

Full Length Research Paper

Growth performance and rumen fermentation characteristics of West African Dwarf bucks fed dietary *Cochlospermum planchonii* rhizome

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Received 14 April, 2020; Accepted 26 May, 2020

A study was conducted to investigate the optimum inclusion level of *Cochlospermum planchonii* in diets of West African Dwarf (WAD) goats. Twenty five (25) WAD bucks aged 6 to 8 months and assigned to five treatments (T₁- T₅) of five goats each were used. Goats in T₁ were given normal diet and served as the control, while those in T₂, T₃, T₄ and T₅ were respectively given diets with inclusion levels of 5, 10, 20 and 40% *C. planchonii*. Feed intake, body weight (BWT) and body condition score (BCS) were evaluated weekly from day 0 (D0) to D84, while rumen pH, rumen ammonia, urinary and faecal nitrogen were assessed on D84. The total forage intake across the treatments was comparable ($p > 0.05$), but the total concentrate intake by T₅ (12.1 ± 0.8 kg) was significantly ($p < 0.05$) lower than the rest of the treatments. Supplementation of *C. planchonii* was associated with enhanced weight gain among the supplemented groups. The rumen pH of T₄ and T₅ were 6.2 ± 0.04 and 6.1 ± 0.1 respectively and these were significantly ($p < 0.05$) higher than those of T₁ (5.8 ± 0.1), T₂ (5.7 ± 0.1) and T₃ (5.6 ± 0.1), 6 h post feeding. At 12 h post feeding, the pH of T₅ was significantly ($p < 0.05$) higher than the rest of the treatments, while at 18 h post feeding, there was no significant difference in the rumen pH of all the treatments. The mean total volatile fatty acid produced by T₁ (59 ± 8.9) was significantly ($p < 0.05$) higher than that of T₅ (37.8 ± 6.3). It was therefore, concluded that supplementation of *C. planchonii* in diets of West African Dwarf goats up to 20% could exert beneficial effects on their productivity.

Key words: *Cochlospermum planchonii*, feed intake, dietary inclusion, rumen fermentation, performance, West African Dwarf bucks.

INTRODUCTION

Livestock rearing provides a strong economic support to peasant farmers in rural areas of Nigeria where 80% of

the population reside (Inoni, 2010). A wide range of services and products such as animal power, wool and

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supplementary nutrition are the benefits of livestock production (Devendra, 1993). However, in rural areas where modern veterinary health care system is very poor, the inhabitants have developed several indigenous veterinary health care practices to maintain livestock populations (Matekaire and Bwakura, 2004).

Ethnoveterinary practice is the application of local knowledge, skills, methods and beliefs in the management of animal health using natural plant products (Tiwari and Pande, 2010). These plants are used variously as anti-parasitic, antidiarrhoeal, antimicrobial as well as anti-inflammatory agents (Alawa et al., 2003; Ademola et al., 2004; Atawodi et al., 2005; Anyanwu and Okoye, 2017; Rawat et al., 2016; Oguntibeju, 2018). Other beneficial effects of plants in farm animal production include improved feed intake, increased secretion of digestive enzymes and improved immune system (Juyal and Singla, 2006; Dhama et al., 2014; Gheisar and Kim, 2018). Medicinal plants are also known to stimulate the endocrine system for enhanced reproductive capacity in both male and female animals (Chauhan et al., 2014; Khojasteh et al., 2016).

The use of *Cochlospermum planchonii* (leaves and roots) in the treatment of various disease conditions has become popular in the West African sub-region where it is widely distributed as a common weed of cultivation (Burkill, 1985). The leaves have been used in the treatment of diarrhoea, emesis and oedema (Anthony et al., 2005) while the roots are used for the treatment of typhoid fever, urinary tract infections and gastrointestinal disturbances (Nafiu et al., 2011; Isah et al., 2013). The plant is a preferred choice for grazing cattle in Burkina Faso (Nikiema, 2005). The phytochemical constituents of *C. planchonii* include saponins, alkaloids, phenolics, carbohydrates, flavonoids, glycosides, cardiac glycosides, triterpenes, tannins and steroids (Nafiu et al., 2011; Isah et al., 2013). Tannins, saponins, phenolics, alkaloids and flavonoids have been shown to possess anti-bacterial, anti-viral and anti-parasitic activities while in addition, tannins and flavonoids are thought to have anti-diarrheal activity (Enzo, 2007). There is scientific evidence that dietary inclusion of phytochemical components especially tannins positively affect average daily gain (ADG), decrease bloat in ruminants and decrease ruminal degradability of crude protein (Teferedegne, 2000; Min et al., 2006). This study was therefore conducted to evaluate the effects of dietary inclusion of *C. planchonii* on performance and rumen fermentation parameters of West African Dwarf bucks.

MATERIALS AND METHODS

Location of the study

The study was conducted at the Veterinary Teaching Hospital Complex, College of Veterinary Medicine, Federal University of Agriculture, Makurdi, Benue State, Nigeria. Makurdi is located within the Guinea Savanna Zone on longitudes 7° 47' E and

latitudes 6° 25' N, with an undulating topography of 1,500 to 3,000m.

Plant collection and processing

Rhizomes of *C. planchonii* were collected within the premises of the Federal University of Agriculture, Makurdi in March 2017. The rhizomes were peeled and carefully separated into small strands which were allowed to dry under shade for 7-8 days.

Study design and treatments

A total of 25 male WAD bucks aged 6-8 months were assigned to five dietary treatments ($T_1 - T_5$) groups of five goats each. Group T_1 was placed on a diet with 0% inclusion of *C. planchonii* meal, while $T_2 - T_5$ had 5, 10, 20 and 40% of *C. planchonii*, respectively included in their diet. Feed intake was measured daily while body weight and body condition score were measured weekly from D0 up to D84 of the experiment. On D78, three goats were selected randomly from each group for metabolism study. Rumen fluid was collected from experimental goats for determination of pH, rumen ammonia nitrogen and total volatile fatty acids, while the urine and faecal samples were analyzed for nitrogen balance.

Experimental animals and their management

The animals were purchased from Wannune goat market, in Tarka Local Government Area of Benue State, Nigeria. On arrival, they were dewormed using 2.5% oral suspension of albendazole (Albidol®, Concept Pharmaceuticals Ltd.), a broad spectrum anthelmintic, at the dose of 7.5 mg/kg. They were treated prophylactically against trypanosomosis using diminazene diaceturate (Dimaze®, Vetoquinol) at 3.5 mg/kg body weight and coccidiosis using 2.5% oral suspension of Toltrazuril (Kepcox®, Kepro B.V.) at the dose of 20 mg/kg body weight. The experimental animals were also treated against external parasites (fleas, lice and ticks) using 0.6% Permethrin powder which was dusted liberally all over the body of the animals, and then vaccinated against *Peste Des Petit Ruminants* (PPR), using *Peste Des Petit Ruminant Vaccine* (NVRI, Vom, Nigeria). The goats were identified using neck tags and housed in the experimental animal house located within the Veterinary Teaching Hospital Complex, Federal University of Agriculture, Makurdi.

The experimental animals were acclimatized for four weeks under the intensive management system (zero grazing), and the new feeding regime. The goats were fed twice daily: between 0800-0900 h and 1600 - 1700 h while water was provided *ad libitum*. One kilogramme of fresh *Andropogon gayanus* (Gamba grass) was fed to each goat in two divided rations (500 g in the morning and another 500 g in the evening) and this was supplemented with 250 g concentrate. Every morning before fresh feed was given; leftover of the previous day feed was carefully recovered and weighed. Weighing of feed and the leftover was done with an electronic Mettler balance (Zhongshan Camry Electronic Co. Ltd.). The difference between what was given and the leftover was recorded as feed consumed. Total feed consumption was determined by adding daily feed consumed over the total number of days for the experiment, while the average daily feed consumed was determined by dividing the total feed consumed (in grammes) by the number of days of the experiment.

Feed analysis

Feed samples were oven dried at 60°C until a constant weight was

Table 1. Proximate composition of experimental diets (% DM basis).

Component	Diets					Forage
	T1(0%)	T2 (5%)	T3 (10%)	T4 (20%)	T5 (40%)	
Dry matter	93.5	94.1	91.2	94.2	94.1	90.1
Crude protein	14.5	14.0	15.4	15.7	14.0	5.94
Crude fibre	5.89	7.38	8.68	10.1	16.0	39.9
Neutral detergent fibre	57	55	54.7	48.7	47.6	69.5
Acid detergent fibre	21.1	12.9	16.6	19.9	26.1	43.4
Lignin	2.8	3.7	4.2	4.5	5.2	7.0
Cellulose	17.4	10.1	12.1	15.7	20.9	36.4
Hemicellulose	35.9	42.1	38.1	28.8	21.5	26.1
Ether extract	7.50	6.60	4.10	4.20	7.00	1.30
Ash	5.30	5.45	6.40	6.75	9.20	6.65
Tannins (mg/g)	0.05	0.08	0.14	0.15	0.16	0.009
ME (KJ/KG)	3.21	3.13	2.83	1.79	1.63	1.02

obtained for proximate analysis according to the procedure of AOAC (2000) (Table 1). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to the methods of Van Soest et al. (1991) using an ANKOM 220 Fibre Analyzer (ANKOM Technology Corporation, NY, USA). Hemicellulose was calculated as NDF – ADF and cellulose as ADF – ADL (Rinne et al., 1997).

Body weight changes and body condition score

The goats were weighed on arrival and weekly thereafter until the end of the study using a Camry weighing balance (Zhongshan Camry Electronic Co. Ltd. Hong Kong, China). The initial body weight was taken as the weight recorded on day zero (D0) while final body weight was taken as the weight on the last day of the experiment. Total weight gain was calculated by subtracting the initial bodyweight from the final body weight. Mean weight gain was calculated by dividing total weight gain (grammes) by the number of days of the experiment. The body condition score (BCS) of all the animals were assessed on arrival and subsequently once weekly as described by Detweiler et al. (2008).

Ruminal fermentation parameters

Ruminal fluid was collected on D83 of the study through rumenocentesis using a 16 gauge needle with a 10 ml syringe from each of the animals used for the experiment at 6, 12 and 18 h post feeding. The puncture site was the ventral rumen at the left side on the horizontal line level with the top of the patella about 5-10 cm caudal to the last rib. The site was disinfected before inserting the needle. After the collection of rumen fluid the sample site was again disinfected to avoid infection. A digital pH meter was used to determine the pH of the rumen fluid immediately after collection. About 15 ml of rumen fluid was acidified with 10ml of 10% v/v sulphuric acid (H₂SO₄) solution, and frozen at -4°C until when required for the determination of total volatile fatty acid (AOAC, 2000) and ammonia nitrogen (Minor et al., 1977).

Faecal and urine nitrogen balance

Urine samples were collected into plastic containers containing 10% H₂SO₄ over a 7 day period. Samples of urine were collected by

putting the experimental animals in metabolic cages with elevated platforms. An aluminium tray was constructed with a sieve like cloth cover to allow passage of urine but prevented the passage of faecal material. The aluminium tray was placed under the cage at 6.00 pm and urine was collected from the tray at 8.00 am in the morning before the animals were fed. Urine collected was bulked and 10% of the total daily urine collected was sub-sampled and kept at -4°C until required for laboratory analysis. Faecal samples were collected by putting experimental animals on elevated platforms in metabolic cages with a piece of carton placed under the platform. The piece of carton was taken out in the morning to collect all the faecal droppings over the night period. Fifty grammes of daily faecal samples collected from each experimental animal was oven dried at 60°C to a constant weight. At the end of the collection period, the daily samples collected from each animal were thoroughly mixed together and a sub-sample was taken from the bulk and milled with a Christy and Norris mill to pass through 1 mm mesh before storage in air-tight containers for proximate analysis (AOAC, 2000).

Statistical analysis

All statistical analyses were done using SPSS (2017) version 21.0 for windows and results summarized as means ± standard errors of means. Data on parameters recorded on more than a single day, such as bodyweight, body condition score and feed intake were analysed by Repeated measures (Rm) ANOVA (Crawley, 1993). Parameters taken once such as body weight gain, volatile fatty acids and rumen pH were analyzed by one way ANOVA. Variant means were separated by the Duncan's multiple range test and probabilities (p) of 0.05 or less were considered significant.

RESULTS

Feed intake

Results of total forage intake, total concentrate intake, total feed intake and mean feed intake are presented in Table 2. The total and mean concentrate intake of T₅ was significantly (p < 0.05) lower than the rest of the treatment groups. The results revealed a decrease in feed intake with increasing concentration of *C. planchonii*. There was

Table 2. Feed intake of goats fed varying levels of *C. planchonii*.

Parameter	Inclusion level				
	0%	5%	10%	20%	40%
Total forage intake (kg)	17.9±0.3 ^a	17.9±0.2 ^a	18.3±0.3 ^a	18.0±0.3 ^a	17.5±0.3 ^a
Mean forage intake (g/d)	213.4±3.4 ^a	213.6±2.4 ^a	218.1±3.2 ^a	213.9±4.0 ^a	208.1±3.1 ^a
Total conc. intake (kg)	17.4±0.5 ^a	15.3±0.6 ^a	15.6±0.8 ^a	16.4±0.7 ^a	12.1±0.8 ^b
Mean conc. intake(g/d)	207.6±6.2 ^a	182.6±6.9 ^a	185.0±9.8 ^a	195.0±8.0 ^a	143.8±9.2 ^b
Total feed intake (kg)	35.16±0.49 ^a	33.27±0.57 ^a	33.87±0.9 ^a	34.25±0.76 ^a	29.55±0.66 ^b
Mean feed intake (g/d)	421.00±5.8 ^a	396.2±6.73 ^a	403±10.4 ^a	408.8±9.11 ^a	351.8±7.92 ^b

^{abc} Means with different superscripts within a row differ significantly ($p < 0.05$).

Table 3. Growth performance of goats fed varying levels of *C. planchonii*.

Parameter	Inclusion level				
	0%	5%	10%	20%	40%
Initial weight (kg)	7.3±0.3 ^a	7.5±0.2 ^a	7.4±0.3 ^a	7.5±0.9 ^a	7.4±0.3 ^a
Final weight (kg)	10.8±0.6 ^a	10.4±0.4 ^a	10.4±0.4 ^a	10.5±0.2 ^a	8.8±0.5 ^b
Total weight gain (kg)	3.5±0.4 ^a	2.9±0.4 ^{ab}	3.0±0.6 ^{ab}	2.9 ±0. ^{8ab}	1.4±0.3 ^b
Av. daily gain (g/day)	41.9±4.9 ^a	34±4.5 ^{ab}	36.2±7.2 ^{ab}	34.8±9.4 ^{ab}	18.9±2.7 ^b

^{abc} Means with different superscripts within a row differ significantly ($p < 0.05$).

a significant ($p < 0.05$) effect of time on feed intake but no significant ($p > 0.05$) interaction between time and treatment.

body condition score of the experimental animals as well as significant ($p < 0.05$) interaction between time and group.

Growth performance and body condition score

The growth performance response of goats fed varying levels of dietary *C. planchonii* is presented in Table 3. The mean initial body weight of experimental animals was 7.41 ± 0.19 kg. The mean weekly body weight as illustrated in Figure 1 showed a gradual and fairly constant increase in all the treatment groups from D0 to D84. However, the increase in mean bodyweight of T₅ was significantly ($p < 0.05$) lower than the rest of the treatment groups from D49 of the study. The highest body weight gain of 3.52 kg was recorded by T₁ while T₅ recorded the lowest weight gain of 1.44 kg. Similarly, the mean weight gain of T₁ was 41.9 g/day while that of T₅ was 18.94 g/day. Time had a significant ($p < 0.01$) effect on body weight gain but there was no significant ($p > 0.05$) interaction between time and treatments.

The result of body condition score as illustrated in Figure 2 showed there was a gradual and fairly constant increase in the body condition score of all treatments from D0 to D56. Thereafter, the body condition score of T₅ began to decline while that of the other treatments continued to appreciate till the end of the study. From D63 to D83, the body condition score of T₅ became significantly ($p < 0.05$) lower than the rest of the groups. There was a significant ($p < 0.05$) effect of time on the

Effect on rumen fluid

The pH of the experimental goats was measured at 6, 12 and 18 h post feeding and the results are presented in Table 4. The pH at 6 h post feeding significantly ($p < 0.05$) differed across treatment groups, with T₄ and T₅ being higher than the rest of the treatment groups. At 12 h post feeding, the pH of T₅ was significantly ($p < 0.05$) higher than those of the other inclusion levels. However, at 18 h post feeding, there were no significant ($p > 0.05$) differences in pH across the treatments. The mean total volatile fatty acids (TVFA) across treatments showed that T₁ had the highest (59.00 mm/l) TVFA concentration which was significantly ($p < 0.05$) higher than T₅ but did not differ from other inclusion levels. In general, the concentration of TVFA decreased as the level of *C. planchonii* inclusion increased (Table 5).

The effect of dietary *C. planchonii* on mean rumen ammonia is presented in Table 5. Rumen ammonia concentration was highest (55.31 mg/l) in T₁ and this was significantly ($p < 0.05$) higher than other treatments.

Effect on urine nitrogen

The percentage of urine nitrogen differed significantly ($p <$

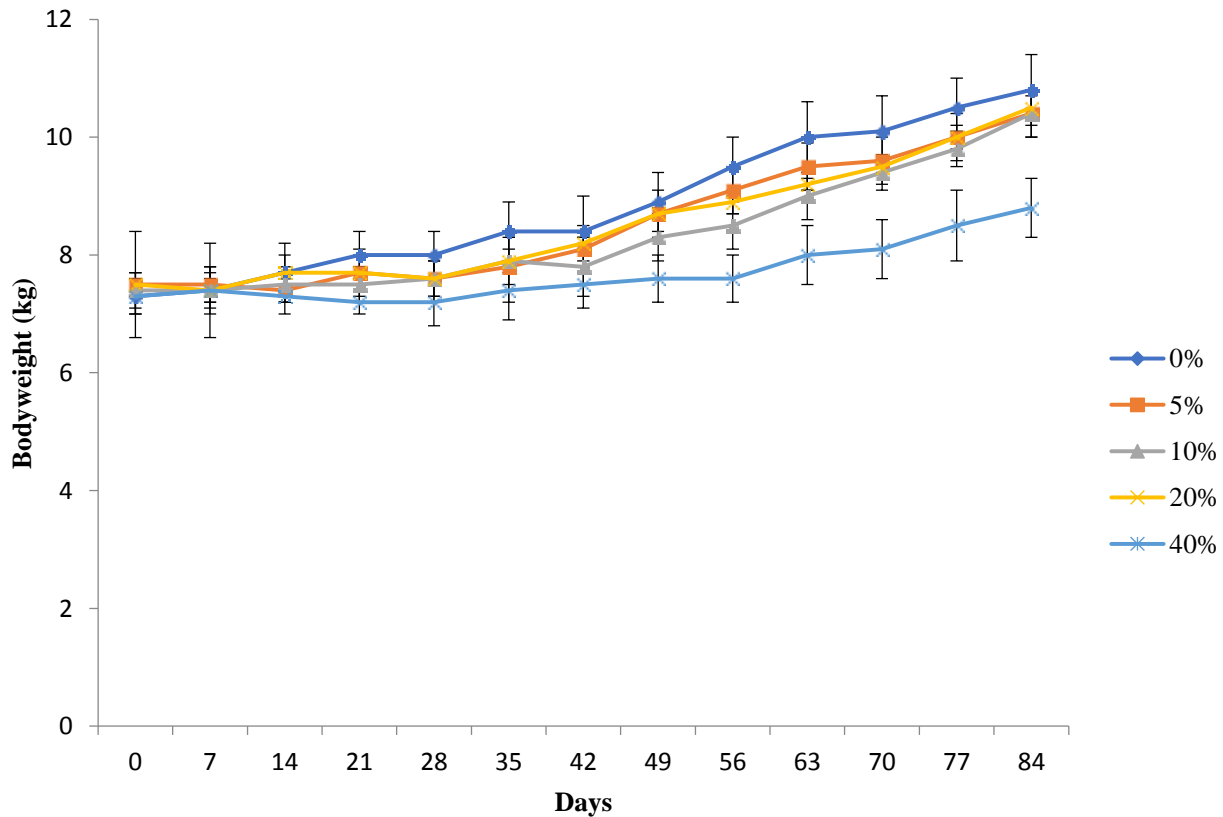


Figure 1. Effect of dietary *C. planchonii* inclusion on the body weight of WAD goats.

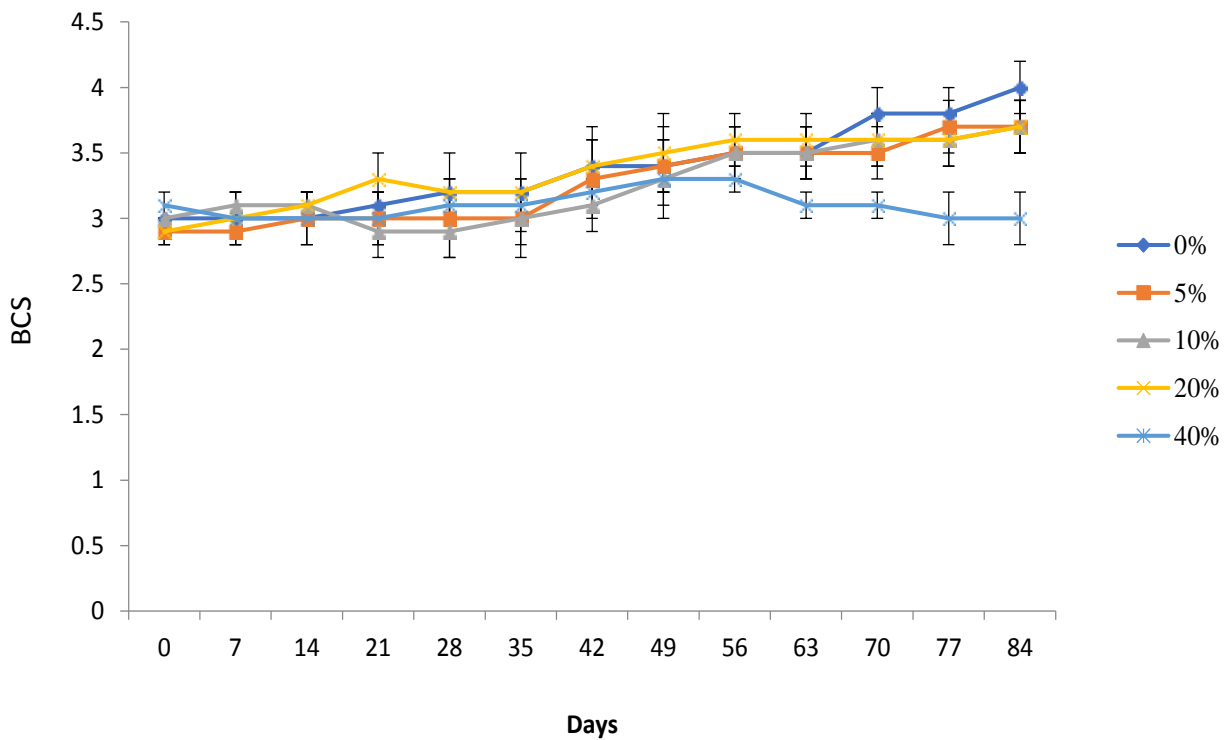


Figure 2. Mean weekly body condition score of goats fed graded levels of *C. planchonii*.

Table 4. Effect of *C. planchonii* inclusion in diet of WAD goats on rumen pH.

Parameter	Inclusion level				
	0%	5%	10%	20%	40%
6 hrs post feeding	5.82±0.1 ^b	5.70±0.07 ^b	5.60±0.05 ^b	6.16±0.04 ^a	6.13±0.08 ^a
12 hrs post feeding	5.16±0.27 ^b	5.14±0.13 ^b	5.18±0.19 ^b	5.15±0.12 ^b	5.80±0.18 ^a
18 hrs post feeding	6.26±0.23	6.06±0.12	6.23±0.10	6.33±0.30	6.37±0.15

^{abc} Means with different superscripts within a row differ significantly ($p < 0.05$).

Table 5. Effect of *C. planchonii* inclusion in diet of WAD goats on rumen volatile fatty acids, rumen ammonia and urine nitrogen.

Parameter	Inclusion level				
	0 %	5 %	10 %	20 %	40 %
Total VFA (mm/l)	59.0±8.86 ^a	50.25±1.03 ^{ab}	48.0±2.68 ^{ab}	47.25±3.47 ^{ab}	37.75±6.33 ^b
NH ₃ (mg/100ml)	55.31±7.74 ^a	50.52±4.23 ^a	45.05±4.16 ^a	43.1±2.28 ^a	22.81±1.87 ^b
Urine N ₂ (%)	0.39±0.04 ^a	0.41±0.03 ^a	0.28±0.02 ^b	0.19±0.02 ^c	0.10±0.01 ^d
Faecal N ₂ (%)	3.93±0.01 ^a	3.47±0.14 ^{ab}	3.43±0.31 ^{ab}	3.61±0.15 ^a	2.96±0.02 ^b

^{abc} Means with different superscripts within a row differ significantly ($p < 0.05$).

0.05) across treatments (Table 5). The T₁ and T₂ had comparable urine nitrogen values while the rest of the treatments were significantly ($p < 0.05$) lower than T₁. As the concentration of *C. planchonii* was increasing, the concentration of urine nitrogen was decreasing with T₅ having the least concentration of urine nitrogen at D84 of the study.

DISCUSSION

The crude protein obtained in all the diets exceeded 8%, the minimum limit needed by rumen microbes for optimum activity (Norton, 1994). This suggests that the quality of the diets met the requirements for effective rumen function. The crude fibre increased with increasing levels of *C. planchonii* in the diets and this may be attributed to the high cell wall constituents usually present in plant materials (Anbarasu et al., 2004). Dry matter intake of the concentrate decreased as the concentration of *C. planchonii* increased in the diets. The average daily concentrate intake ranged from 144 to 208 g/day and this was lower than the range of 364 to 457 g/day obtained by Adedeji et al., (2014) who fed concentrate and groundnut husk to West African Dwarf goats and 529 to 559 g/day by Ajayi et al. (2014) who also fed concentrate diets to WAD goats. These differences may be attributed to the high fibre content of the diet in the present study. Goats fed concentrate diet containing 30% pine bark were reported to have normal feed intake (Min et al., 2015) whereas those that were fed pine bark containing 3.2% had increased feed intake (Min et al., 2012). Solaiman et

al. (2010) reported that dry matter intake of growing goats increased when *Sericea lespedeza* ground hay (6.5 % condensed tannins in dry matter) replaced alfalfa meal in grain mixes, and Turner et al. (2005) reported that goats receiving the condensed tannins *S. lespedeza* hay (2.31%) had higher DMI than those fed alfalfa based diets. In this study, the results obtained for inclusion levels of 0, 5, 10 and 20% agreed with earlier reports (Turner et al., 2005; Solaiman et al., 2010; Min et al., 2012). This result might be due to considerable amounts of total tannins which possess anti-nutritional properties that decreased its palatability and rate of digestion as well as the high ash content (Abd El-Rahman et al., 2006; Patra and Saxena, 2010; Vargas-Magana et al., 2013). The DMI of fresh *A. gayanus* forage ranged from 208 to 213 g/day which was similar across the inclusion levels and this agrees with the report of Campbell et al. (2007) and Grande et al. (2014).

The level of *C. planchonii* inclusion affected the body weight of the experimental animals. The results indicated that all the treatment groups gained weight throughout the duration of the study. The weight gain of 18.9 to 41.9 g/day obtained in this study was similar to those reported by Ndemanisho et al. (1998) and Asaolu et al. (2012), for West African Dwarf (WAD) goats in the Southern Guinea Savannah where the average daily gain ranged from 22.3 to 60.1 g/day; while Makun et al. (2016) reported a range of 20.8 to 41.4 g/day in the Northern Guinea Savannah. The result was however, much higher than the 11.2 to 17.9 g/day reported by Ogunmoye (1995) for WAD goats fed soya bean based diets. Generally, T₁ had the highest total and average weight gain of 3.5 kg and 41.9 g/day,

respectively, and these were comparable with total and average daily gains of groups offered 5, 10 and 20% *C. planchonii* meal in this study. Meanwhile, the group that was offered 40% inclusion had the least total and average weight gain of 1.4 kg and 18.9 g/day, respectively, which differed significantly from the other treatments. Similar results have been reported by several authors on different forage legume supplementations (Sultan et al., 2009; Tripathi and Karim, 2010; Njidda and Nasiru, 2010). The low weight gain and growth rate of animals fed 40% inclusion could be related to low digestibility and energy content of the diet and also the binding effect of tannins to dietary proteins to inhibit utilization of endogenous proteins (Ngwa et al., 2002). Previous studies suggest that when supplementing or substituting forage legumes as protein sources, a higher level of crude protein has to be fed to alleviate the protein binding effects of tannins (Gilboa et al., 2000).

Body condition scoring is a subjective assessment of the fat level and muscle thickness around the lumbar vertebrae, breast bone and the rib cage (Treacher et al., 1986; eXtension.org. 2009). The body condition of goats in developing countries of the world varies substantially because of seasonal fluctuations in quantities and qualities of available feeds and, limited economic resources for use as nutrient-dense supplements (Urrutia-Morales et al., 2012). The inclusion of *C. planchonii* at 0, 5, 10 and 20% improved the body condition score of the goats throughout the experiment. On the other hand, animals fed with 40% inclusion were able to maintain their condition score till D56 when they began to lose body condition. The reasons for the decrease in body condition could be attributed to the low energy content of the diet as well as the reduction in the amount of feed consumed.

The pH is an efficient marker of rumen metabolism (Khaing et al., 2016). The ruminal fluid pH is probably the most important ruminal factor affecting microbial population and their activities (Nagaraja, 2012). The optimal pH range for microbial growth and fibre digestion reported by van Soest (1994) was 6.2- 7.2, while Karma (2005), Jallow and Hsia (2011), and Adebayo et al. (2017) reported values of 6.0 -6.9, 6.0- 7.2 and 6.3- 6.6, respectively. The results obtained in the present study revealed that time of sampling and dietary treatments had effects on the ruminal pH values of WAD goats fed varying levels of dietary *C. planchonii*. The values obtained at 6 h post feeding showed that the 20 and 40% inclusion levels were significantly higher than the other inclusion levels. Samples taken 12 h post feeding showed a significantly higher value for 40% inclusion level compared to the rest of the inclusion levels, while values taken at 18 h post feeding showed no significant differences across the treatment groups. The pH values recorded at the 12 h sampling period were lower than those of 6 and 18 h periods; it suggests an increase in the rumen fermentation of dietary treatments. Changes in

rumen pH of goats fed varying dietary treatments with respect to sampling time are suggestive of varying buffering capacity and degradation of feed in the rumen (Castillo-Gonzalez et al., 2014). These findings could be due to the increase in the production of saliva and/or changes in saliva composition induced by tannins present in *C. planchonii* meal. Similar findings have been previously reported (Silanikove et al., 2001; Salem et al., 2013; Yusuf et al., 2017). On the contrary, previous studies have also shown that dietary *Leucaena leucocephala* and *Manihot esculenta* leaves (Harun et al., 2017), dietary oak (Abarghuei et al., 2011), and Parkar leaves (Singh et al., 2011) did not affect the pH of the rumen.

The ruminal concentration of ammonia nitrogen is an effective indicator of microbial activity in the rumen (Adeyemi et al., 2016; Khaing et al., 2016). The minimum concentration of ammonia nitrogen needed for microbial protein synthesis is 5- 7 mg/dl (NRC, 1985) while the concentrations in the range of 10 - 20 mg /dl is needed for optimum fibre degradation in the rumen (Leng, 1990). In this study, there was a decrease in the concentration of ammonia nitrogen with increasing level of *C. planchonii* inclusion in the diet. The highest concentration of rumen ammonia nitrogen was observed in the 0% inclusion group, while the 40% inclusion group recorded the lowest value. The rumen ammonia nitrogen observed in this study were similar to the values of 20.08 -36.61 mg/L reported by Yashim (2014) in sheep fed *Ficus sycomorus* leaf diet and fell within the 2- 8 mg/dl reported for high producing ruminant livestock (Drewnoski and Poore, 2012). The decrease in the rumen ammonia nitrogen with increasing *C. planchonii* inclusion is suggestive of the protein binding effect of tannins which reduced the amount of protein available for degradation.

Total volatile fatty acids (VFA) was significantly affected by inclusion levels of *C. planchonii* meal with goats fed 0% recording the highest level of production (59 mm/L) while the least (37 mm/L) was obtained from the 40% inclusion group. Increased VFA concentration has been reported to be an indication of increased microbial activity (Oosting, 1993; Osakwe and Steingass, 2006; Liu et al., 2009). The lower production of VFA for the 40% inclusion level could be due to lower solubility of nitrogen and reduced availability of amino acids for VFA production (Yashim, 2014). The observation made in this study agrees with the report of Getachew et al. (2008) who also recorded lower VFA production by adding condensed tannins in batch culture of mixed rumen microorganisms. Other researchers have also reported that tannins could bind to proteins and to a lesser extent carbohydrates, thus slowing down their degradation in the rumen by lowering the activity of fibrolytic enzymes (Bhatta et al., 2005; Patra et al., 2012; Al-Kindi et al., 2017). The results of nitrogen balance showed decreased faecal and urinary losses with increasing levels of *C. planchonii* in the diets. The values of urinary nitrogen loss obtained in this study

fell within the range of 0.3- 0.4 g/day, but faecal nitrogen loss was above the 0.9- 2.3 g/day reported by Babayemi and Bamikole (2006). The decrease in faecal nitrogen loss observed in this study contradicts earlier reports of increased faecal nitrogen loss with increasing levels of tannins in diets (Carulla et al., 2005; Bengaly et al., 2007; Yousuf et al., 2014). High rumen degradation of dietary protein could be responsible for the high faecal nitrogen loss recorded by the 0% group. Longo et al. (2008) observed that protein- tannin complexes from different plant sources are utilized differently in an animal species. Therefore, the effect of *C. planchonii* on faecal nitrogen excretion may also be attributed to a decreased utilization of protein-tannin complex at the cellular and tissue levels.

Conclusions

This study demonstrated that inclusion of *C. planchonii* rhizome in diets of West African Dwarf goats had significant effect on their performance. Inclusion of up to 20 % *C. planchonii* rhizome in diets of WAD goats had beneficial effects as seen in improved feed intake, body weight gain and body condition score. Rumen fluid metabolites following such inclusion of *C. planchonii* were not negatively affected as supplemented groups had their values within normal range which implies rumen microflora was not depleted and hence fermentation was not affected. Therefore, for optimal productivity, *C. planchonii* could be supplemented in the concentrate of goat diets.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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