EFFECTS OF DIFFERENTLY TREATED *THEOBROMA CACAO* POD HUSK SILAGE AND CASSAVA PEEL MEALS ON NUTRIENT UTILIZATION AND WEIGHT GAIN OF WEST AFRICAN DWARF GOATS

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ABSTRACT

The waste from agricultural produce is increasingly being viewed as a valuable source of alternative feed ingredients for livestock in spite of its usual fibrous nature, poor nutrients quality and low digestibility. This necessitated the need to upgrade the nutrient qualities. Thus, this study was conducted to assess the nutrient utilization and growth performance of West African Dwarf (WAD) goats fed ensilage of Theobroma cacao pod husk (TCPH) treated with non-protein nitrogen sources. Four diets were formulated such that; diet A, B, C and D respectively contained 10 % inclusion of raw TCPH, lye, poultry litter and urea-treated ensiled TCPH replaced with cassava peel meal in a concentrate diets; and fed to twenty-four WAD goats in a completely randomized design for sixty-three days. From the result; nutrient composition, nutrient intake, digestibility, nitrogen balance, weight gain and feed gain ratio were significantly (p<0.05) influenced by the dietary treatment. The highest crude protein (12.57 %), nitrogen balance (6.09 g/day) and least crude fibre (10.43 %), theobromine (1.36 %), and feed gain ratio (11.39) were obtained in goats fed diet D (10 % inclusion of urea-treated cocoa pod husk meal (CPHM) in the diet). Hence, ensiled urea-treated cocoa pod husk meal could enhance growth performance of goats without any adverse effect.

Keywords: Urea, Cocoa pod husk, Cassava peel meal, Digestibility, Performance, West African Dwarf goat

INTRODUCTION

2011 National Agricultural Sample Survey indicated that Nigeria was endowed with an estimated 19.5 million cattle, 72.5 million goats, 41.3 million sheep, 7.1 million pigs and 28,000 camels with Nigerian human population of about 195,656,437 in 2018. The lingering competition for feed or food by these two parties coupled with the ever increasing inflation rate has led to a tremendous increase in price of conventional feed resources in the country. There is need to ensure food security in the country. Hence, there is need to reduce the wide gap between animal protein need (35 g/day) and supply (8 g/day) in the diet of Nigerians (Skoet and Stamoulis, 2006) and if WAD goats are adequately harnessed, they can be used to bridge the gap. But their productivity is constrained by shortage of good quality and quantity feed, especially during the long dry season which results in poor nutrition, hence reduced their optimal performance.

Thus, there is need to identify more nutritious feeds to alleviate the prevailing nutritional problems and one of such promising crop residue is cocoa (*Theobroma cacao*) pod husk. Cocoa-pod husk is a by-product of the cocoa harvesting industry and it forms about 80 % of the cocoa fruit and it is essentially a waste product except for the negligible amount used in the manufacture of local soap and feeding of livestock. It is estimated that 0.8 to 1.0 million tons of cocoa pod husk is generated annually in cocoa farms in Nigeria (Smith, 1984). Cocoa pod is low in protein (6 %), high crude fibre (35.5 %) and high in cell wall components (57 % ADF, 66 % NDF and 24 % lignin) (Smith *et al.,* 1988; EFSA, 2008). Studies using high inclusion levels of untreated cocoa pod in diets have resulted in lower digestibility and poor growth performance in animals (Smith and Adegbola, 1982), confirming its low nutritional quality. Cocoa pod husk contain less theobromine (1.5 – 4.0 g/kg) compared to other cocoa by-products like cocoa bean shell (8.0 – 16.9 g/kg) and cocoa bean meal (20.0 – 33.0 g/kg) as reported by EFSA (2008).

All of these therefore, necessitated the development of appropriate physicochemical and biological treatment to nutritionally upgrade the husk (Adamafio, 2013; Omotoso *et al.,* 2017). Though, non-protein nitrogen (NPN) compounds are used by bacteria in the rumen of ruminants and these compounds are broken down to ammonia during the normal fermentation process in the rumen and has proven to be efficient in degrading fibrous feeds for optimum utilization by livestock (Fajemisin *et al.,* 2013). The use of urea, ammonia, lye solution and poultry litter to upgrade the nutritive value of straws and other low quality crop residues have been in use worldwide in the last three decades (Chineke *et al.,* 2013). Urea and poultry litter are the most commonly used. Inexpensive non-protein nitrogen (NPN) is alternative source and attractive protein replacement compared with nowadays tremendously expensive natural proteins. Proven chemicals such as sodium hydroxide, calcium hydroxide, potassium hydroxide and ammonia gas generated from urea under anaerobic conditions renders fiber more fragile and disrupt the bond between lignin and other digestible components in fibrous feedstuff thereby increases crude protein content, feed intake and digestibility of fibrous feeds and consequently, livestock productivity (Sutikno, 1997).

A suitable alternative which, under limited testing, appears as effective as sodium hydroxide is the caustic ash solution of some crop residues. Cocoa-pod ash, for example, contains about 44 mg of potassium per kg, and according to Adebowale (1985) the ash solution contains about 21 and 29 % OH ions in the form of NaOH and KOH respectively. Hence, this study was conducted to evaluate the performance of West African Dwarf (WAD) goats fed composite cocoa pod husk treated with lye, poultry droppings and urea.

MATERIALS AND METHODS

Experimental Site: The study was carried out at the Ruminant Section of the Teaching and Research Farm, and chemical analyses were done in the Nutrition Laboratory of the Department of Animal Production and Health, Federal University of Technology, Akure (FUTA) which is located on Latitude 7.15^0N and Longitude 5.12^0E and is of hot, wet equatorial climate. The mean annual rainfall is about 1,500 mm while the mean annual temperature is usually arround 26^oC (NMA, 2014).

Collection and Processing of Composite Cocoa Pod Husk: Cocoa pod husk was collected at cocoa plantation/farmland, Akure, Ondo State, sun-dried for 8 – 12 days, crushed at the FUTA feed mill to 2 mm particle size. The crushed pods were divided into four equal portions, the first portion was raw, second portion was treated with lye (cocoa pod ash) solution (v:w), third portion was treated with poultry droppings (1 kg poultry litter / 1 kg cocoa pod husk meal [CPHM]) and the fourth portion was treated with 5 % urea solution (1 litre urea solution / 1 kg CPHM) and each ensiled in 400 litres capacity plastic drums under anaerobic condition for 28 days, dried and thereafter stacked for use. The cassava peels were collected at cassava processing industries in Akure and its environs. The peels was treated by sun drying for 3 – 5 days depending on the intensity of the sun to reduce the cyanide content and moisture content while other convectional feed ingredients were bought at a reputable feed mill industry in Akure.

Diet Formulation: All dietary ingredients were analyzed for their proximate composition (AOAC, 2002) and four diets were formulated such that raw, lye (cocoa pod ash), poultry droppings and urea-treated ensiled were incorporated at 10 % inclusion into the diets that contained cassava peel meal (CPM) (Table 1).

Experimental Animals and Management: Twenty four WAD goats (does and bucks) of age range 1 – 2 years with an average live weight of 8.75 ± 0.51 kg were assigned to four dietary treatments of six replicates (3 does and 3 bucks) per treatment in a completely randomized design experiment. The goats were housed individually in pen measuring 1.8 x 0.5 m. The goats were acclimatized for thirty days during which routine managements like feeding on grasses and concentrate supplement. The animals were vaccinated against *Pesté-Petit dé Ruminanté* (PPR) using PPR vaccine at the rate of 1 ml per 10 kg body weight of an animal, treated against endo and ecto parasite using ivermectin at 1 ml per 10 kg body weight of animal subcutaneously, and drenched with albendazole. Acclimatization periods of 7 days (after quarantine) were allowed before commencement of data collection. The goats were fed with experimental diets, early in the morning (8:00 am) and cool, fresh drinkable water were supplied (*ad libitum*) during the experimental period of sixty three days. The daily feed intakes were determined by deducting the refusals from the quantity offered. The goats were weighed before the commencement of the experiment and repeatedly weighed weekly in the morning before feeding, to observe any weight change using spring-balance (hanging scale).

Digestibility Trial: The goats were placed in individual metabolic cages for a separate collection of urine and faeces and the digestibility trial will lasted for two weeks for digestibility trial. The goats were adapted to the metabolic cage for the first one week, while the second week was for samples collection. Total faeces were collected in the morning before feeding and watering during last 7 days of the experiment. The faeces were weighed fresh and 10 % of faeces collected from each animal were taken and oven-dried at 105^0 C for 48 hours to determine dry matter (DM) of the faeces. The faecal sample for each animal were thoroughly mixed, milled in a laboratory hammer mill to pass a 2 mm sieve and put in sealed polythene bags. These were stored in a cupboard at room temperature until required for analysis. The urine were also collected into a plague bucket placed under each cage to which 2 – 3 drops of 25 % H_2SO_4 were added in order to curtail volatilization of the ammonia from the urine (Ahamefule *et al*., 2006). The daily volume of urine output per animal for a period of 7 days were recorded and 10 % of daily output were saved in stopper plastic bottles, numbered and stored in a deep refrigerator at -5^0 C. Apparent digestibility of the diets were calculated as difference between nutrients intake and excretion in the faeces, expressed as a percentage of nutrient intake, while nitrogen retained by the animals were calculated as the difference between nitrogen intake and nitrogen excreted.

Laboratory and Statistical Analysis: The air-dried sample of feed and faeces from all the experimental animals were analysed for proximate, fibre fractions, gross energy and theobromine concentration, while urine samples were analysed for nitrogen according to standard procedures of AOAC (2002) procedures.

The data collected were subjected to analysis of variance using SAS (2008) and where significant differences were found, the means were separated using Duncan New Multiple Range Test of the same package.

RESULTS

Chemical Composition: Table 2 presents the nutrient composition of 10 % inclusion levels of raw and differently treated cocoa pod husk plus CPM fed to WAD goats and all the parameters observed were significantly influenced ($p<0.05$) by the treatment except DM. The DM contents of the diets ranged from 88.42 to 88.91 %.

Table 1: Gross composition of raw and differently treated *Theobroma cacao* pod husk meal-diets fed to West African dwarf goats

Ingredients (%)	A	B	C	D
Raw TCPH	10.00	0.00	0.00	0.00
Lye solution treated TCPH	0.00	10.00	0.00	0.00
Poultry dropping treated TCPH	0.00	0.00	10.00	0.00
Urea-treated TCPH	0.00	0.00	0.00	10.00
Cassava peels	40.00	40.00	40.00	40.00
Brewer dried grain	25.00	25.00	25.00	25.00
Wheat offal	5.00	5.00	5.00	5.00
Palm kernel cake	17.70	17.70	17.70	17.70
Bone meal	1.00	1.00	1.00	1.00
Salt	0.30	0.30	0.30	0.30
Premix	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00

Table 2: Chemical composition of 10 % inclusion levels of raw, lye, poultry droppings and urea-treated ensiled cocoa pod husk meal-diets fed to WAD goats

Parameters	A	B	C	D
Dry matter (DM)	88.52±0.52	88.49 ± 0.52	88.75 ± 0.55	88.91 ± 0.56
Crude protein (CP)	9.71 ± 0.14^{d}	10.15 ± 0.18^{c}	11.17 ± 0.18^{b}	12.57 ± 0.17^{a}
Crude fibre (CF)	16.74 ± 0.78^{a}	14.62 ± 0.72^{b}	11.39 ± 0.73^{c}	10.43 ± 0.75^{d}
Ether extract (EE)	5.31 ± 0.26^{a}	4.20 ± 0.25^{b}	3.62 ± 0.22^{c}	3.17 ± 0.22^{d}
Ash	6.58 ± 0.20^{a}	5.82 ± 0.18^{b}	5.51 ± 0.18^{c}	5.27 ± 0.16^{d}
Nitrogen free extract (NFE)	50.17 ± 1.61^{c}	53.70 ± 1.62^{b}	57.06 ± 1.67^{a}	57.47 ± 1.72^{a}
Gross energy (KJ/100g DM)	14.80 ± 0.20^{a}	14.69 ± 0.18^{b}	14.66 ± 0.17^{b}	14.63 ± 0.16^{b}
Neutral detergent fibre (NDF)	55.87 ± 1.85^{a}	53.96 ± 1.83^{b}	53.83 ± 1.82^{b}	50.05 ± 1.80^{c}
Acid detergent fibre (ADF)	46.20 ± 1.43^{a}	43.14 ± 1.42b^{c}	43.57 ± 1.43^{b}	42.64 ± 1.39^{c}
Acid detergent lignin (ADL)	15.53 ± 0.71a	12.19 ± 0.69^{b}	12.54 ± 0.70^{b}	10.18 ± 0.66^{c}
Hemicellulose	9.67 ± 0.19^{b}	10.82 ± 0.22^{a}	10.26 ± 0.21^{ab}	7.41 ± 0.20^{c}
Cellulose	30.67 ± 0.10^{c}	30.95 ± 0.11^{c}	31.03 ± 0.11^{b}	32.46 ± 0.11^{a}
Theobromine	1.70 ± 0.14^{a}	1.51 ± 0.12^{b}	1.42 ± 0.11^{c}	1.36 ± 0.09^{d}

abc = means within the same row with different superscripts are significantly (P<0.05) different. A: Raw cocoa pod husk, B: Lye (cocoa pod ash) treated ensiled cocoa pod husk, C: Poultry droppings treated ensiled cocoa pod husk, D: Urea treated ensiled cocoa pod husk

Diet D had the highest DM and the least DM was recorded in diet B. The values of the crude protein (CP) ranged from 9.71 % (diet A) to 12.57 % (diet D). The highest crude fibre (CF) content was observed in diet A (16.74 %), while the least value was recorded for diet D (10.43 %). Ether extracts value of diet A (5.31 %) was the highest. The ash content of the diets decreased across the dietary treatment with 10 % inclusion levels of differently treated CPHM in the diets. Diet D had the highest nitrogen free extract (57.47 %) while diet A had the least (50.17 %). The gross energy of the diet A (14.80 KJ/100g DM) was the highest and least in diet D (14.63 KJ/100g DM). The highest NDF (55.87 %), ADL (15.53 %), hemicellulose (10.82 %) and cellulose (30.67 %) were obtained in goats fed diet A. Theobromine concentration of the diets was highest (1.70 %) in diet A (10 % inclusion of raw CPHM in the diet) and least (1.36 %) in diet D (10 % inclusion of UTCPHM in the diet).

Nutrient Intake: The nutrients intake values of WAD goats fed 10 % inclusion levels of raw, lye treated ensiled, poultry-droppings treated ensiled and urea-treated ensiled cocoa pod husk plus cassava meals were presented in Table 3. The sex effect on nutrients intake by the goats were not significantly different (p>0.05).

Table 3: Sex effect on nutrient intake by West African dwarf goats fed 10 % inclusion levels of raw and differently treated CPHM diets

Source of variation			Dry matter	Crude protein	Crude fibre	Ether extract	Ash	Nitrogen free extract	Gross energy
Sexes		**F**	291.85 ± 7.18	35.28 ± 0.55	44.74 ± 1.10	13.94 ± 0.42	19.47 ± 0.07	178.43 ± 2.18	48.41 ± 1.32
		M	280 ± 7.15	33.89 ± 0.53	42.99 ± 0.09	13.39 ± 0.41	18.70 ± 0.06	171.43 ± 2.14	46.51 ± 1.29
Diets		**A**	261.30 ± 8.16^{c}	28.69 ± 0.08^{d}	49.41 ± 2.65^{a}	15.67 ± 0.78^{a}	19.42 ± 0.10^{a}	148.10 ± 5.19^{c}	43.69 ± 1.24^{b}
		B	296.84 ± 8.18^{b}	34.05 ± 1.00^{c}	44.04 ± 2.58^{b}	14.09 ± 0.75^{b}	19.52 ± 0.10^{a}	180.14 ± 5.17^{b}	49.28 ± 1.25^{a}
		C	300.60 ± 8.31^{ab}	37.83 ± 1.01^{b}	38.58 ± 2.48^{bc}	12.26 ± 0.68^{c}	18.66 ± 0.09^{b}	193.26 ± 5.20^{a}	49.65 ± 1.26^{a}
		D	302.55 ± 8.30^{a}	42.77 ± 1.07^{a}	35.49 ± 2.35^{c}	10.79 ± 0.69^{d}	17.93 ± 0.09^{b}	195.56 ± 5.21^{a}	49.78 ± 1.28^{a}
	Diets	**Sex**							
Sexes x Diets	**A**	**F**	271.75 ± 0.45^{c}	29.84 ± 0.07^{d}	51.39 ± 0.30^{a}	16.30 ± 0.10^{a}	20.20 ± 0.04^{a}	154.02 ± 0.32^{d}	45.44 ± 0.10^{c}
		M	250.85 ± 0.40^{cd}	27.54 ± 0.05^{e}	47.44 ± 0.20^{ab}	15.05 ± 0.08^{b}	18.65 ± 0.03^{b}	142.17 ± 0.14^{e}	41.94 ± 0.05^{d}
	B	**F**	302.78 ± 0.50^{ab}	34.73 ± 0.10^{c}	50.02 ± 0.30^{a}	14.37 ± 0.07^{bc}	19.91 ± 0.03^{b}	183.74 ± 0.55^{b}	50.26 ± 0.20^{a}
		M	290.90 ± 0.48^{b}	33.37 ± 0.10^{c}	48.06 ± 0.20^{ab}	13.81 ± 0.05^{c}	19.13 ± 0.03^{b}	176.53 ± 0.48^{c}	48.29 ± 0.14^{b}
	C	**F**	306.61 ± 0.50^{ab}	38.59 ± 0.15^{b}	39.35 ± 0.15^{b}	12.51 ± 0.05^{c}	19.04 ± 0.03^{b}	197.13 ± 1.05^{a}	50.65 ± 0.20^{a}
		M	294.59 ± 0.48^{b}	37.08 ± 0.15^{b}	37.81 ± 0.04^{c}	12.02 ± 0.05^{c}	18.29 ± 0.02^{c}	189.40 ± 0.55^{b}	48.66 ± 0.14^{b}
	D	**F**	314.65 ± 0.52^{a}	44.49 ± 0.29^{a}	36.91 ± 0.04^{c}	11.22 ± 0.04^{d}	18.65 ± 0.02^{c}	203.39 ± 1.05^{a}	51.78 ± 0.20^{a}
		M	290.45 ± 0.48^{b}	41.06 ± 0.29^{a}	34.07 ± 0.03^{d}	10.36 ± 0.03^{e}	17.22 ± 0.01^{d}	187.74 ± 0.55^{b}	47.79 ± 0.14^{b}

abc = means along same column with different superscripts are significantly (P<0.05) different. M = Male; F= Female. A: Raw cocoa pod husk, B: Lye (cocoa pod ash) treated ensiled cocoa pod husk, C: Poultry droppings treated ensiled cocoa pod husk, D: Urea treated ensiled cocoa pod husk

The results revealed that female goats consumed more of their feed/nutrients than the males. The nutrients intake was significantly influenced ($p<0.05$) by the treatment. The nutrients intake increased with increased inclusion of 10 % urea-treated CPHM except for CF, EE and ash. The dry matter intake (DMI) ranged from 261.30 g/day (diet A) to 302.55 g/day (diet D). The goats fed diet D had the highest intake (302.55 g/day). However, goats fed diet C had statistically similar ($p>0.05$) DMI value (300.60 g/day) but numerically different. The crude protein intake (CPI) ranged from 28.69 g/day (diet A) to 42.77 g/day (diet D). However, goats fed 10 % inclusion level of urea-treated ensiled cocoa pod husk plus CPM based-diet (diet D) consumed more protein than other goats fed other experimental diets. The crude fibre intake (CFI) ranged between 35.49 g/day (diet D) and 49.41 g/day (diet A), while goats fed diet A had highest ether extract (15.67 g/day). The ash value of goats fed diet D was the least and the highest nitrogen free extract of 195.56 g/day was recorded among goats fed diet D. The highest gross energy intake (49.78 g/day) was recorded for diet However, the values obtained for WAD goats fed diets C and D are statistical similar($p>0.05$). Meanwhile, the least energy intake (43.69 g/day) was recorded for goats fed diet A. The interactive effects of goat sexes x diets showed that there was significant influence ($p<0.05$) by the treatments. The dry matter intake ranged from 250.85 g/day (Male fed diet A) to 314.65 g/day (Female fed diet D), the highest crude protein intake values were observed in goats fed diets D, and bucks had 41.06 g/day while the females had 44.49 g/day. The crude fibre intake ranged from 34.07 g/day (males fed diet D) to 51.39 g/day (females fed diet A) and the least ether extract intake (EEI) value (10.36 g/day) was recorded for male fed diet E. Ash intake ranged from 17.22 g/day (males fed diet D) to 20.69 g/day (females fed diet B). It was observed that the female goats fed diet E had highest nitrogen free extract (NFE) intake (203.39 g/day) however, the male goats fed diet A had the least value (142.17 g/day). The gross energy intake ranged from 41.94 g/day (males fed diet A) to 51.78 g/day (females fed diet D).

Fibre Fractions Intake: Table 4 presents the fibre fractions intake by WAD goats fed 10 % inclusion levels of raw and differently treated cocoa pod husk meal (TCPHM) diets. The NDF intake of goats fed diet A had least intake (164.92 g/day). The ADF intake by goats was significantly influenced ($p<0.05$) by the treatment. However, the goats fed diet A had the least ADF value (136.38 g/day). The ADL intake values ranged from 34.64 g/day (diet D) to 45.84 g/day (diet A). The least hemi-cellulose and cellulose intake values observed in this study were observed in goats fed diets D (25.22 g/day) and A (90.53 g/day) respectively.

The sex effect on fibre fraction intake by the goats were not significantly different ($p>0.05$). The results revealed that females consumed more of the feed than male goats. The effect of sex times diet on fibre fraction intake was influenced by treatment on CPHM in the diets. The least value of the NDF intake (166.91 g/day) was recorded for male goats fed diet D. The highest ADF intake values were observed in female goats fed diet C. The ADL intake ranged from 33.95 g/day (males fed diet D) to 46.76 g/day (females fed diet A) and the least hemi-cellulose intake value (24.71 g/day) was recorded for male fed diet D. Cellulose intake ranged from 88.72 g/day (males fed diet A) to 112.67 g/day (females fed diet D).

Nutrients Digestibility: The nutrients digestibility of WAD goats fed 10 % inclusion levels of raw and differently treated CPHM in the diets was presented in Table 5. The percentage nutrients digestibility was relatively higher in female goats than the males. However, the values obtained were not significantly ($p>0.05$) influenced by the sex. The dry matter digestibility ranged from 67.37 % (diet A) to 76.56 % (diet D), while the crude protein digestibility ranged from 63.77 % (diet A) to 78.17 % (diet D). However, goats fed 10 % inclusion level of urea-treated ensiled CPHM plus CPM in the diet consumed more protein than goats fed other test diets.

Table 4: Sex effect on fibre fractions intake by WAD goats fed 10 % inclusion levels of raw and differently treated cocoa pod husk meal diets

Source of variation			Neutral detergent fibre	Acid detergent fibre	Acid detergent lignin	Hemi-cellulose	Cellulose	Theo-bromine
Sexes		**F**	176.83 ± 0.44	145.56 ± 0.68	42.53 ± 0.02	31.26 ± 0.06	103.04 ± 0.02	4.99 ± 0.02
		M	169.89 ± 0.38	139.86 ± 0.90	40.86 ± 0.09	30.04 ± 0.50	98.99 ± 2.00	4.79 ± 0.08
Diets		**A**	164.92 ± 0.08^{c}	136.38 ± 0.08^{c}	45.84 ± 0.80^{a}	28.54 ± 0.20^{c}	90.53 ± 0.62^{c}	5.07 ± 0.03^{a}
		B	181.01 ± 1.12^{a}	144.71 ± 0.90^{b}	40.89 ± 0.40^{c}	36.30 ± 0.50^{a}	103.82 ± 0.98^{b}	5.02 ± 0.03^{a}
		C	182.32 ± 1.12^{a}	147.57 ± 1.36^{a}	42.47 ± 0.60^{b}	34.75 ± 0.30^{b}	105.10 ± 0.98^{b}	4.81 ± 0.02^{b}
		D	170.31 ± 0.80^{b}	145.10 ± 0.90^{b}	34.64 ± 0.04^{d}	25.22 ± 0.08^{d}	110.46 ± 1.50^{a}	4.63 ± 0.01^{c}
	Diets	**Sex**						
Sexes x Diets	**A**	**F**	168.22 ± 0.08^{d}	139.10 ± 0.20^{c}	46.76 ± 0.30^{a}	29.12 ± 0.07^{c}	92.34 ± 0.50^{c}	5.12 ± 0.78^{a}
		M	161.62 ± 0.03^{e}	133.65 ± 0.19^{d}	44.93 ± 0.29^{ab}	27.97 ± 0.06^{cd}	88.72 ± 0.31^{d}	4.92 ± 0.56^{b}
	B	**F**	184.63 ± 1.99^{a}	147.61 ± 1.09^{ab}	41.71 ± 0.22^{b}	37.02 ± 1.04^{a}	105.90 ± 1.30^{ab}	5.17 ± 0.80^{a}
		M	177.39 ± 0.15^{b}	141.82 ± 0.30^{bc}	40.07 ± 0.21^{b}	35.57 ± 0.09^{b}	101.75 ± 0.87^{b}	4.96 ± 0.57^{b}
	C	**F**	185.97 ± 1.98^{a}	150.52 ± 2.01^{a}	43.32 ± 0.29^{ab}	35.45 ± 0.09^{b}	107.20 ± 2.18^{a}	4.91 ± 0.52^{b}
		M	178.68 ± 0.15^{b}	144.62 ± 0.70^{b}	41.62 ± 0.22^{b}	34.06 ± 0.08^{b}	103.00 ± 1.29^{ab}	4.71 ± 0.27^{bc}
	D	**F**	173.72 ± 0.09^{c}	148.00 ± 1.09^{ab}	35.33 ± 0.01^{c}	25.72 ± 0.04^{d}	112.67 ± 2.22^{a}	4.72 ± 0.27^{bc}
		M	166.91 ± 0.08^{d}	142.20 ± 0.69^{b}	33.95 ± 0.01^{c}	24.71 ± 0.04^{d}	108.25 ± 2.19^{a}	4.54 ± 0.04^{c}

abc = Means along same column with different superscripts are significantly (P<0.05) different. M = Male; F= Female. A: Raw cocoa pod husk, B: Lye (cocoa pod ash) treated ensiled cocoa pod husk, C: Poultry droppings treated ensiled cocoa pod husk, D: Urea treated ensiled cocoa pod husk

Table 5: Nutrients digestibility (%) of WAD goats fed 10 % inclusion levels of raw and differently treated cocoa pod husk meal diets

Source of variation			Dry matter	Crude protein	Crude fibre	Ether extract	Nitrogen free extract	Gross energy
Sexes		**F**	72.21 ± 0.08	73.17 ± 0.08	76.53 ± 0.09	72.64 ± 0.08	71.11 ± 0.06	69.25 ± 0.09
		M	69.38 ± 0.11	70.31 ± 0.12	73.53 ± 0.10	69.79 ± 0.12	68.33 ± 0.14	66.54 ± 0.08
Diets		**A**	67.37 ± 1.20^{d}	63.77 ± 2.21^{c}	69.04 ± 1.56^{d}	65.29 ± 1.98^{d}	64.84 ± 1.51^{d}	62.64 ± 2.12^{d}
		B	70.42 ± 1.21^{c}	74.68 ± 2.34^{b}	74.48 ± 1.81^{c}	69.39 ± 2.01^{c}	68.64 ± 1.52^{c}	65.27 ± 2.13^{c}
		C	72.22 ± 1.32^{b}	77.65 ± 2.57^{a}	77.10 ± 1.84^{b}	73.24 ± 2.08^{b}	73.13 ± 1.75^{b}	71.76 ± 2.16^{b}
		D	76.56 ± 1.35^{a}	78.17 ± 2.58^{a}	82.63 ± 1.87^{a}	80.34 ± 2.18^{a}	76.43 ± 1.81^{a}	76.48 ± 2.21^{a}
	Diets	**Sex**						
Sexes x Diets	**A**	**F**	68.72 ± 2.00	65.05 ± 2.89	70.42 ± 3.01	66.60 ± 1.32	66.14 ± 1.61	63.89 ± 1.31
		M	66.02 ± 1.56	62.49 ± 4.51	67.66 ± 1.89	63.98 ± 4.21	63.54 ± 3.54	61.39 ± 4.19
	B	**F**	71.83 ± 3.06	76.17 ± 5.27	75.97 ± 4.09	70.78 ± 4.51	70.01 ± 1.67	66.58 ± 2.35
		M	69.01 ± 2.01	73.19 ± 3.19	72.99 ± 4.08	68.00 ± 1.47	67.27 ± 3.62	63.96 ± 4.32
	C	**F**	73.66 ± 3.07	79.20 ± 5.56	78.64 ± 3.16	74.70 ± 4.56	74.59 ± 3.92	73.20 ± 4.58
		M	70.78 ± 3.06	76.10 ± 5.34	75.56 ± 4.14	71.78 ± 4.54	71.67 ± 3.87	70.32 ± 4.44
	D	**F**	78.09 ± 3.11	79.73 ± 5.56	84.28 ± 4.43	81.95 ± 4.65	77.96 ± 3.95	78.01 ± 4.65
		M	75.03 ± 3.09	76.61 ± 5.29	80.98 ± 4.12	78.73 ± 4.57	74.90 ± 3.91	74.95 ± 4.61

abc = means within the same row with different superscripts are significantly (P< 0.05) different. A: Raw cocoa pod husk, B: Lye (cocoa pod ash) treated ensiled cocoa pod husk, C: Poultry droppings treated ensiled cocoa pod husk, D: Urea treated ensiled cocoa pod husk

The CF digestibility of WAD goats ranged between 69.04 % (diet A) and 82.63 % (diet D), while goats fed diet D had highest EE digestibility (80.34 %) and highest NFE digestibility (76.43 %).

Fibre Fraction Digestibility: Table 6 presents the fibre fraction digestibility of WAD goats fed 10 % inclusion levels of raw and differently TCPHM plus CPM diets. The sex effect significantly ($p>0.05$) influenced the fibre fraction digestibility however, female goats digested the fibre fractions components better than the males. The neutral detergent fibre (NDF) had the highest digestibility value of 78.12 % in goats fed diet D. However, the goats fed diet A had least digestibility value (70.14 %). Goats fed diet A had the least value (74.18 %) of acid detergent fibre (ADF) digestibility; acid detergent lignin was best digested in goats fed diet D (74.01 %). The least digestibility values of hemicelluloses (64.54 %) and cellulose (73.93 %).

From all the parameters observed, it was noted that the interactive effect between sex and diets on digestibility of WAD goats were significantly influenced ($p>0.05$) by the different treatment on the CPHM in the diets. The NDF digestibility ranged from 69.00 % (males fed diet A) to 79.68 % (females fed diet D). The highest ADF digestibility was recorded for female goats fed diet D (81.92 %). The ADL digestibility ranged from 63.38 % (males fed diet A) to 75.49 % (females fed diet D) and the least hemi-cellulose digestibility was recorded for male goats fed diet A. It was observed that the female goats fed diet D (78.32 %) had the highest cellulose digestibility; however the male goats fed diet A had the least value (72.45 %).

Nitrogen Utilization: The nitrogen utilization of WAD goats fed 10 % inclusion levels of raw and differently treated CPHM diets was presented in Table 7. The nitrogen intake and nitrogen balance (g/day) of WAD goats were significantly influenced ($p<0.05$) by the treatment. The sex effect on nitrogen utilization were not significantly influenced ($p>0.05$) by the treatment. The results of the sex effect on the nitrogen utilization revealed that female goats utilized more of the nitrogen than the males. The observed nitrogen intake by the male goats was 5.42 g/day and the value recorded for the female goats was 5.64 g/day. The observed nitrogen balance by the female goats was 5.19 g/day and the male goat was 4.98 g/day. The nitrogen intake ranged from 4.59 g/day (diet A) to 6.84 g/day (diet D). The faecal nitrogen and urinary nitrogen of goats fed diet A was the least value (0.11 and 0.04 g/day) respectively. The goats fed diet D had the highest faecal and urinary nitrogen loss. The nitrogen balance recorded for goats fed diet D had the highest value (6.09 g/day). The result of interactive effect of sex x diets on nitrogen utilization revealed that the parameters evaluated were not significantly ($p>0.05$) influenced by the dietary treatments. The nitrogen intake ranged from 4.50 g/day (males fed diet A) to 6.98 g/day (females fed diet D); the female goats fed diet D had the highest nitrogen intake (6.98 g/day). The least nitrogen absorbed was recorded for male goats fed diet A (4.35 g/day) and the highest nitrogen balance was recorded for female goats fed diet D (6.22 g/day). The performance characteristics of WAD goats fed 10 % inclusion levels of raw and differently TCPHM plus CPM diets. The results of the sex effect on performance revealed that female goats utilized more of their diets than the male goats. The average daily weight gain of males and females were 18.83 g/day and 19.23 g/day respectively, while the feed to gain ratio of male and female were 17.33 and 17.05 respectively.

Furthermore, the effect of diets on growth performance of the goats was significant ($p<0.05$) influenced by the treatment except initial body weight however, goats fed diet A had the least average final body weight (0.83 kg). The daily weight gain recorded for goats fed diet D was the highest (26.56 g/day) while the least (9.22 g/day) was recorded for goats fed diet A. The feed to gain ratio ranged from 11.39 (diet D) to 28.34 (diet A). Meanwhile, no mortality was recorded for goats fed diet D however; mortalities were recorded on treatment A to C. The interactive effect of goat sexes x diets on performance characteristics revealed that the weekly body weight, daily

Table 6: Fibre fraction digestibility (%) of WAD goats fed 10 % inclusion level of raw and differently treated cocoa pod husk meal diets

Source of variation			Neutral detergent fibre	Acid detergent fibre	Acid detergent lignin	Hemicellulose	Cellulose
Sexes		**F**	74.90 ± 0.24	78.69 ± 0.23	69.89 ± 0.19	69.72 ± 0.18	76.92 ± 0.21
		M	71.96 ± 0.19	75.60 ± 0.18	67.15 ± 0.18	66.99 ± 0.10	73.91 ± 0.20
Diets		**A**	70.41 ± 1.24^{d}	74.18 ± 0.83^{c}	64.67 ± 1.48^{d}	64.54 ± 0.95^{c}	73.93 ± 0.41^{c}
		B	72.89 ± 1.28^{c}	77.23 ± 0.09^{b}	68.22 ± 1.56^{c}	68.60 ± 0.96^{b}	75.67 ± 0.45^{b}
		C	75.05 ± 1.27^{b}	78.11 ± 1.00^{b}	70.56 ± 1.58^{b}	70.07 ± 0.97^{a}	75.89 ± 0.45^{b}
		D	78.12 ± 1.30^{a}	80.31 ± 1.00^{a}	74.01 ± 1.65^{a}	70.53 ± 0.96^{a}	76.78 ± 0.48^{a}
	Diets	**Sex**					
Sexes x Diets	**A**	**F**	71.82 ± 2.61^{c}	75.66 ± 2.08^{c}	65.96 ± 3.11^{c}	65.83 ± 2.04^{bc}	75.41 ± 1.39^{b}
		M	69.00 ± 2.14^{d}	72.70 ± 2.01^{d}	63.38 ± 3.08^{d}	63.25 ± 2.10^{c}	72.45 ± 1.29^{d}
	B	**F**	74.35 ± 2.65^{b}	78.77 ± 2.17^{ab}	69.58 ± 3.12^{b}	69.97 ± 2.11^{ab}	77.18 ± 1.52^{a}
		M	71.43 ± 2.22^{c}	75.69 ± 2.08^{c}	66.86 ± 3.10^{c}	67.23 ± 2.09^{b}	74.16 ± 1.36^{c}
	C	**F**	76.55 ± 2.70^{ab}	79.67 ± 2.16^{ab}	71.97 ± 3.12^{b}	71.47 ± 2.17^{a}	78.32 ± 1.52^{a}
		M	73.55 ± 2.66^{b}	76.55 ± 2.14^{b}	69.15 ± 3.11^{b}	68.67 ± 2.09^{b}	75.24 ± 1.41^{b}
	D	**F**	79.68 ± 2.75^{a}	81.92 ± 2.20^{a}	75.49 ± 3.14^{a}	71.94 ± 2.16^{a}	77.41 ± 1.53^{a}
		M	76.56 ± 2.71^{ab}	78.70 ± 2.16^{ab}	72.53 ± 3.12^{b}	69.12 ± 2.10^{ab}	74.37 ± 1.41^{b}

abc = means within the same row with different superscripts are significantly (P< 0.05) different. *A: Raw cocoa pod husk, B: Lye (cocoa pod ash) treated ensiled cocoa pod husk, C: Poultry droppings treated ensiled cocoa pod husk, D: Urea treated ensiled cocoa pod husk*

Table 7: Effect of sex on nitrogen utilization (g/day) and growth performance characteristics of WAD goats fed 10 % inclusion levels of raw and differently treated cocoa pod husk meal diets

Source of variation			Nitrogen intake	Faecal nitrogen	Urinary nitrogen	Nitrogen balance	Initial weight (kg)	Final weight (kg)	Weight gain (kg)	Daily weight gain (g/d)	Feed gain ratio	Number of mortality
Sexes		**F**	5.64 ± 1.18	0.32 ± 0.01	0.14 ± 0.01	5.19 ± 0.10	9.14 ± 0.06	10.72 ± 0.06	1.57 ± 0.02	18.83 ± 0.23	17.33 ± 0.05	1.43 ± 0.02
		M	5.42 ± 1.08	0.30 ± 0.01	0.14 ± 0.01	4.98 ± 0.18	8.78 ± 0.05	10.26 ± 0.05	1.47 ± 0.02	19.23 ± 0.22	17.05 ± 0.04	1.37 ± 0.02
Diets		**A**	4.59 ± 0.19^{d}	0.11 ± 0.01^{c}	0.04 ± 0.01^{c}	4.44 ± 0.05^{d}	9.03 ± 0.09	9.86 ± 0.17^{c}	0.83 ± 0.01^{c}	9.22 ± 0.23^{c}	28.34 ± 0.06^{a}	2.00 ± 0.01^{a}
		B	5.45 ± 1.17^{c}	0.42 ± 0.03^{b}	0.15 ± 0.02^{b}	4.88 ± 0.11^{c}	8.93 ± 0.15	10.83 ± 0.21^{b}	1.90 ± 0.03^{b}	21.10 ± 0.47^{b}	14.06 ± 0.04^{b}	1.00 ± 0.01^{b}
		C	6.05 ± 1.23^{b}	0.39 ± 0.03^{b}	0.21 ± 0.04^{a}	5.45 ± 0.14^{b}	8.93 ± 0.19	10.80 ± 0.29^{b}	1.87 ± 0.03^{b}	20.78 ± 0.51^{b}	14.46 ± 0.04^{b}	1.00 ± 0.01^{b}
		D	6.84 ± 1.25^{a}	0.50 ± 0.03^{a}	0.25 ± 0.05^{a}	6.09 ± 0.18^{a}	8.93 ± 0.21	11.33 ± 0.33^{a}	2.39 ± 0.05^{a}	26.56 ± 0.59^{a}	11.39 ± 0.01^{c}	0.00 ± 0.00
	Diets	**Sex**										
Sexes x Diets	**A**	**F**	4.68 ± 0.13	0.11 ± 0.02	0.04 ± 0.01	4.53 ± 0.07^{d}	9.21 ± 0.33	10.99 ± 0.37^{ab}	0.72 ± 0.01^{d}	9.91 ± 0.39^{d}	28.70 ± 0.04^{a}	2.04 ± 0.08^{a}
		M	4.50 ± 0.14	0.11 ± 0.02	0.04 ± 0.01	4.35 ± 0.09^{d}	8.85 ± 0.27	9.03 ± 0.23^{c}	0.89 ± 0.02^{d}	9.30 ± 0.34^{d}	28.40 ± 0.04^{a}	1.96 ± 0.07^{ab}
	B	**F**	5.56 ± 0.18	0.43 ± 0.03	0.15 ± 0.01	4.98 ± 0.10^{c}	9.11+0.30	10.81 ± 0.31^{b}	1.70 ± 0.04^{b}	22.90 ± 0.49^{ab}	14.20 ± 0.04^{bc}	1.00 ± 0.07^{b}
		M	5.34 ± 0.16	0.41 ± 0.03	0.15 ± 0.01	4.78 ± 0.11^{c}	8.75 ± 0.23	10.35 ± 0.23^{c}	1.60 ± 0.03^{b}	21.22 ± 0.44^{c}	14.92 ± 0.05^{c}	1.00 ± 0.07^{b}
	C	**F**	6.17 ± 0.20	0.40 ± 0.03	0.21 ± 0.02	5.56 ± 0.13^{b}	9.11 ± 0.29	10.89 ± 0.29^{b}	1.78 ± 0.03^{b}	20.20 ± 0.45^{c}	14.08 ± 0.04^{bc}	1.02 ± 0.07^{b}
		M	5.93 ± 0.19	0.38 ± 0.02	0.21 ± 0.02	5.34 ± 0.15^{b}	8.75 ± 0.25	10.43 ± 0.28^{b}	1.68 ± 0.04^{b}	20.47 ± 0.45^{c}	14.80 ± 0.03^{c}	0.98 ± 0.07^{b}
	D	**F**	6.98 ± 0.29	0.51 ± 0.05	0.26 ± 0.03	6.22 ± 0.17^{a}	9.11 ± 0.30	11.02 ± 0.38^{ab}	2.31 ± 0.05^{a}	26.14 ± 0.52^{a}	11.55 ± 0.03^{d}	0.00 ± 0.00
		M	6.71 ± 0.21	0.49 ± 0.05	0.25 ± 0.03	5.97 ± 0.15^{b}	8.75 ± 0.26	11.54 ± 0.41^{a}	2.38 ± 0.05^{a}	25.33 ± 0.48^{b}	11.82 ± 0.02^{d}	0.00 ± 0.00

abc = Means on the same row but with different superscripts are significantly different (P<0.05). A: Raw cocoa pod husk, B: Lye (cocoa pod ash) treated ensiled cocoa pod husk, C: Poultry droppings treated ensiled cocoa pod husk, D: Urea treated ensiled cocoa pod husk body weight changes and feed/gain ratio determined were not significantly (p>0.05) influenced by the dietary treatment. The final weight of the goats ranged from 9.03 kg (males fed diet A) to 11.54 kg (males fed diet D), while the daily weight gain ranged from 9.30 g/day to 26.14 g/day. However, male (25.33 g/day) and female (26.14 g/day) goats fed diet E had the highest daily weight gain respectively. The feed to gain ratio ranged from 11.55 (females fed diet D) to 28.70 (females fed diet A). However, the result revealed that female goats fed diet D utilized their feed better than other goats and no mortality was recorded on the treatment.

DISCUSSION

The dry matter (DM) contents of all the experimental diets were comparably low to DM contents reported by Uza *et al.* (2005) when treated cassava peels with 8 % urea. This might be attributed to the dry nature and coarseness of the diets. Though, the high DM value noticed in diet C could be attributed to the dry nature of the poultry manure used. Also, it could also be noted that the CP content of poultry dropping-treated CPHM; and 5 % urea-treated CPHM had improved values over the 10 % inclusion of raw and lye treated CPHM. This indicated that the significant improvement could be as a result of the nitrogen contribution derived from uric acid, which can be efficiently used by rumen microbes for protein production, and perhaps, because of the processing method (ensiling technology and proper drying) and these CP contents are adequate to enact microbial activities in the rumen and these was evident in their feed consumption level probably due to the palatability of the diets. Consequently, nutrient intake values was best for diet containing 10 % inclusion level urea-treated TCPH in the concentrate diet. Meanwhile, theobromine concentration intake reduced significantly in UTCHM diets. Hence, it could be said that the urea treatment enhanced the nutritional quality of the diet by degrading the fibrous nature of the pod and relatively detoxify the theobromine concentration.

The nutrient intake progressively increased across the treatment with increased supply or availability of nitrogen/nutrients in the diets. Dry matter intakes (DMI) were stimulated by the protein quality of the diets. Crude fibre intake (CFI) gradually declined with increased CPI. These results agreed with the report of Okoruwa and Agbonlahor (2016) when the growth performance of WAD sheep fed cocoa pod husk with soursop pulp meals was evaluated.

The lower nutrient intake by the bucks could be traced to the arrangement of goats in the pen - they placed side by side, and could see each other and thus, the bucks concentrated more on how to service the does, hence, lost their ingestive drives. The result of this study showed that inclusion level of UTCPH in the diets both increased the nitrogen absorbed and retained by the experimental goats better than other treatments. The increment in nitrogen retention agreed with the results of Fajemisin *et al.* (2013) when WAD goats were fed urea treated corn cob silage diets. The observed increment also compared favourably with the result of Erika and Anuraga (2015) in an experiment to improve the nutritional quality of cocoa pod through chemical and biological treatment for ruminant feeding. The urea treatment provided an additional source of nitrogen which can be utilized by rumen microbes for their microbial protein synthesis and subsequent utilization of the protein by the host animals (Erika and Anuraga, 2015) and this is evident in the does fed diet E as they performed better than others. The probable conversion of volatile fatty acid from urea treated CPHM, produced by microbial action in the rumen to metabolisable energy is a major advantage of treating cocoa pod with urea (Iyayi *et al*., 2001).

The effect of urea treatment on the CPHM diets was evident in improved utilization and apparent nutrients digestibility of the diets because the rumen microbes combined the ammonia with products of carbohydrate metabolism to form amino acids and hence, proteins. The proteins formed in this manner (from NPN compounds) are similar in amino acid content to the proteins available to the animal when the principal source of dietary nitrogen is intact protein. The bacteria and protozoa, and the protein they contain, are digested by the animal farther on in the digestive tract. In this manner, the ruminant animal makes use of certain NPN compounds even though it does not possess enzymes of its own for their breakdown. Thus, the fibre fractions and nutrients were well utilized. The mortality recorded in treatment fed diet A, B and C could be attributed to the residual effect of long time feeding of the pod which limits its use in livestock industries. Before the death of those animals, the following were noticed; increased heartbeat rate, increased urination and while post-mortem was done, internal bleeding was noticed. All these are indications of theobromine poisoning according to Adamafio (2013). Several reports indicated that feed intake is an important factor in the utilization of feed by ruminant livestock and a critical determinant of energy intake and performance in small ruminants (Ososanya *et al*., 2010).

The growth response by the WAD goats revealed that WAD goats fed diet D (10 % inclusion of 5 % urea-treated CPHM in concentrate diet) had the overall best performance in terms of highest crude protein, crude protein intake, nutrient digestibility coefficient values, nitrogen balance and least crude fibre content and feed gain ratio. This supported the report of Panday (2016) that urea feeding has advantageous effects on body weight, growth rate, and milk yields of animals. This is probably because urea contains 46.7 % of nitrogen compared to 16 – 18.87 % for most feed proteins source. Hence, feeding urea reduces the need for imported protein supplements with no deleterious effects on the animal and its use is based on its easy transformation into ammonia.

Conclusion: The study established that WAD goats fed 10 % inclusion level of urea-TCPHM plus CPM diet performed best. It is evident that the urea treatment upgraded the nutritional quality (degraded the fibre and enhanced the protein quality) of cocoa pod husk meal. Thus, ruminant farmers should harness the potentials in the cocoa pod husk for improved and sustainable ruminant animal production.

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