| Acid Detergent Fibre | 30.83 | 59.62 |
| Acid Detergent Lignin | 25.37 | 29.72 |
| Ash | 7.42 | 27.56 |
| Cellulose | 5.46 | 29.90 |
| Hemicellulose | 31.98 | 7.88 |

**Table 3: Weight gain, feed intake and dry matter digestibility**

| Variables | control | 20%CRW | 40%CRW | 20%GRW | 40%GRW | SEM |
|---|---|---|---|---|---|---|
| Final LW (kg) | 11.53 | 11.00 | 11.63 | 10.50 | 10.30 | 2.01 |
| Initial LW (kg) | 8.60 | 8.07 | 8.73 | 7.60 | 8.60 | ND |
| Total No. of days) | 82 | 82 | 82 | 82 | 82 | ND |
| Total weight gain (kg) | 2.93 | 2.93 | 2.90 | 2.90 | 1.70 | 0.83 |
| Total feed intake (g) | 3756.41 | 3617.28 | 2959.18 | 2929.29 | 3695.65 | ND |
| FCE | 0.78 | 0.81 | 0.98 | 0.99 | 0.46 | 0.31 |
| Feed cost/LW gain (₦/kg) | 344 | 233.17 | 160.85 | 235.59 | 274.39 | ND |
| Dry matter intake (g/day) | 284.94 | 274.49 | 270.28 | 205.63 | 239.48 | 70.66 |
| Organic matter intake (g/day) | 259.33 | 246.50 | 240.74 | 179.94 | 201.31 | 62.65 |
| Crude protein intake (g/day) | 34.91 | 36.71 | 49.68 | 29.70 | 34.58 | 12.98 |
| Dry matter digestibility (%) | 72.53a | 59.45a | 71.62a | 68.84a | 53.05b | 3.80 |
| Organic matter digestibility (%) | 74.65a | 72.73a | 74.81a | 70.59a | 58.58b | 3.62 |
| Crude protein digestibility (%) | 76.26c | 88.17ab | 97.89a | 91.33b | 88.40ab | 2.28 |

FCE-Feed Conversion Efficiency; SEM – Standard Error of Mean abc – mean along the same row with different letters are significantly different ($p<0.005$).

## CONCLUSION

The inclusion of rumen waste in the diets of goats certainly can be a remedy to an ever increasing cost of conventional feed ingredients, thereby making goat production affordable to farmers.

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# ACCEPTABILITY AND *IN VITRO* FERMENTATION CHARACTERISTICS OF WEST AFRICAN DWARF (WAD) SHEEP FED DIETS CONTAINING GRADED LEVELS OF NEEM AND BITTER LEAF PLANTS

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**ABSTRACT**
*The poor performance of ruminant animals during the lean season coupled with increased methane emission that causes global warming has necessitated the search for alternative feed additives (additives) that could be used as both growth stimulants and methane inhibitors. This study focused on investigating the acceptability, in-vitro gas fermentation and methane production levels of neem and bitter leaf in rations formulated for West African Dwarf sheep. Twenty-one sheep were used and subjected to seven dietary treatments: Control diet (T1), 5% Neem leaf (T2), 10% Neem leaf (T3), 5% Neem leaf + 5% Bitter leaf (T4), 5% Bitter leaf (T5), 10% Bitter leaf (T6) and 2.5% Neem leaf + 2.5% Bitter leaf (T7) in a completely randomized design. The average dry matter feed intake was significantly (P<0.05) influenced by the experimental diets. The T1 sheep was significantly (P<0.05) higher compared with those fed other diets throughout the 7-days period. The order of preference of the sheep fed treatment diets was T1>T5>T7>T6>T2>T4>T3. The production of gas was significantly (P<0.05) influenced by the incubation period and herbs inclusion. The T1 (0% herbs) produced more gas than the rest of the treatments, T5 (bitter leaf) at 5% inclusion level produces relatively less methane gas and preferred. Likewise, neem leaf and bitter leaf at 2.5% (T7) inclusion level each produced a lower methane gas. In conclusion, addition of herbs into the diet of ruminants could improve feed efficiency and also reduce methane emission.*
**Keywords: acceptability, bitter leaf, *in vitro* fermentation, methane and neem leaf**

## INTRODUCTION
Ruminants production in tropical countries is constraint with scarcity of forage in terms of quantity and quality throughout the year (Ogunbosoye, 2016). These animals cannot be sustained on conventional feedstuff, as a result of stiff competition between man and other non-ruminant farm animals; coupled with the exorbitant prices of the grains, other farm produce and their by-products. With dwindling world economies and persistent increase in the world population, demand for animal protein is also increasing at a level far beyond the supply (as mostly felt in the developing countries like Africa and Asia). Therefore, to enhance food security, there is need to intensify production of ruminant animals and its products from other feed resources that are readily available, cheap, non-toxic to the animals and may not be consumed by human.
Globally, temperature increase has led to unpredictable rainfall pattern in some parts of the world (Gerstengarbe and Werner, 2008), as a result of the volume of methane emission in livestock farms. Therefore, a more efficient strategy to reduce enteric methane ($CH_4$) in ruminants is easily achieved through selection of grasses of high quality (high in water-soluble carbohydrates), forage legumes containing secondary metabolites like tannins and fruits/plants containing saponins, provided that they do not affect intake and digestibility. Improved nutrition of cattle through feeding of high quality forages can result in high animal performance and in the reduction of $CH_4$ emitted per unit of dry matter intake and per unit of product.
Methane emission by ruminants is one of the most important sources of global warming, having a great impact on the environment. Greenhouse gas emission (especially methane) from ruminants, has been recognized as an important issue worldwide as it is a driver for global warming and climate change (Kim *et al*., 2012). Goodland and Anhang, 2009 reported that livestock production and its by-products are responsible for at least 51 percent of global warming gases; estimated to be between 4.1 and 7.1 billion tonnes of carbon dioxide equivalents per year, equating to 15-24% of total global

anthropogenic greenhouse gas emissions (Wanapat *et al*., 2013). Also, synthetic antibiotics used as growth promoters in livestock production (Botsoglou and Fletouris, 2001) have been found to cause public health problems as a result of their residual effect on the consumers, consequent upon food and safety globally advocated (Gurbuz1 and Ismael, 2016).

Therefore, animal nutritionists are being tasked to develop alternative feed supplements that will replace synthetic ones. To enhance food security, there is need to intensify production of ruminant animals and its products from other feed resources that are readily available, cheap, non-toxic to the animals and may not be consumed by humans. An utmost attention has been given to medicinal herbs as replacements for antibiotic growth promoters (Ibrahim *et al*. 2005). Herbs have already been used as growth promoters in practice (Ocak*et al*., 2008).

Ruminant nutritionists have evaluated many substances such as essential oil, plant and plant extracts, plant secondary metabolites e.t.c. to manipulate the rumen microbial ecosystem to reduce methane emission (Kim *et al*., 2012). However, organic acids are present at relatively high concentrations in the leaf tissue of plants and attempts should be made to select and breed forages with higher levels of these compounds. Meanwhile, herbs have already been used as growth promoters in practice (Ocak*et al*., 2008). Herbs such as garlic (*Allium sativum*), lemongrass (Cymbopogon citrates, DC. Stapf.) and peppermint (Mentha xpiperita) are widely used as antibacterial agents and extensively used to maintain the microbial ecosystem of the gastrointestinal tract especially in tropical regions. Garlic has been studied as aqueous or ethanol extracts or as a dried powder (Shin and Kim, 2004) as it contains a high level of organosulfur compounds such as allicin, ajoene, diallyl disulfide (Chi *et al*., 1982). Sarnataro and Spanghero, 2020 reported the use of tannin-rich plants and tannins extracts to improve ruminal microbial activities, rate of fermentation in the rumen (Fagundes *et al*., 2020), antioxidant status and health of ruminant animals (santos *et al.*, 2021) and mitigates enteric methane production (Gomma and Gado,2021). Therefore, there is need to search for more natural alternatives to modify/manipulate the rumen environment, increase the efficiency of feed utilization, and inhibiting the ruminal methanogenesis.

Indigenous African herbs such as bitter leaves and neem leaves have not been explored as replacement for synthetic antibiotics in ruminant production despite their richness in phytochemicals. Therefore, influence of the inclusion of dried neem and bitter leaf in ruminant feed was examined for acceptability and *in vitro* fermentation by West African Dwarf (WAD) sheep.

## MATERIALS AND METHODS

### Experimental Site

The experiment was conducted at the Small Ruminant Unit at the Teaching and Research Farm Faculty of Agriculture, Kwara State University Malete, Nigeria.

### Experimental Design and Diet Formulation

The study was conducted in a completely randomized design (CRD) with seven treatments replicated 3 times. The seven experimental treatments administered were:

Treatment 1: Control (0% herb)
Treatment 2: 5% inclusion level of Neem leaf
Treatment 3: 10% inclusion level of Neem leaf
Treatment 4: 5% Neem leaf + 5% Bitter leaf
Treatment 5: 5% inclusion level of Bitter leaf
Treatment 6: 10 % inclusion level of Bitter leaf
Treatment 7: 2.5% Neem leaf + 2.5% Bitter leaf

The sheep were quarantined upon arrival for 30 days using Albendazole (dewormer at 12.5 mg/kg body weight), dusted with ectoraid against ectoparasites and treated with oxytetracycline HCl (a broad-spectrum antibiotics) prior to the commencement of the experiment. The sheep were offered diets in a group of three sheep per pen. The sheep were allowed to choose the feed freely, while clean water was provided *ad libitum*.

### Procurement and preparation of leaves

Neem and bitter leaves were collected within the University Research Farm, air dried at room temperature, then milled into fine powder, sieved through a gauge and kept for subsequent use. The Daniella leaves were also harvested fresh, dried and included in the ration formulation.

**Table 1: Composition of the formulated diets (%)**

| Ingredients | T1 | T2 | T3 | T4 | T5 | T6 | T7 |
|---|---|---|---|---|---|---|---|
| Daniella | 20 | 15 | 10 | 10 | 15 | 10 | 15 |
| Neem leaf | - | 5 | 10 | 5 | - | - | 2.5 |
| Bitter leaf | - | - | - | 5 | 5 | 10 | 2.5 |
| Corn bran | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| Cassava peel | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| SBCW | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Palm kernel cake | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Bone meal | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Oyster shell | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Urea | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Common salt | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Chemical composition**

Crude protein, crude fibre, ether extract and ash concentrations of the experimental diets were estimated. The DM content of the diets was determined by drying in a forced-air oven at 60ºC until constant weight was achieved. After drying, samples were ground to pass through a 2 mm sieve and then subjected to proximate analysis according to AOAC, (2005). NDF, ADF and ADL were analyzed according to Van Soest *et al.* (1994) procedure.

**Feed intake**

The WAD sheep were used in a cafetaria feed preference study which lasted for 14 days with 7 days of adaptation. They were housed in a well-ventilated open pen in three groups. Two (2kg) of each diet was introduced to the animals in different containers. The positioning of the diets in the pen was changed daily to avoid the animals sticking to the same feed in the particular position. The feeding of the animals was monitored for 2 hours (08:00-10:00) daily. Average daily intake was calculated by deducting the refusal from the amount served.

**Acceptability Study**

After one week of acclimatization, the acceptability study was determined using the method described by Ogunbosoye (2016). Feed acceptability was determined from Co-efficient of Preference (CoP) value calculated from the ratio between the intakes of each individual feed sample and the average intake of all the feed offered. CoP less than unity is considered rejected, while CoP greater than unity is well accepted.

***In vitro* fermentation study**

Rumen fluid was obtained from the WAD sheep through suction tube before the morning feed and sieved with four layered cheese cloth and kept in a water bath at 39ºC under $CO_2$ saturation. Incubation was carried out in 120 ml calibrated syringes in four batches at 39 ± 1º C. To 200 mg sample in the syringe was added 30 ml inoculum that contained rumen liquor and buffer (9.8g $NaHCO_3$ + 2.77g $Na_2HPO_4$ + 0.57g KCl + 0.47g NaCl + 0.12g MgSO4. $7H_20$ + 0.16g $CaCI_2$. $2H_2O$ in a ratio (1:4 v/v) under continuous flushing with $CO_2$. The gas production was measured at 3, 6, 9, 12, 15, 18, 21 and 24h (Menke and Steingass, 1988). The average volume of gas produced from the blanks was deducted from the volume of gas produced per sample to estimate the actual gas volume generated in vitro.

**Methane production**

At the end of 24 hours' incubation, 4 ml of NaOH (10 M) was introduced using 5 ml capacity syringe as reported by Fievez *et al.* (2005). The content was inserted into the silicon tube, which was fastened to the 120 ml capacity syringe. The clip was then opened while the NaOH was gradually released. The content was shaken while the plunger began to shift position to occupy the vacuum created by the absorption of $CO_2$. The volume of methane was read on the calibration.

**Estimated parameters**

Metabolizable Energy (ME, KJ/kgDM) was calculated as ME = 2.20 + 0.136GV + 0.057CP + 0.0029CF (Menke and Steingass, 1988), organic matter digestibility (OMD, %) = 14.88 + 0.88Gv + 0.45CP + 0.651 XA (Menke and Steingass, 1998). Short chain fatty Acids (SCFA, µmol) as 0.0239Gv – 0.0601 (Getachew *et al*., 1999) was obtained where Gv, CP, CF and XA are total gas volume, crude protein crude fiber and ash respectively.

**Data Analysis**

All the data collected were subjected to analysis of variance using DSAASTAT (2011). Statistical package and treatments were separated using Least Significant Difference (LSD) test at 5% level of significance.

**RESULTS AND DISCUSSION**

Presented in Table 2 is the chemical composition of the experimental diets. The crude protein (CP) content was higher in T5 (21.89), T7 (21.58), T4 (20.88) and T6 (20.69) compared with control diet (20.67) while the T2 had the lowest crude protein (CP)content. T7 has the highest crude fibre (CF) content of 18.11% followed by the control diet 18.05% while the least value was recorded in T3. Values for ether extract ranged from 3.48 to 4.03%, all the treatments had more ether extract content than the control diets except T2 which had the least value (3.48%). There were more of ash content in T4 (9.54%), T6 (9.43), T7 (9.25) than the control diet (9.14) which recorded same value with T5. NDF, ADF and ADL recorded the same trend, with T5, T2, T7 and T3 having higher value than the control diet while T4 had the least value.

The concentrations of CP (18.77–21.89%) recorded in the experimental diets suggest that the leaves have appreciable amount of protein that may be made available to the rumen microbes which leads to increase in digestibility of the feed thereby resulting in increase in productivity especially when fed to sheep during the dry season. These values were influenced by the incorporation of bitter leaves in the diets. The observation is an indication that bitter leaves could be fed to the sheep during the dry season, when it is abundantly available. The CP contents of the experimental diets were in agreement with report obtained elsewhere (Odedire and Oloidi, 2014) when wild sunflower meal was fed to West African dwarf goat. Similar CP content was recorded by Tadesse *et al*. (2015) when fed *Millitia ferruginea* leaf meal was fed to goats. The CP contents were enough to support healthy rumen ecology of the ruminant animals.

**Table 2: Chemical composition of the experimental diets**

| | Treatments | | | | | | |
|---|---|---|---|---|---|---|---|
| **Parameters (%)** | T1 (0%MP) | T2 (5% NL) | T3 (10% NL) | T4 (5% NL & 5%BL) | T5 (5% BL) | T6 (10% BL) | T7 (2.5% NL & 2.5% BL) |
| Dry Matter | 11.46 | 11.87 | 12.11 | 11.21 | 11.03 | 12.31 | 11.16 |
| Crude Protein | 20.67 | 18.77 | 19.88 | 20.88 | 21.89 | 20.69 | 21.58 |
| Ether Extract | 3.59 | 3.48 | 4.03 | 3.65 | 3.78 | 3.71 | 3.82 |
| Crude Fibre | 18.05 | 15.13 | 15.05 | 17.84 | 17.68 | 17.04 | 18.11 |
| Ash | 9.14 | 7.48 | 8.26 | 9.54 | 9.14 | 9.43 | 9.25 |
| NDF | 61.73 | 65.13 | 61.89 | 58.86 | 67.81 | 60.57 | 62.88 |
| ADF | 42.75 | 49.76 | 43.11 | 37.15 | 51.47 | 39.83 | 46.39 |
| ADL | 13.81 | 15.87 | 13.94 | 11.68 | 17.15 | 12.06 | 14.88 |

NDF = Neutral Detergent Fibre; ADF = Acid Detergent Fibre; ADL = Acid Detergent Lignin, MP =Medicinal plant, NL = Neem leaf, BL = Bitter leaf

Table 3 shows the feed intake of WAD sheep fed the experimental diets. The average dry matter feed intake was significantly ($P<0.05$) influenced by the experimental diets. The values for the sheep fed diets T1 (control diet) was significantly ($P<0.05$) higher and better than that of other sheep fed the other experimental diets throughout the 7 days' period of the trial. It can be observed that the sheep fed T5 had a very close feed intake to sheep fed the control diets. This was followed by the sheep fed T7 while the sheep fed T3 consumed the least feed among the experimental animals. The order of preference of the sheep for the experimental was T1>T5>T7>T6>T2>T4>T3.

The variation in the feed intakes of the sheep fed the experimental diets may be attributed to the unfamiliar taste of the diets and the presence of some phytochemicals which may be the saponins, alkaloids, tannins, glycosides and flavonoids which are associated with characteristics odour and bitter taste of both neem and bitter leaves (Bonsi *et al.*, 1995). It has been reported that these phytochemicals if not reduced can significantly influence the palatability and intake of neem and bitter leaves meal by the animal (Nanang *et al.,* 1997). This result is consistent with the findings of Olosunde and Odeyinka (2017) on goat fed bitter leaf as feed supplement. The significant dry matter intake obtained in the diet containing 5% bitter leaf (T5) may be due to the higher protein content of the diet. This is in line with the result obtained by Aye and Adegun (2013) that diet high in protein content increases intake by the animals.

In the present study, the acceptability of the diets, measured by the Coefficient of Preference (CoP) of the sheep showed that apart from the control diet (T1) which was most preferred by the sheep, diets containing bitter leaf only at 5%, and neem and bitter leaf at 2.5% each (T5 and T7 respectively) were also preferred by the sheep as the CoP was above unity compared to other dietary treatments. A diet is considered acceptable, when CoP is equal to or greater than 1(unity) and assumed to be unacceptable (rejected) when CoP is less than 1 (Ososanya and Olorunnisomo, 2015; Ogunbosoye, 2016). A number of factors may influence acceptability of feed by small ruminants such as taste, texture and palatability.

**Table 3: Feed intake of West African dwarf sheep fed the treatment diets**

| Days | Treatments | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **T1** | **T2** | **T3** | **T4** | **T5** | **T6** | **T7** | ***P-value*** |
| 1 | 242.33$^{a}$ | 140.67$^{de}$ | 87.67$^{f}$ | 101.33$^{e}$ | 201.67$^{b}$ | 144.00$^{d}$ | 165.00$^{c}$ | ** |
| 2 | 255.33$^{a}$ | 142.00$^{c}$ | 121.00$^{c}$ | 111.67$^{d}$ | 248.66$^{a}$ | 154.00$^{b}$ | 127.67$^{cd}$ | ** |
| 3 | 281.00$^{a}$ | 121.67$^{e}$ | 103.33$^{e}$ | 106.67$^{e}$ | 266.67$^{b}$ | 177.50$^{d}$ | 209.00$^{c}$ | ** |
| 4 | 323.33$^{a}$ | 86.67$^{d}$ | 121.67$^{d}$ | 200.00$^{c}$ | 216.67$^{bc}$ | 239.00b | 234.33$^{bc}$ | ** |
| 5 | 402.67$^{a}$ | 207.67$^{d}$ | 115.00$^{e}$ | 127.33$^{e}$ | 258.33$^{c}$ | 262.50b | 235.67$^{bc}$ | ** |
| 6 | 485.67$^{a}$ | 146.33$^{e}$ | 120.00$^{f}$ | 144.33$^{e}$ | 294.00$^{b}$ | 157.50d | 250.33$^{c}$ | ** |
| 7 | 539.33$^{a}$ | 167.67$^{e}$ | 139.00$^{f}$ | 166.33$^{e}$ | 333.33$^{b}$ | 207.50d | 266.67$^{c}$ | ** |

abcdef = Means with the same letters within the column are not significantly different (P> 0.05) LSD = Level of significant different
T1= 0%MP, T2=5% NL, T3=10% NL, T4=5% NL+5%BL, T5=5% BL, T6=10%BL, T7=2.5%NL+2.5%BL, MP=medicinal plant, NL=neem plant and BL=bitter leaf

**Table 4.3 Acceptability of the treatment diets by West African dwarf sheep**

| Days | Treatments | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **T1** | **T2** | **T3** | **T4** | **T5** | **T6** | **T7** | **LSD** |
| 1 | 1.49$^{a}$ | 0.93$^{cd}$ | 0.58e | 0.67$^{de}$ | 1.33$^{ab}$ | 0.93$^{cd}$ | 1.09$^{bc}$ | ** |
| 2 | 1.53$^{a}$ | 0.85$^{bc}$ | 0.73$^{d}$ | 0.67$^{d}$ | 1.5$^{a}$ | 0.95$^{b}$ | 0.77$^{cd}$ | ** |
| 3 | 1.56$^{a}$ | 0.67$^{d}$ | 0.57$^{d}$ | 0.59$^{d}$ | 1.47$^{a}$ | 0.99$^{c}$ | 1.16$^{b}$ | ** |
| 4 | 1.75$^{a}$ | 0.65$^{d}$ | 0.47$^{e}$ | 0.62$^{d}$ | 1.08$^{c}$ | 1.17$^{bc}$ | 1.26$^{b}$ | ** |
| 5 | 1.75$^{a}$ | 0.90$^{c}$ | 0.50$^{d}$ | 0.55$^{d}$ | 1.12$^{b}$ | 1.14$^{b}$ | 1.03$^{bc}$ | ** |
| 6 | 2.12$^{a}$ | 0.64$^{d}$ | 0.53$^{e}$ | 0.63$^{d}$ | 1.28$^{b}$ | 0.72$^{d}$ | 1.09$^{c}$ | ** |
| 7 | 2.07$^{a}$ | 0.64$^{e}$ | 0.54$^{f}$ | 0.64$^{e}$ | 1.28$^{b}$ | 0.80$^{d}$ | 1.03$^{c}$ | ** |

abcdef = Means with the same letters within the column are not significantly different (P> 0.05) LSD = Level of significant different

Ogunbosoye (2016) reported that plant physical structure and chemical composition are the most vital factors that influence preference for food. The acceptance of bitter leaf (T5) by the sheep despite their bitter taste compared to others may be attributed to the high and better CP content than the other diets used in this study. It may also be due to the possibility that animals get accustomed to the taste over time. It has been reported that small ruminants prefer sweet plant and generally reject bitter plants (Ososanya and Olorunnisomo, 2015) in contrary to what was obtained in this study.

There were significant variations in the gas volume production. The volume produced under each treatment continue to increase at three hours interval. This trend is an indication that more degradation is still possible after 24 hours of incubation due to rises in the gas at every three hours. The production of gas was significantly (P<0.05) influenced by the incubation period as well as the level and types of medicinal plants in the diets. T1 produced more gas followed by treatment T5, T4, T6 and then T7 while T3 and T4 had the least gas production (Table 4). Similar trend was also observed by Ogunbosoye (2016) on foliage of leaves of forages for ruminants. There are many factors that may determine the amount of gas produced during fermentation, such as the nature and level of fibre, the presence of secondary metabolites (Babayemi *et al.*, 2004) and potency of the rumen liquor for incubation. The production of less gas by the other treatments compared to the control diet suggests that neem and bitter leaves contained some anti-nutrients which may inhibit degradation of these diets by the microbes in the rumen.

Methane ($CH_4$) production was highest in T1 than other treatments, while T2, T3 and T7 having the lowest value. It varies from 3 ml/200mg DM to 12 ml/200mg DM. The amount of methane produced depends on the level of fermentation. It's a colossal energy waste but it is a parameter to measure feedstuff digestibility in the rumen of an animal (Njidda and Nasiru, 2010).

Figure 1: Fermentation pattern of the environmental diets incubated at 24hrs

It was observed from this study that the control(without medicinal plant) diet with high gas production produces more methane. This is an indication that the phytochemicals present in these herbs inhibit methanogens, thereby reduce the activities of the microorganisms which aid feed digestion. The higher the feed degradation in the rumen, the higher the methane production. This finding is in accordance with the report of Babayemi and Bamikole (2009) and Ogunbosoye (2016).

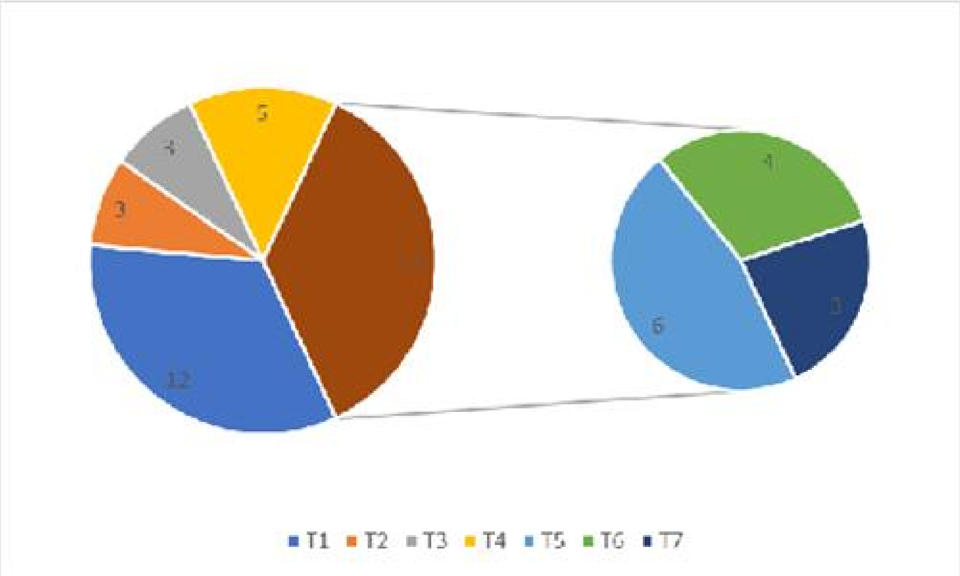


Figure 2: Methane production (ml/200mg DM) of the experimental diets at the end of 24hrs incubation

**CONCLUSION**

It was observed from this study that dietary supplementation of neem and bitter leaves had influence on the feed intake, acceptability and methane production of the animals. Hence, a combination of neem and bitter leaves could be used as feed supplement in the diet of sheep to improve the growth rate and still have an improved, healthy and greener environment.

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