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NUTRIENT DIGESTIBILITY AND RUMEN FERMENTATION PROFILES OF GOATS FED DIETS CONTAINING UREA TREATED SUGARCANE WASTE AND KOLANUT HUSK

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ABSTRACT

A feeding trial that lasted 84days was conducted to assess the effect of urea-treated sugarcane waste and kolanut husk on rumen fermentation profiles and nutrient digestibility of West African dwarf female goats. A total of twenty four animals of about 5 – 6 months were randomly allocated to four treatment diets. Each treatment diet was replicated twice with three goats in a completely randomized design. The four formulated treatment diets include: T_A (100% guinea grass that served as the control diet), T_B (50% guinea grass and 50% urea treated sugarcane waste), T_C (50% guinea grass and 50% urea treated kolanut husk), and T_D (50% guinea grass and urea treated 25% sugarcane waste with 25% kolanut husk). The results showed that goats fed T_A were significantly ($P < 0.05$) highest in acetate (56.03%) while digestibility of ash (73.05%) was highest in goats fed T_B. Rumen ammonia nitrogen concentration (20.42mg/100ml) was significantly ($P < 0.05$) higher for goats on T_C than other treatment diets. Total volatile fatty acids (72.63Mmol/litre), propionate (15.95%), butyrate (7.94Mmol/litre) with digestibility of dry matter (73.01%), crude protein (80.96%), crude fibre (72.49%), ether extract (58.93%) and nitrogen free extract (71.31%) were significantly higher ($P < 0.05$) in goats placed on T_D compared with those on $T_{A,}$ T_B and $T_{C.}$ Rumen pH fluid of goats showed no significant difference ($P > 0.05$) among treatment diets. It can therefore be concluded that supplementation of 25% urea-treated sugarcane waste and 25% urea-treated kolanut husk to 50% guinea grass can enhance rumen fermentation profiles and improve nutrient digestibility in goats.

Keywords: Rumen fermentation, Digestibility, Urea, Agro-by-products, Goats.

INTRODUCTION

Inadequate feeding of livestock has been identified as one of the major factors responsible for poor performance of ruminant in the tropics. Ruminants are exposed to severe nutritional stress in Nigeria, most especially during the dry season. Forages available in this period are usually fibrous and devoid of most essential nutrients that are required for increasing rumen microbial fermentation and improved performance of the host animal (Okoruwa, 2015). This problem of scarcity and poor-quality feeds have led to weight losses, low birth rate and poor resistance to diseases in goats. This scenario of erratic supply of feeds has aggravated to low animal protein availability for human consumption in Nigeria (Akinfemi *et al*., 2018). Small scale farmers cannot afford the investment required to establish improved pastures or purchase concentrate feeds supplement to alleviate dry season poor growth rate and low performance of goats. Thus, it has become imperative for ruminant nutritionists to investigate ways of utilizing unconventional feeds that are of no nutritional benefits to man for feeding various classes of ruminants (Akinbode *et al*., 2018).

Kolanut husk and sugarcane waste are such unconventional feeds that have been identified {Saleh and Kaankuka, (2016) and Odebumi *et al.* (2009) as readily available feed inputs that can be referred to for feeding goats as supplements to pastures during the dry season. Though they can improve valuable nutrient in supporting goat performance, their limiting factors such as poor intake and low digestibility due to high fibre with low protein content require them to be treated in order to improve their nutrient quality as feeds. Kolanut husk and sugarcane waste that comprised peels with bagasse are produced in large quantities in south-south Nigeria. They contribute to environmental pollution and nuisance in areas where they are intensively produced. Some authors {Erasmus *et al*. (1986) and Ochepo *et al*. (2012)} have reported that treatment of sugarcane waste and kolanut husk with urea improve nitrogen content, digestibility and utilization of fibre by small ruminants. However, the information about supplementing urea treated sugarcane waste and kolanut husk or their combination with guinea grass in the diet of growing goats is scarce. Hence, this study was coined to determine the rumen fermentation profiles and nutrient digestibility of female goats fed diets containing urea treated sugarcane waste and kolanut husk.

MATERIALS AND METHODS

Description of the Study area

The study was conducted at the Sheep and Goat Unit of the Teaching and Research Farm, Ambrose Alli University, Ekpoma, Nigeria. The area is located on longitude 6.09^0E and latitude 6.42^0N within the humid climatic zone of southern Nigeria. The mean annual rainfall and temperature of the area is about 1556mm and 31^0C respectively with relative humidity of about 78%. The vegetation of this geographical zone represents an interface between the tropical rainforest and derived savanna.

Preparation of Experimental Diets

Guinea grass was obtained from Ambrose Alli Teaching and Research Farm between October and December. It was allowed to wilt overnight before manually chopped to length of about 4 – 5cm. Kolanut husk and sugarcane waste that comprised peels with bagasse (dry pulpy residue left after the extraction of juice from sugar cane) were collected from their processing areas within Ekpoma. The kolanut husk and sugarcane waste were fermented using urea solution. Two kilograms of urea was dissolved in 50 litres of water and carefully sprinkled on 50kg dry sugarcane waste and kolanut husk before they were thoroughly mixed separately. The treated sugarcane waste and kolanut husk were filled into large separate drums, compacted, sealed tightly with polyethylene sheets and covered with a heavy object placed on their cover. The ammoniated ensiled sugarcane waste and kolanut husk were opened after two weeks and sundried for 3days to eliminate volatile ammonia gas that can cause ammonia toxicity, before crushed into meals separately.

The ratio of the urea treated sugarcane waste; kolanut husk and their mixture as supplement to the basal diet (guinea grass) were 50:50 and 50:25:25, while guinea grass was served as the control diet. Hence the four treatment diets comprised T_A (100% guinea grass) ,T_B (50% guinea grass and 50% urea treated sugarcane waste) ,T_C (50% guinea grass and 50% urea treated kolanut husk), and T_D (50% guinea grass and urea treated 25% sugarcane waste with 25% kolanut husk).

Animals and their Management:

Twenty-four West African dwarf female goats were sourced from Ekpoma livestock market for the study. They were about 5 – 6months old with an average body weight of 5.00 ± 0.58kg. The goats were acclimatized for three weeks, during which they were de-wormed with albendazol bolus and sprayed using Diazinol 60% against internal and external parasites respectively, following the manufacturers recommendation. They were also treated with oxytetracycline against bacterial infection and vaccinated against *Pestes des petit* using PPR vaccine.

At the end of the adaptation period, the goats were randomly selected and assigned to each of the four experimental diets based on their balanced initial body weight. Each treatment was replicated twice with three goats in a completely randomized design. Goats were housed in individual pens and each pen was bedded with wood shaving that was changed twice weekly. Experimental diets were given at 5% dry matter of their body weight to the goats twice daily at about 8:00am and 5:00pm. The diets were completely mixed to discourage selective feed intake. Goats had free access to drinking water in their respective pens. The experiment lasted for 84days excluding the three weeks for adoption periods.

Rumen Study

Rumen fluid samples were taken at two hours post feeding once every week from the twenty-four goats throughout the study period. The rumen liquor was collected by means of suction tube thrust into the rumen compartment. As soon as the rumen fluid was obtained, the pH was measured within two minutes of collection by using manual digital pH meter. Fraction of the rumen fluid collected was pooled out and bulked together for each goat and made free of coarse particle by filtration with cheese cloth. Ten percent of the filtrate was then acidified with 1ml of a 5% (v/v) orthophosphoric acid solution and stored frozen in the airtight plastic containers to measure total volatile fatty acid concentration and it fractions. The other filtrated part was added to 10% sulphuric acid solution before they were stored in the refrigerator for analysis of ammonia nitrogen (NH_3 – N) concentration.

Digestibility Study

The digestibility study was carried out for 14days. Three West African dwarf female goats per treatment were selected and transferred into individual metabolic cages made for separate collection of faeces and urine. Treatment diets were offered to each goat daily with fresh clean water. After the first seven days, faeces voided per goat per day were collected at the last seven days of the trial. They were weighed and 10% aliquot of each day's collection of faeces from each goat was taken to the laboratory for dry matter determination. The oven-dried faeces were later bulked milled and stored in air-tight containers depending on the chemical analysis. Thus, the apparent digestibility of nutrient was determined using the formula:

Nutrient digestibility:

$$\frac{\text{nutrient intake} - \text{nutrient in faeces}}{\text{Nutrient intake}} \times \frac{100}{1}$$

Chemical and Statistical Analyses

Sample of urea treated sugarcane waste and kolanut husk with the experimental diets were analysed for proximate composition using the procedure of AOAC (2005). The oven dried faecal samples were also analysed for proximate composition (AOAC, 2005). Total volatile fatty acids concentration was determined by steam distillation process using Markham micro-distillation apparatus as described by Yusuf *et al.* (2013), while individual volatile fatty acids were analysed using gas chromatography (Vasta *et al*., 2009). Rumen ammonia nitrogen concentration was determined as described by Lanyansunya *et al.* (2007).

Data obtained from rumen fermentation profile and nutrient digestibility were subjected to analysis of variance (ANOVA) and significant difference between means were separated using Duncan multiple range test (SAS, 2009).

RESULTS AND DISCUSSION

The proximate compositions of the experimental diets are shown in Table 1. Dry matter content recorded in diet T_A (97.02%)

was highest, followed by T_B (93.42%) and T_D (92.08%) before T_C (90.73%). The observation indicates good feed preservation without spoilage. The crude protein values that ranged from 7.89 to 15.24% were higher in test diets (T_B, T_C and T_D) than the control diet (T_A). The variation observed could be as a result of urea added to test ingredients. It is of interest to note that crude protein values recorded in test diets were above the 8% C.P. required satisfying the maintenance requirements of goats (Norton, 2003). Crude fibre had the highest value in T_A (40.23%) and lowest in T_C (26.96%). The reduction of crude fibre content in test diets could be attributed to the ability of urea to produce ammonia during ensiling which helped to breakdown the lignin wall in the feed ingredients. Ash and ether extract values that ranged from 6.61 to 7.96% and 0.89 to 1.26% respectively, were low and close in range values. This could possibly be responsible for the content of minerals and fats present in the diets. Nitrogen free extract content that decreased in values with increase in crude fibre was higher in T_D (41.97%) and T_C (41.66%) than T_A (40.02%) and T_B (35.37%). The decrease in nitrogen free extract with increase in crude fibre content in the proximate gave credence to the report of Okoruwa and Bamigboye (2017) that dietary fibre is inversely related to energy utilization. The proximate composition of sugarcane waste and kolanut husk in this study was slightly different from the values reported by Saleh and Kaankuka (2016) and Odebumi *et al*. (2009) respectively. The addition of urea in the feeds could possibly be responsible for such variation.

Table 1: Proximate composition (%DM) of Urea treated test ingredients and experimental diets.

			Experimental Diets			
Parameters	**SW**	**KH**	**T_A**	**T_B**	**T_C**	**T_D**
Dry matter	92.82	87.43	97.02	93.42	90.73	92.08
Crude protein	10.06	12.49	7.89	13.02	15.24	13.63
Crude fibre	31.99	13.68	40.23	36.12	26.96	31.54
Ash	8.03	6.34	6.88	7.96	6.61	7.79
Ether extract	1.18	1.63	0.89	1.04	1.26	1.15
Nitrogen free extract	41.56	53.29	40.02	35.37	41.66	41.97

SW = sugarcane waste, KH = kolanut husk

As shown in Table 2, are the rumen fermentation profiles of goats fed experimental diets. Rumen pH that is sensitive to rumen environmental changes and microbial fermentation was not significantly ($P > 0.05$) influenced by treatment diets. Neutralization of rumen by urea treated test diets could probably have created buffer system which normally keep the pH of the rumen within the bounds for favourable fermentation to occur, despite the great variation caused by test diets. However, the rumen fluid pH values (6.37 – 6.68) recorded in this study were relatively stable and fell within the normal rumen pH range of values (6.0 – 7.0) reported for optimal microbial fermentation (Calsamiglia *et al*., 2008). Ammonia nitrogen concentration was reported as one of the major nitrogen sources used by rumen microbes to synthesis microbial protein which will stabilize rumen ecology for the production of protein nitrogen for ruminants (Zhang *et al*., 2015). The rumen ammonia nitrogen concentration of these goats was significantly ($P < 0.05$) highest in T_C (20.42mg/100ml) followed by T_D (17.06mg/100ml) and T_B (15.95mg/100ml) before T_A (9.34mg/100ml). This implies that more ammonia nitrogen was produced by goats on test diets due to higher fermentation rate for efficient capture to improve microbial protein synthesis than the control diet. The ammonia nitrogen values obtained in this study fell within the reference values reported by Villalba *et al*. (2006). These authors indicated that rumen ammonia nitrogen has a good profile with values between 2 and 5mg/100ml as a minimum rumen fluid for maximized rumen microbial synthesis, 15mg/100ml rumen fluid to maximize fibre digestion and 20mg/100ml rumen fluid to maximum intake. This explains that the ammonia nitrogen produced in the rumen of these studied goats were not in excess that would have led to high blood urea nitrogen in the goats. Total volatile fatty acids that play significant role in energy production of ruminants ranged between 60.34 and 72.63 Mmol/litre. Significant ($P < 0.05$) higher values were obtained in goats placed on T_B and T_D than those on T_A and T_C. This variation in this result might be connected with the test ingredients in the diets which led to changes in the production of rumen microbial fermentation and accumulation of total volatile fatty acids at specific pH value in the rumen. This fact is in consistent with the previous studies of Yusuf *et al*. (2013) and Okoruwa (2015) who suggested that total volatile fatty acids concentration in the rumen depends on factors such as digestibility, rate of absorption, rumen pH, rate of digesta passage from rumen to other parts of the digestive tracts as well as the microbial population in the rumen and their activities. Goats on control diet T_A (56.03%) were better significantly ($P < 0.05$) in production of acetate proportion in the rumen than those in test diets. This result is expected since higher amount of fibre in T_A was not neutralized by alkali treatment. This agrees with the report of Okoruwa (2015) that alkali treated diet neutralize about one third of volatile fatty acids produced in the rumen to sufficiently maintain fluid flow and pH control on the rumen. Propionate and butyrate fractions of volatile fatty acids that ranges from 8.11 to 15.92% and 3.98 to 7.94% respectively were significantly ($P < 0.05$) highest in goats on T_D and lowest in those on T_A. The low propionate and butyrate proportions observed in goats on control diet might constrain goats' performance as propionate has been reported as major glycogenic fatty acid production in ruminants (Kholif *et al.*, 2014).

Table 2: Rumen fermentation profiles of goats fed experimental diets

Parameters	Experimental Diets				
	T_A	T_B	T_C	T_D	SEM ±
Rumen pH	6.68	6.40	6.52	6.37	0.05
NH_3 – N (mg/100ml)	9.34^c	15.95^b	20.42^a	17.06^b	0.12
TVFAs (Mmol/litre)	60.34^b	70.72^a	65.83^b	72.63^a	1.95
Acetate (%)	56.03^a	48.97^b	46.33^b	42.82^c	1.23
Propionate (%)	8.11^c	12.62^b	10.69^b	15.92^a	0.62
Butyrate (%)	3.98^c	5.83^b	4.93^b	7.94^a	0.19

NH3 – N = Ammonia nitrogen
TVFAs = Total volatile fatty acids
^{a,b,c} Means in the same row with varying superscript differ significantly (P < 0.05)

Presented in Table 3, is the nutrient digestibility of goats fed diets containing urea-treated sugarcane waste and kolanut husk. Thorough understanding of unique ways of assessing digestibility in livestock increases the probability of achieving optimum ruminant performance in the tropics (Ikhimioya and Okoruwa, 2017). Dry matter digestibility of goats was significantly (P < 0.05) highest in T_D (73.01%) and lowest in T_A (51.67%). The reduced value of dry matter digestibility obtained in T_A could be attributed to poor nutrient retention with corresponding decrease in dry matter output of the goats. Digestibility of crude protein that ranged between 56.47 and 80.96% was significantly better in the test diets compared with the control diet. It could be possible that the test diets had higher levels of soluble crude protein that supplied more nutrients and better utilized to enhance nutrient availability than the control diet. This is in line with the findings of Akinbode *et al*. (2018) who reported that urea-treated supplemented feeds enhance crude protein efficiency and digestibility of poor-quality diets, as it supplies needed ammonia require for rumen microbial fermentation. Crude fibre digestibility was significantly (P < 0.05) highest in goats on T_C(70.03%) and T_D (72.49%) followed by T_B (67.64%) and T_A (49.68%). The least crude fibre digestibility recorded for goats on T_A could be as a result of enzymatic hydrolysis by the rumen microbes which could not digest the cell wall components and increase the fiber digestibility. High fibre in diets have been reported by Akinfemi *et al*. (2018) to cause poor feed retention thereby not allowing enough time for digestive enzymes to hydrolyze the fibre component of the diets. Ash digestibility values that ranged from 59.79% to 73.05% was significantly (P < 0.05) different among treatment diets. This disparity observed among the treatment diets could probably give an idea of the amount of mineral nutrient retained in the studied goats. Values of ether extract digestibility that ranged between 49.79 and 58.93% were significantly (P < 0.05) greater in T_B and T_D compared with T_A and T_C. It is of interest that ether extract digestibility of this study followed the same trend as total volatile fatty acids, which confirm the results of Kholif *et al.* (2014) who claimed a positive relationship between dietary energy and fat utilization, since fat and volatile fatty acids are said to be contributors of energy production in ruminants. Nitrogen free extract digestibility values (54.12 to 71.31%) had similar pattern of variation as dry matter digestibility. It could be deduced from this observation that factors affecting dry matter digestibility also relate to these nutrients, since they are components of dry matter. This is in agreement with the report of Okoruwa and Bamigboye (2017) that dry matter digestibility has a positive correlation with nitrogen free extract digestibility, hence is a direct tool use to determine how well ruminant absorb nitrogen free extract.

Furthermore, it is reasoned that urea-treated supplemented feed provides an ideal environment needed by rumen micro-organisms to process the mostly high fibre feeds eaten by ruminants and provide enough nutrients for the animal's body processes as well as fulfilling the production for which they are kept.

Table 3: Nutrient digestibility (%) of goats fed diets containing urea treated sugarcane waste and kolanut husk

Parameters	Experimental Diets				
	T_A	T_B	T_C	T_D	SEM ±
Dry matter	51.67^c	66.21^b	64.11^b	73.01^a	0.79
Crude protein	56.47^b	77.89^a	78.45^a	80.96^a	1.06
Crude fibre	49.68^c	67.64^b	70.03^a	72.49^a	1.23
Ash	61.27_c	73.05^a	59.79^c	66.99^b	1.63
Ether extract	49.79^b	56.64^a	50.82^b	58.93^a	0.34
Nitrogen free extract	54.12^c	67.01^b	65.92^b	71.31^a	0.98

[a,b,c]Means in the same row with varying superscript differ significantly ($P < 0.05$)

CONCLUSION

From the results of this study, it can be concluded that 25% urea treated sugarcane waste and 25% urea treated kolanut husk or their mixture can effectively serve as supplement feed ingredients in the diet of goats without any negative effect on rumen fermentation profiles and nutrient digestibility rather improve their performance most especially in the dry season, when forages are poor in quality.

However, this improvement was better enhanced in goats fed 50% guinea grass and 25% urea-treated sugarcane waste with 25% urea treated kolanut husk. Hence, this diet was recommended for better performance of goats.

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