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Original Article

Performance, nutrient intake, digestibility and nitrogen utilization of West African Dwarf goats fed graded cocoa leaf meal fortified with urea

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Abstract

This study was conducted to examine the impact of graded cocoa leaf meal (CLM) fortified with urea on performance, nutrient intake, digestibility and nitrogen balance of West African Dwarf goats of both sexes raised under intensive management system. Twelve (12) animals grouped into three treatments, containing four animals per treatment were randomly assigned to the three treatments designated as Groups 1 - 3 where Group 1 (control) contained 0% CLM, Group 2 (2.5% CLM) and Group 3 (5% CLM) in a completely randomized design for a period of 63 days. Data obtained on performance and nutrient digestibility trials were subjected to one-way Analysis of Variance. Final weight, weight gain and daily weight gain followed similar trends across the groups with highest (7.83 kg, 2.64 kg and 41.94 g/day), respectively for animals in Group 2 while least values were obtained in other groups. Better comparable feed conversion ratio (FCR) was recorded for goats in Group 2 (6.38) and Group 1 (7.83). Nutrient intake was higher (11.98 and 10.85 g/day) for crude protein in animals placed in Groups 2 and 3, respectively while the least (8.83 g/day) was obtained for animals in Group 1. The ash had highest (1.097 %) digestibility for animals in Group 1, which was comparable to the value (0.605 %) obtained for animals in Group 2, while the least value (0.248 %) was obtained for animals in Group 3. The highest ether extract digestibility (3.262 %) was obtained in animals in Group 2. Nitrogen intake was higher (262. 84 g/day) in animals in Group 1 while lower similar values (185.31 and 157.89 g/day) were obtained in animals in Group 2 and 3, respectively. It could be concluded that 2.5% CLM positively influenced the performance of WAD goats in terms of weight gain, nutrient intake, digestibility and nutrient utilization.

INTRODUCTION

Goat production has been considered as a valuable small ruminant enterprise with the potential of meeting world's increasing demand for animal protein in less developed countries (Okunade *et al*., 2014) by producing a good source of meat and milk for human consumption. Goats represent about 30% of ruminant livestock in Africa and the largest group of small ruminant livestock in Nigeria (FAOSTAT, 2011). In Nigeria, goats contribute about 24 % of the meat supply; thus, making them the second most important livestock species in

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the country (Oni, 2002). Okoruwa *et al*. (2013), however, reported that goats in Nigeria suffer severe nutritional stress in the dry season as a result of the acknowledged seasonal fluctuations in availability and quality of natural pastures, as characterized by their low production, reproductive performance, slow growth rate, and increased susceptibility to pests and diseases (Tolera *et al*., 2000; Ajagbe *et al*., 2015; Jiwuba and Udemba, 2019).

Feed intake is an important factor in small ruminant nutrition (Jiwuba, 2020). If the feed intake by the animals is too low, it will affect the production of animals which results in poor feed efficiency (Ahmad *et al*., 2018). So, the weight gain of West African Dwarf goats sometimes may be determined by the voluntary feed intake by the animal. The amount of feed intake can be influenced by the nutritional composition of the feed; a poor nutritional feed will lead to low feed intake in the animal (Ahmad *et al*., 2018). The low performance of animals could be attributed to poor feeding, most especially during the dry season.

Ruminant owners raise their animals on natural grasses, which are intrinsically poor in nutritive value, low in digestibility and scarce during the dry season (Babayemi *et al*., 2009). Dry season results in a rapid decline in the quantity and quality of forages leading to low forage intake and digestibility with consequent poor animal performances (Ajagbe *et al*., 2015). Thus, the need for a cheap and readily available alternative feed ingredients to enhance goat production. Ojebiyi *et al*. (2002) earlier noted that a potential alternative feed ingredient must not be a staple item that is directly eaten by man to avoid scarcity. This has led to the search for shrubs and tree foliage which could be used as cheaper available alternative supplements to grasses (Okoruwa *et al*., 2016), especially during the dry season.

Dry leaf of *Theobroma cacao* is one of such alternative feed resources which are readily available and relatively cheaper than the conventional feed and at the same time not important as an item of human food (Adamafio, 2013). Studies have shown that multipurpose trees can be used as cheap protein supplements which can improve voluntary intake, digestibility and general performance of animals fed low quality feeds (Kakengi *et al*., 2001). Also, Kuswandi (2011) stated that the use of cocoa biomass as an alternative feed must be mixed with other feed ingredients in order to meet the nutritional needs of livestock.

Cocoa plantations have a great opportunity for goat development, because about 60-70% of cocoa biomass can be utilized as goat feed ingredients (Gunawan *et al*., 2017). The inclusion of cocoa leaf in the diets of goats stimulated feed intake and growth of the animals. Addition of dried cocoa leaf in the goats' diet occasioned in a significant increase in weight gain, milk production and fertility which could be attributed to the high protein, fibre and mineral contents of the dried cocoa leaf meal (Renna *et al*., 2022).

One of the major qualities of alternative feed resources is their ability to provide adequate nutrients that meet up with body requirements of the animal in question without compromising the animals' performance, reproduction, health as well as availability, acceptability, environmental friendly and reduction in the cost of feeding the animals (Makinde *et al.*, 2017). Medicinal importance of cocoa leaf has been reported in treating asthma, body weakness, diarrhoea, fractures, loss of appetite, malaria, parasites, pneumonia, cough, colic and poisoning in humans and animals (MPP, 2023). Biomass from cocoa can be used directly as forage for livestock (Ajayi *et al.*, 2005). However, their efficient utilization by ruminants could better be achieved when mixed with a higher nitrogenous source to augment for nitrogen deficiency (Gunawan, 2017).

Nitrogen is very essential in the synthesis of microbial protein in the rumen, which is essential for the rumen function and the general performance of the ruminant. Nitrogen balance status shows the extent to which the body is maintaining adequate protein balance (Min *et al*., 2015). One of the cheapest non-protein nitrogen sources is urea; which is a good alternative source of protein. Urea has been extensively used in ruminant nutrition as a source of non-protein nitrogen (Mazinani *et al*., 2021; Ayankoso *et al*., 2021; Ayankoso and Yusuf, 2022). So, supplementation of urea, which is non-protein nitrogen that can be rapidly hydrolyzed to ammonia in the rumen to improve the nutrition of low-quality agricultural by-products, will be of immense benefits (Papadopoulos *et al*., 2001). Therefore, investigation on supplementation of plant remains, like dry cocoa leaf, which are readily available all year round, especially during dry season, when fortified with urea could improve the performance, digestibility, utilization and nitrogen balance of West African Dwarf goats. Hence, this study aimed at investigating the effect of graded cocoa leaf meal fortified with urea on performance, nutrient intake, digestibility and nitrogen balance of West African Dwarf goats.

MATERIALS AND METHODS

Experimental site

The study was carried out at the Goat unit of the Teaching and Research Farm, Adekunle Ajasin University, Akungba-Akoko (AAUA), Ondo State, Nigeria. The site is located in the rain forest vegetation zone of South-western Nigeria between latitude 7°28'55" N and longitude 5 °46'05" E. The annual rainfall ranges from 1500 - 2000 mm with a temperature range of 23 - 26 ° C (Olabode, 2014).

Experimental Animals and Management

Twelve (12) growing West African Dwarf goats aged 5 - 6 months with average weight of 5.35±0.33 kg were used for the experiment. The animals were obtained from a popular local goat market in Oka-Akoko, Ondo State which is some miles away from the experimental site. On the arrival of the animals, they were quarantined for a period of 28 days and treated with ivermectin® at 0.1 ml/10 kg body weight which was administered subcutaneously to control worms. 5% Tetranor® at 0.5 ml/10 kg body weight was administered intramuscularly, and multivitamin® was given at 3 ml to each of the animals. The animals were also treated against external parasite by applying Pour on®. These exercises were carried out daily for three consecutive days.

The experimental pens were properly swept, cleaned and disinfected with Lysol® solution on two occasions within an interval of two weeks and also allowed to rest for another 2-weeks prior to the commencement of the experiment. The goats were weighed at the beginning of the experiment and once weekly before offering them feed. The animals were housed in individual pens in an open-sided type of house with corrugated iron roofing sheet and slatted floor. The animals were fed at 4 % of their body weight which was adjusted on weekly basis throughout the experimental period. Water was made available *ad libitum.* The experimental animals were reared on intensive management.

Experimental Diet

The concentrate offered as supplementary diet (Table 1) comprising maize, wheat offal, palm kernel cake (PKC), rice husk, urea, salt and bone meal was obtained from a reputable feed mill in Ikare-Akoko, Ondo State.

Experimental Design

The 12 experimental animals were grouped into three treatments, with four animals per treatment where each animal was a replicate. The animals were randomly assigned to the three treatments balanced for weight and designated as Groups 1 - 3 where Group 1 was the control fed 0% of cocoa leaf meal (CLM), Group 2 was fed 2.5% of CLM while Group 3 was fed 5% of CLM in a completely randomized design (CRD).

Proximate Analysis

The diets were analyzed for proximate composition according to the method described by AOAC (2005) while the fibre fractions were determined in accordance to the method of Van Soest *et al.* (1991).

Data collection on growth and dry matter intake

Data was obtained on performance of the animals in terms of weight gain, average daily weight gain, dry matter intake, feed conversion ratio, and average daily dry matter intake.

***Body weight**:* Weight of individual animal was measured at the commencement of the trial and subsequently on weekly basis before offering feed throughout the experiment using Measuretech® digital hanging scale of 50 kg capacity.

***Weight gain**:* This was determined as the final weight at the end of the experiment minus initial weight of the animal at the commencement of the experiment.

Average daily weight gain (ADWG): This was determined by dividing the total weight gained of each animal by the entire period of the experiment.

Dry matter intake: This was measured by recording the quantities of feed offered and quantities refused. The difference in the dry matter of feed offered and feed refused was taking as dry matter intake.

Daily dry matter intake: This was carried out by dividing the total dry matter intake by the number of days of the experiment.

Feed conversion ratio: It was measured by estimating the ratio of the dry matter intake to weight gain of animal.

$$FCR = \frac{\text{Daily dry matter intake (g/day)}}{\text{Daily weight gain (g/day)}}$$

FCR = Feed Coversion Ratio

Nutrient Digestibility Trial

At the completion of 63 days of feeding trial to assess the effect of cocoa leaf meal fortified with urea on performance of the experimental animals, three animals per treatment were moved to the metabolism cages. An adjustable period of seven days was allowed in the metabolism cage, after which the digestibility trial was carried out for a period of five days. Water was made available ad libitum and concentrate feed were offered at 4 % of the live body weight of each animal. Faeces passed out by each experimental goat were collected, weighed and recorded every day for five days before the daily feeding. This was carefully mixed together and 20 % of representative samples were taken and refrigerated at -4°C for later analysis. The feed offered and left over samples were also collected. Composite samples of feed offered, refusal and faeces at room temperature were oven dried at 60 °C for 72 hours. This was ground and screened through a 1 mm sieve which was used for analysis. Digestibility of dry matter (DM) was estimated and presented on dry matter basis. Standard analyses of feed and faecal samples were carried out in accordance with AOAC (2005) for DM, ash, nitrogen, and ether extract (EE). The neutral detergent fibre (NDF) was determined as described by Van Soest *et al*. (1991) while the acid detergent fibre (NDF) was analyzed according to AOAC (2005) using an ANKOM200 Fibre Analyser unit. Neutral Detergent Fibre was assayed without the use of alpha amylase but with sodium sulphate. Both NDF and ADF were expressed without residual ash.

Statistical Analysis

The data obtained were subjected to one-way Analysis of Variance in a completely randomized design (CRD) using SPSS 2015 version 23. Means among treatments showing significant differences were separated using the Duncan's multiple range test of the same package. The statistical model used is as follow: $Y_{ij} = \mu + T_i + \Sigma_{ij}$

Where:

Y_{ij}: Dependent variables

μ: Population mean

T_i: Effect of i^{th} on blood serum

Σ_{ij}: Residual error.

RESULTS

Table 1 showed the gross proximate composition of the experimental diets used for the study, which contained cocoa leaf meal at 0, 2.5 and 5 % inclusion levels for groups 1, 2 and 3, respectively with uniform quantity (0.50 %) of urea across the groups. Table 2 presented the proximate compositions and fibre fraction analyses of the experimental diets.

The growth performance characteristics of West African Dwarf goats fed varied levels

Table 1. Gross compositions of the experimental diets

Ingredient (%)	Group 1 (Control)	Group 2 (2.5 % CLM)	Group 3 (5 % CLM)
Maize	15.00	15.00	15.00
Cocoa leaf meal	0	2.50	5.00
Urea	0.50	0.50	0.50
Palm kernel cake	28.00	28.00	28.00
Rice husk	20.00	20.00	20.00
Wheat offal	32.50	30.00	27.50
Bone meal	2.00	2.00	2.00
Salt	2.00	2.00	2.00
Total	**100.00**	**100.00**	**100.00**
Calculated Nutrients			
Metabolizable energy (MJ/Kg DM)	22.33	22.22	22.99
Crude protein	12.95	13.07	13.38
Crude fibre	13.95	14.12	14.16

of dry cocoa leaf meal are as showed in Table 3. The final weight, weight gain and daily weight gain followed similar trends across the groups with the higher values of 7.83 kg, 2.64 kg and 41.94 g/day, respectively recorded for animals in Group 2 while lower similar values were obtained in other groups. The metabolism weight gain had highest (2.06 $kgBW^{0.75}$) value for animals in Group 2 meanwhile the least (1.08 $kgBW^{0.75}$) was obtained for animals in Group 3. In the like manner, total feed intake (16.26 kg), daily feed intake (258.15 g/day) and dry matter intake (283.68 g/day) were higher (P<0.05) in animals in Group 2 whereas lower similar values were obtained in animals in Groups 1 and 3. Better comparable feed conversion ratio (FCR) was recorded for goats in Group 2 (6.38) and Group 1 (7.83). Conversely, poorer (11.58) FCR was obtained for animals in Group 3.

The nutrient intake of West African Dwarf goats fed varied levels of dried cocoa leaf meal supplemented with urea is shown in Table 4. Crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were significantly (P<0.05) influenced. Crude protein was higher (11.980 and 10.850 g/day) in animals placed in Groups 2 and 3, respectively while lower (8.830 g/day) was obtained for animals in Group 1.

Table 2. Proximate composition and fibre fraction analysis of experimental concentrate diets

Parameters (%)	Group 1 (Control)	Group 2 (2.5 % CLM)	Group 3 (5 % CLM)
Ash	6.37	6.67	6.00
Ether extract	9.57	10.14	10.48
Crude protein	10.83	11.98	11.85
Crude fibre	11.56	12.31	12.82
Nitrogen free extract	48.80	45.78	45.82
Dry matter	87.13	86.88	86.97
Neutral detergent fibre	75.71	60.12	74.76
Acid detergent fibre	77.22	71.32	76.26
Acid detergent lignin	38.20	38.25	49.46
Hemicellulose	39.02	23.07	26.80

Table 3. Growth performance characteristics of West African Dwarf goats fed varied levels of dry cocoa leaf meal

Parameters	Group 1 (Control)	Group 2 (2.5 % CLM)	Group 3 (5 % CLM)	SEM	P-value
Initial weight (kg)	5.04	5.18	5.48	0.123	0.378
Final weight (kg)	6.79^{b}	7.83^{a}	6.58^{b}	0.198	0.000
Weight gain (kg)	1.75^{b}	2.64^{a}	1.10^{b}	0.243	0.004
Daily weight gain(g/day)	27.78^{b}	41.94^{a}	17.50^{b}	3.86	0.004
Metabolic weight gain ($kgBW^{0.75}$)	1.52^{b}	2.06^{a}	1.08^{c}	0.154	0.003
Total feed intake (kg)	13.61^{b}	16.26^{a}	12.77^{b}	0.545	0.000
Average daily feed intake (g/day)	216.06^{b}	258.15^{a}	202.65^{b}	8.65	0.000
Dry matter intake (g/day)	237.43^{b}	283.68^{a}	222.69^{b}	9.51	0.000
Feed conversion ration	7.83^{b}	6.38^{b}	11.58^{a}	0.835	0.003

Values are means and SEM (Standard Error of Means). [a,b,c:] Means on the same row with different superscripts are significantly (P < 0.05) different.

The least value (76.787 g/day) for nitrogen detergent fibre intake was obtained in animals placed in Group 2 while highest values (84.72 g/day) were obtained in goats in Group 3 which is comparable to the value (81.705 g/day) for animals in Group 1. Acid detergent lignin intake had lower values of 38.250 and 38.20 g/day in animals in Groups 2 and 1, respectively while higher value of 49.527 g/day was obtained for animals in Group 3.

Table 4. Nutrient intake of West African Dwarf goats fed varied levels of dry cocoa leaf meal supplemented with urea

Parameters (g/day)	Group 1 (Control)	Group 2 (2.5 % CLM)	Group 3 (5 % CLM)	SEM	P-value
Ash	6.345	6.670	6.255	0.667	0.051
Ether extract	8.640	9.735	8.687	0.1897	0.051
Crude protein	8.830[b]	11.980[a]	10.850[a]	0.491	0.002
Crude fibre	10.560	10.310	10.820	0.0774	0.071
Nitrogen free extract	54.800	50.780	51.980	0.703	0.063
Dry matter	89.145	89.475	88.592	0.045	0.053
Neutral detergent fibre	81.705[ab]	76.787[b]	84.720[a]	1.422	0.039
Acid detergent fibre	77.220	71.320	75.260	0.914	0.061
Acid detergent lignin	38.20[b]	38.250[b]	49.527[a]	1.898	0.000

[a,b] = means with different superscripts along rows were significantly different (P<0.05).

The nutrient digestibility of West African Dwarf goats fed varied levels of dry cocoa leaf meal supplemented with urea is shown in Table 5. The results showed that crude fibre, nitrogen free extract, dry matter and neutral detergent fibre digestibility values were not significantly (P>0.05) influenced. The ash had the highest digestibility value of 1.097 % for animals in Group 1, which is comparable to the value of 0.605 % obtained for animals in Group 2, while the least value of 0.248 % was obtained for animals in Group 3. Ether extract had higher digestibility value (3.262 %) in animals in Group 2 while lower similar values (2.207 and 2.070 %) were obtained for animals in Groups 3 and 1, respectively. Higher values of 4.405 and 5.200 % were recorded for crude protein digestibility of animals in Groups 2 and 3, respectively

Table 5. Nutrient digestibility of West African Dwarf goats fed varied levels of dry cocoa leaf meal supplemented with urea

Parameters (%)	Group 1 (Control)	Group 2 (2.5 % CLM)	Group 3 (5 % CLM)	SEM	P-value
Ash	0.248[b]	0.605[ab]	1.097[a]	0.143	0.017
Ether extract	2.070[b]	3.262[a]	2.207[b]	0.224	0.025
Crude protein	3.863[b]	4.450[a]	5.200[a]	0.535	0.001
Crude fibre	1.820	1.315	1.330	0.129	0.204
Nitrogen free extract	2.820	2.425	1.625	0.440	0.593
Dry matter	10.821	12.057	11.459	0.519	0.169
Neutral detergent fibre	29.725	28.432	34.372	1.230	0.099
Acid detergent fibre	23.88[a]	13.645[c]	18.38[b]	1.516	0.000
Acid detergent lignin	25.66[b]	23.845[c]	37.042[a]	2.079	0.000
Hemicellulose	28.45	25.23	21.24	1.052	0.060

[a,b,c] = Means with different superscripts along rows were significantly different (P<0.05).

while the least (3.863 %) was obtained for animals in Group 1. Acid detergent fibre digestibility value was highest (23.88 %) in animals in Group 1 followed by those in Group 3 (18.38 %) while the least value of 13.645 % was obtained in goats in Group 2. Acid detergent lignin digestibility value was highest (37.042 %) in animals in Group 3, followed by those in Group 1 (25.66 %) while the least (23.845 %) was obtained for those in Group 2. Digestibility of hemicellulose was highest (28. 45 %) in animals in Group 1, followed by animals in Group 2 (25.23 %) while the least (21.24 %) was obtained for animals in Group 3.

Table 6. Nitrogen utilization of West African Dwarf goats fed varied levels of dry cocoa leaf meal supplemented with urea

Parameters (g/day)	Group 1 (Control)	Group 2 (2.5 % CLM)	Group 3 (5 % CLM)	SEM	P-value
Nitrogen Intake	262.84[a]	185.31[b]	157.89[b]	18.89	0.029
Faecal Nitrogen	0.11	0.11	0.12	0.002	0.115
Urinary Nitrogen	1.21[b]	1.17[c]	1.25[a]	0.012	0.010
Nitrogen Output	1.32[b]	1.28[c]	1.37[a]	0.014	0.000
Nitrogen Absorbed	261.73	184.14	156.64	18.895	0.290
Nitrogen Retained	261.52	184.03	156.52	23.021	0.322
Nitrogen Digestibility (%)	99.58	99.37	99.20	5.11	0.621

[a,b,c] = Means with different superscripts along rows were significantly different (P<0.05).

Table 6 shows the nitrogen utilization of West African Dwarf goats fed varied levels of dry cocoa leaf meal supplemented with urea. Among the parameters investigated on nitrogen utilization, only nitrogen intake, urinary nitrogen and nitrogen output were observed to be significantly (P<0.05) influenced. Nitrogen intake was higher (262. 84 g/day) in animals in Group 1 while lower similar values of185.31 and 157.89 g/day were obtained in animals in Groups 2 and 3, respectively. Higher faecal nitrogen (0.12 g/day) was recorded for animals in Group 3 while lower value of 0.11 g/day was obtained for animals in Groups 1 and 2. Urinary nitrogen, which followed similar trend with nitrogen output, was highest (1.25 g/day) for animals in Group 3 while the least (1.17 g/day) was obtained for those in Group 2.

DISCUSSION

The ash content determined for the cocoa leaf meal (CLM) used in compounding the experimental diets in this study falls within the range of3.0 – 9.65 % reported by Okoli *et al*. (2001). This implies that CLM is rich enough to meet up with the mineral element requirements of West African Dwarf goats. The values obtained for the calculated crude protein and crude fibre were higher than the values determined. This variation could be due to the quality of the ingredients used, storage procedures, sample preparation and method of analysis which is in consonance with Brisibe *et al*. (2009). The values obtained for crude protein of the experimental diets were higher than the 7 % minimum requirement recommended by Norton *et al*. (1998) for effective rumen function of healthy goats. Similarly, crude fibre of the experimental diets used in this study was higher than the range of 9.63 - 11% recommended by Ekanem *et al.* (2022). Higher crude fibre of the experimental diets suggested adequate rumination and better performance of the animals which agreed with Sowande (2004) who reported that higher crude fibre is important for goats in the maintenance of best possible ruminal actions.

All the experimental diets had dry matter contents up to 86%, which is in consonance with the report of Adekanbi *et al*. (2020), and this suggested that cocoa leaf meal supplemented with urea in such proportions is capable of meeting the nutritional requirements for effective rumen function and metabolic activities. Acid detergent fibre, NDF and ADL values for all experimental groups were within the value ranges of 49.02 - 76.03%, 52.51 - 75.70% and 51.60 - 75.30%, respectively as reported by Asaolu *et al*. (2012) and the values had been reported to be moderately adequately when compared with high quality forages which ruminant graze effectively (Bakshi *et al*., 2013). Higher proportion of NDF obtained in this study could favourably influence dry matter intake and dry matter digestibility, this is in line with the report of Bakshi *et al*. (2014) that reported higher dry matter intake and digestibility due to increased proportion of NDF. Moderately high values of hemicellulose across the treatment groups could improve dry matter intake, as opined by Oladele *et al*. (2011) who reported that higher cellulose and hemicellulose improve dry matter intake of ruminant animals.

According to Oladele *et al*. (2011), cocoa leaf meal had higher protein content, fibre content and other nutrients such as vitamins and minerals that can be effective in improving weight gain in ruminants. This could be responsible for the improved feed intake and growth performance recorded for West African Dwarf goats in this study. The improved performance (in term of weight gain, metabolic weight gain and feed conversion ratio) recorded at 2.5% CLM inclusion level might be the optimum level in which WAD goats could maximally utilize the resources. Outcome of this study is in agreement with the findings of Ahmad *et al*. (2018) who found all growth performance parameters to be significantly ($P<0.05$) influenced in growing pigs fed with cocoa leaf meal.

The higher total feed intake recorded in animals in Group 2 might have necessitated corresponding increase in the final weight gain. The range obtained for final weight across the three groups were lower compared to the range of 10.4 – 10.8 kg reported by Mhomga *et al*. (2022) for WAD goats which could result from the variation in age, sex, initial weights of the animals at the commencement of the study and length of time used for the study. The average daily weight gain range obtained in this study was higher than range (11.2 – 17.9 g) reported by Owusu-Boakye *et al*. (2021) for WAD goats fed dry cocoa leaf meal fortified with urea. However, the average daily weight gain range obtained was closely related to range values of 20.8 – 41.4 g/day and 18.9 – 41.9 g/day reported by Makun *et al*. (2016) and Mhomga *et al*. (2022), respectively for WAD goats. The variation observed could be attributed to the effect of the dry cocoa leaf meal used and age of the goats.

Comparable best FCR obtained for animals in Groups 1 and 2 in this study suggested that dry CLM could be included in ruminant diets at 2.5% without any deleterious effect. The FCR obtained in goats in Group B was lower than earlier findings of Owusu-Boakye and Ofori (2019), who reported a range of 7.56 – 9.76 in WAD goats fed dry cocoa leaf meal fortified with urea. The differences observed might be due to the effect of difference in ages of the animals and other components added to the feed like urea.

The ash content reported for cocoa leaf meal supplemented with urea on nutrient intake of WAD goats in this study were higher than the range of 5.15 - 5.77 % reported for WAD goats fed nitrogen supplemented cassava peel meals (Ajagbe et al., 2020). The difference could be traced to variation in forage types, season, and other included feed ingredients (Oyewole and Aderinola, 2021). Similarly, the significant values obtained for CF on nutrient intake of the WAD goats in this study were lower than the range of 15.31-19.31 % reported by Oloche et al. (2015). The reduction in CF in this study might have caused increase in feed intake (McDonald and Edwards, 2006). The NDF and ADF contents obtained for nutrient intake falls within the value of >65 % reported for poor quality forages (Lemus, 2009) which might affect the digestion and utilization of the diets. Although it could be noted that the least values for NDF and ADF in Group 2 diet might be optimum level for the combination of urea and CLM to positively influence nutrient intake.

Digestion in ruminant animals is highly influenced by the level of protein and fibre in the diet. The CP digestibility was favoured in diets supplemented with urea which could increase microbial functions in the rumen, as reported by Adewumi and Ajayi (2010). Similar fibre digestion values across the groups indicated that CLM did not have any adverse effect on the animals and capable of influencing microbial synthesis in the rumen and consequently increase digestibility, as reported by Oyaniran et al. (2018). The values of NFE obtained for digestibility in this study was lower than the range of 70.11 - 73.91 reported for WAD goats fed cassava peel-cassava leaf meal-based diets (Ukanwoko et al., 2009), which might be due to the variation in ingredients used.

Lower and similar ADL values obtained for nutrient intake of animals in Groups 1 and 2 indicated that inclusion of 2.5% CLM could favour nutrient metabolism and absorption, since ADL is a useful measurement for assessing forage quality as higher levels could indicate decreased digestibility and nutritional value for livestock (Lemus, 2009). Thus, the CF, NDF and ADF intake in this study indicated the ability of the animals, to digest cell wall fractions and process structural carbohydrates, to obtain nutritional benefit from them (Eniolorunda et al., 2008). Hemicellulose can be a source of dietary fiber, providing some health benefits, including aiding digestion and promoting gut health (Lemus, 2009).

Nitrogen balance has been described as a good indicator of the protein value of a diet when the amino acid supply is balanced with the energy supply (Babayemi and Bamikole, 2006). The variations in N-intake might be attributed to the crude protein contents of the diets, bio-availability of the protein due to combination effects of ingredients, and protein intake of the animals as reported by Lamidi (2009). Higher nitrogen intake obtained across Groups 2 and 3 may be attributed to the urea treatment, making the diet more digestible. Thus, bringing about improved microbial degradation and maximized intake. The faecal N output (g/day) of WAD goats was an indication that there could be traces of undigested CP as well as reflection of N – intake level (Ahamefule et al., 2007). The faecal nitrogen value obtained in this study was lower than the 5.18 - 5.64 g/day reported by Chaturvedi and Artabandhu (2013) for sheep fed Prosopis julifora pods and Cenchrus grass. Also, the urinary N – output could probably be due to a reflection of nitrogen in the rumen which depends on the quantity and solubility of the diets. It was reported by Ahamefule and Udo (2010) that the N in the urine might be the one escaped from the rumen as ammonia gas and converted to urea. As a percent of nitrogen intake, nitrogen absorbed by the goats in the diets, which were similar, is a probable indication of a high nutrient digestibility of the diets.

CONCLUSION

This study revealed that the inclusion of dry cocoa leaf meal supplemented with urea in the diets of WAD goats had positive impact on the performance characteristics such as feed intake, weight gain, feed conversion ratio, nutrient intake, nutrient digestibility and nitrogen utilization. Based on the study, it could be recommended that supplementing WAD goat's diet with cocoa leaf meal up to 2.5 % had no deleterious effect on feed breakdown and nutrient intake. This will alleviate the feed stress that small ruminants experience during the long dry seasons. However, more research is needed to determine the optimal levels of this ingredient with/out urea in the diet formulation.

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