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Influence of cocoa pod-based diets on the performance, milk yield and composition of West African dwarf goats.

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Abstract

The agricultural produce known to be a waste product is increasingly being viewed as a valuable source of alternative feed for livestock. The use of these products might have detrimental effect(s) on the animals and this necessitated the need to upgrade the nutrient qualities. So, the combinations of the products as silage could influence the reproductive performance and milk yield of West African dwarf goats.

Twenty sexually mature WAD does aged 7-8 months with average body weight of 9 ± 0.00 kg were sourced from livestock market at Otun Ekiti, Nigeria. They were randomly allotted into five treatment groups and each treatment consisted of 4 does per replicate and thereafter subjected to completely randomized design for thirty-two weeks feeding trial. The diets contained four levels of fermented cocoa pod at 0, 5, 10, 15 and 20 and cassava pulp at 60, 55, 50, 45, 40 percent levels respectively while 40% Acacia leaf were included in all the groups.

Combinations of the silage had significant (P<0.05) effects on the reproductive performance of does. The results revealed that there were increased does body weight (14.60 ± 0.14 kg), birth weight (1.27 ± 0.02 kg) and weaning weight (7.70 ± 0.14 kg) of weaners on diets T5 (20% cocoa pod, 40% cassava pulp and 40% acacia leaves). Likewise, does on 20% cocoa pod, 40% cassava pulp and 40% acacia leaves had high significant (P<0.05) milk composition and (3,400.97 ml/animal/month) milk yield compared to others. Cocoa pod could be included in goats diets up to 20% without adverse effect on the reproductive performance, milk yield and composition.

Keywords: Acacia leaf, Cassava pulp, Cocoa pod, Milk composition, Yield, Reproductive performance, West african dwarf goats.

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Introduction

Livestock such as ruminants like goats are beneficial to farmers and the nation at large. They have many benefits such as Food security, Raw materials for industries, Bride price, Government revenue and income for substituent farmers etc., [1]. The feeds and feeding of these animals are very important sector in ruminant reproduction. Malnutrition had affected livestock production performance in the tropical regions especially during the drought period and has led to retarded growth, poor reproductive performance, low milk yield, diseases infestation and death at last. In order to achieve optimal growth and better reproductive performance in small ruminant such as goats, required conditions such as quality and quantity feeds and good management practices must be ascertained [2]. Their quick reproductive performance and growth rates with shorter gestation period had helped in early returns on investment.

Apata and Adewumi affirmed that most indigenous goats reared in Nigeria produced meat and milk production majorly for home consumption. Milk is a source of animal protein in the tropics where its daily consumption is very low compared with animal protein intake required by man [3]. Cows have been the century source of milk production which produced more than 90% of the total annual domestic milk output despite the fact, it has not met man's demand. So as to sustain man's consumptions of dairy production, there is need for exploring other sources of milk from other species like goats [4]. In rural areas, the milk produced is mainly for home consumptions as source of protein supplements which can later be converted to products like yoghurts, cheeses, ice cream and other dairy products for commercial purposes and this production of milk can be influenced by the quantity and quality of feed ingredients. The variation in milk composition could also be as a result of quantity and quality of feeds given.

The effects of nutrition depend on many factors such as dietary supplement, animal breeds, lactation stage, body conditions and environmental conditions which eventually influenced fats content and fatty acids in milk yield and

composition [5]. Protein contents utility in feeds can also vary within species which could be based on breeds and size of the animals, lactation stage, seasonal changes, climatical factors and health status of the animals [6]. In most cases, a high level of nutrition in dairy animals will depress fat content and increase milk protein content. Sometimes, the concentration may be reduced by the diets composition that contain large amount of fermentable carbohydrate and unsaturated fat. Normally, milk production in does peaks within 2-3 weeks after kidding and reduced rapidly around 8-10 weeks after kidding [7].

The aim of this study was to investigate the influence of combinations of cocoa pod, cassava pulp and acacia leaf silage on the reproductive performance, milk yield and composition of West African Dwarf (WAD) goats [8]. So, we hypothesized that dietary cocoa pod, cassava pulp and Acacia leaves would influence the reproductive performance, milk yield and composition of WAD goats.

Materials and Methods

Experimental site

Following the approval of the protocol for this experiment by the animal welfare of Landmark University, Omu Aran, Kwara State, Nigeria. The feeding trial was conducted at the Teaching and Research Farm of Animal Production Department, Landmark University, Omu Aran, Kwara State, Nigeria.

Silage preparation

Cocoa pods were collected from a reputable cocoa farm at Ijan Ekiti, Ekiti State, Nigeria. The pods were sundried to a moisture content of 37% and pounded (using mortar and pestle) to an average size of 0.6 cm2 and ensiled at 370°C. Cassava pulp and ground cocoa pod with the inclusion of Acacia leaf at different ratio were ensiled in a polythene bag and packed inside 20 litres plastic as described by Patil. All fed materials were analysed for their proximate compositions using AOAC [9]. The wilted chopped Acacia leaf, cocoa pod and cassava pulp were mixed with over ripe banana slurry at rate of 5% of the weight of diets and packed in the bag. Uniform compaction was ensured until the bags were filled and tightly tied. Each plastic was compacted with a 20 kg weight to remove air and create an anaerobic condition for proper fermentation [10].

The bags were closed with the load placed on it until expiration of fermentation (7 weeks). The cocoa pod, cassava pulp and Acacia leaf were combined in ratio as presented in Table 1. The prepared diets were analysed for their proximate composition (AOAC, 2005).

Toxicity and antinutritive factors of fed ingredients

The toxicity and antinutritive factors in cassava pulp was adopted from Montagnac. while that of Acacia leaf was from the study of McSweeney and that of cocoa pod came from Ozung.

Experimental animals and design

Twenty sexually mature WAD does aged 7-8 months with average body weight of 9 ± 0.00 kg were sourced from livestock market at Otun Ekiti, Nigeria [11]. After 14 days of acclimatization, the animals were allotted to five dietary treatments in a completely randomized design with 4 animals per treatment in an intensive system of management thirty-two weeks feeding trial [12].

Experimental animals and management

The experimental animals were kept in well ventilated pens (3m x 1.5m) as described by Olawoye. All the does were weighed and randomly allotted to different dietary groups (Table 1). The animals were dewormed by using a broad spectrum anthelmintic (Super Ivermectin), according to the body weight and sprayed with acaricide (Parannex) against external parasites. 5 ml Ox-tetracycline (OTC) was administered to all the goats intramuscularly to control Contagious Caprine Pleural Pneumonia (CCPP) before onset of the experiment [13]. The experimental diets comprised of ensiled mixed combinations of cassava pulp, cocoa pod and Acacia leaf (Table 1). The animals were managed intensively throughout 150 days gestation period and 90 days reproductive phase and adequate nutrition and health care were ensured throughout the feeding trials. The experimental feeds were given to the animals in one meal ration per day. The silage was supplied 10% above expected daily intake of the animal and fresh water and mineral salt lick were given *ad libitum.*

Feed intake and water intake

Feed and water were offered approximately at the same time in the morning (08 hr). The daily feed intakes were determined by deducting the refusals from the quantity previously offered [14]. The feed and water were offered in the fodder basins and the remaining amounts from the previous day were measured to determine intake.

Reproductive performance, milk yield and composition

Does were monitored daily to detect their oestrous period. The does on heat were observed based on the signs of heat in goats such as restlessness, anorexia, edema of the vulva, vagina mucus discharge, tail moving, frequent noise and oestrus mounting as described by Mohamadi. Those that were on heat were mated by introduction of bucks to induce heat in them by male effect as described by Delgadillo. This was done by introducing one buck to five does and allowed them to have physical contact with them. Then, withdrew the buck after 5 hours and re-introduced after 5 days for effective mating [15]. Although, not all the does came on heat the same day but this method had helped to synchronize the does and brought relative uniformity in the kidding period.

After kidding, the dams were weighed to know the parturition weights, which were taken as the initial weights. The litter size and weight of the kids were recorded 1 hour after parturition, followed by subsequent weekly weight records using a 5 kg capacity sensitive scale. Thereafter, newborn kids were left to suckle their dams freely for the first 5 days to receive colostrum. Prior to each milking

day, the kids were taken away from the does around 6 pm in the evening preceding the day of milking [16]. Also, prior to daily collection of the milk; milking area, utensils, measuring cylinder were cleaned and sterilized. The udders of the does were also cleaned with warm water. After milking, the dams were allowed to nurse their kids for the remaining hours in the day [17].

Data collection

Data were collected on the reproductive performance which included does body weight, birth weight, weaners weight, litter size, gestation length, number weaned, kids' mortality and sex. Litters size was determined by counting the number of kids per doe and their individual birth weights were measured using a sensitive scale [18]. Also, Live Body Weights (LBW) of kids were recorded weekly throughout the earlier lactation period. Collection of milk samples for milk yield commenced from Day 5 post-partum to allow the kids to establish a strong relationship with the dams. The dams were hand milked once per day and thrice per week for the duration of 12 weeks (3 months). This gave 14 hours milk yield. The 14 hours milk yield was converted to daily milk yield by dividing by 14 and multiplied by 24. Milk yield was weighed using a measuring cylinder and recorded in grammes as described by Williams and kept in a refrigerator for further analyses.

Chemical analysis

The milk samples were analysed for proximate composition such as total fat, protein, lactose, specific gravity, total solid, vitamins, ash and minerals of the milk were obtained using analytical methods of AOAC.

Statistical analysis

The data obtained were subjected to analysis of variance (ANOVA) using Statistical Package for Social Scientist (SPSS 20.0, 2014). The level of significance was set at $P<0.05$.

Results

Chemical composition of the experimental diets

The chemical compositions of experimental diets are presented in Table 2. All the parameters observed were significantly influenced ($P<0.05$) by the treatments. It was shown that the highest Dry matter was obtained from Diet 5 (73.19 ± 0.01%) followed by Diet 4 (65.27 ± 0.04%). Diet 5 also had higher Crude Fibre (15.68 ± 0.03%) and Ash (6.17 ± 0.04%) contents. The least NFE (35.08 ± 0.04%) values were also obtained from Diet 5 which had 20% cocoa pod inclusion.

Reproductive performance of West African Dwarf (WAD) goats

The effect of experimental diets on the reproductive performance of WAD does fed diet contained cocoa pod inclusion is presented in Table 3. Treatment effects on litter size, gestation length, number weaned, kids' mortality and sex were not significant ($P>0.05$). The number of kids born in the diet contained 15% and 20% cocoa pod inclusion (2 kids) were the same while those on 5% and 10% cocoa pod inclusion were also the same. There was significant difference ($P<0.05$) in the does body weight when kidded, kids' birth and weaning weight. The results confirmed increased birth weight (1.27 ± 0.02 kg) and weaning weight (7.70 ± 0.14 kg) of does on Diet 5(20:40:40) while those on combinations of Diet 1 (0:60:40) had low (1.18 ± 0.01 kg) and (5.25 ± 0.35 kg) values respectively. No mortality was recorded in all the groups.

Chemical composition in milk WAD does

The milk compositions of West African Dwarf Does are summarized in Table 4. There were significant differences ($P<0.05$) in the Fat, Total Solid, Protein, Lactose, Vitamin A, B2, B12, D and Specific gravity constituents of the milk of the does. Does on Diet 5 (20:40:40) had significant high ($P<0.05$) fat content (4.55%), Protein (3.90%), lactose (4.69%) in milk compared to those on Diet 1(0:60:40) which had fat content (3.53%), Protein (3.14%) and lactose (3.85%). Likewise, does on Diet 5 (20:40:40) showed significantly high ($P<0.05$) Vitamins A, B2, B12 and Vit D concentrations in milk (54.50 IU/100 g, 2.39 mg/100 g, 0.13 µg/100 g, 58.65 IU/100 g) compared to other groups.

Mineral composition in milk of WAD does

The mineral compositions in the milk of WAD goats are summarized in Table 5. The results in this study showed that combinations of cocoa pod, cassava pulp and Acacia leaf had significant ($P<0.05$) effects on mineral composition of the milk of the does. The minerals observed in the milk were sodium, calcium, potassium, magnesium, phosphorus, manganese, copper, selenium, iron and zinc among the treatments. Calcium, magnesium and iron concentrations were significantly high ($P<0.05$) in the milk of does on Diet 5 (20:40:40) above other groups.

Lactation stages in milk yield of does fed combinations of cocoa pod, cassava pulp and acacia leaves

The effects of combinations of cocoa pod, cassava pulp and Acacia leaf on milk yield of West Africa dwarf goats was shown in Figure 1. Does on Diet 5 (20:40:40) was significantly high ($P<0.05$) (3,400.97 ml/animal/month) in monthly milk yield, followed by does on Diet 4 (15:45:40) (2976.46 ml/animal/month) while the least was those on Diet 1 (0:60:40) with (2563.36 ml/animal/month) at the early stage. In mid-production, does on Diet 5 (20:40:40) also had significant high ($P<0.05$) milk yield (4,427.75/animal/month) and (4,115.51/animal/month) at the late stage of lactation was shown in Figure 2. This indicates that the monthly milk yield of does on Diet 5 (20:40:40) goats was significantly high ($P<0.05$) compared to other groups at the three different stages of lactation. Although, there was a slight deviation that was observed at 9th week of lactation whereby the milk yield started decline in all the groups.

Table 1. *Dietary compositions of combinations of cocoa pod, cassava pulp and acacia leaf silage fed west African dwarf does (%).*

Feed Ingredients	**control**				
	Diet 1	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**
Cocoa pod	0	5	10	15	20
Cassava pulp	60	55	50	45	40
Acacia leaf	40	40	40	40	40
Total	100	100	100	100	100

Table 2. *Chemical composition of the experimental diets (% dry matter).*

Parameters (%)	**Diet 1 (0/60/40)**	**Diet 2 (5/55/40)**	**Diet 3 (10/50/40)**	**Diet 4 (15/45/40)**	**Diet 5 (20/40/40)**	**Sem**
Dry matter	65.10 ± 0.03	64.90 ± 0.14	60.46 ± 0.04	65.27 ± 0.04	73.19 ± 0.01	1.37
Moisture content	35.01 ± 0.13	35.33 ± 0.18	39.59 ± 0.02	34.78 ± 0.04	26.91 ± 0.13	1.37
Crude protein	12.53 ± 0.03	11.25 ± 0.02	11.58 ± 0.03	11.94 ± 0.04	12.20 ± 0.14	0.15
Crude fibre	5.19 ± 0.01	6.39 ± 0.01	7.88 ± 0.04	10.62 ± 0.03	15.68 ± 0.03	1.25
Ether Extract	12.13 ± 0.04	13.56 ± 0.03	13.34 ± 0.04	15.58 ± 0.03	18.56 ± 0.04	0.73
Ash	2.48 ± 0.03	2.58 ± 0.03	2.78 ± 0.04	4.78 ± 0.04	6.17 ± 0.04	0.49
Nitrogen free extract	39.34 ± 0.04	37.15 ± 0.04	36.49 ± 0.01	35.25 ± 0.35	35.08 ± 0.04	0.52

Table 3. *Effects of combinations of cocoa pod, cassava pulp and acacia leaf silage on reproductive performance of west African dwarf does.*

Parameters (%)	**Diet 1**	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	**Sem**
Doe body weight (kg)	14.00^{b} ± 0.00	14.20^{b} ± 0.21	14.55^{a} ± 0.07	14.60^{a} ± 0.14	14.65^{a} ± 0.14	0.05
Birth weight of kids (kg)	1.18^{b} ± 0.01	1.19^{b} ± 0.01	1.21^{a} ± 0.01	1.23a ± 0.04	1.27^{a} ± 0.02	0.01
Weaning weight (kg)	5.25^{c} ± 0.35	5.65^{c} ± 0.21	6.25^{b} ± 0.35	7.10a ± 0.14	7.70^{a} ± 0.14	0.03
Litter size	1	1	1	2	2	0.11
Gestation length	150	150	151	151	150	0.31
Number weaned	1	1	1	2	2	0.11
Kids Mortality	0	0	0	0	0	0
Sex of kids	Male	Female	Male	Female	Female	

Note: ^{abc} Means on the same row with different superscripts are significantly different (P<0.05). Diet 1: 0% cocoa pod, 60% cassava pulp and 40% acacia leaf; Diet 2: 5% cocoa pod, 55% cassava pulp and 40% acacia leaf; Diet 3: 10% cocoa pod, 50% cassava pulp and 40% acacia leaf; Diet 4: 15% cocoa pod, 45% cassava pulp and 40% acacia leaf ; Diet 5: 20% cocoa pod, 40% cassava pulp and 40% acacia leaf.

Table 4. *Effects of combinations of cocoa pod, cassava pulp and acacia leaf on milk composition of west African dwarf does.*

Parameters	**Diet 1**	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	**Sem**
Fat (%)	3.53 ± 0.04	4.06 ± 0.02	4.17 ± 0.03	4.23 ± 0.03	4.55 ± 0.02	0.16
Protein (%)	3.14 ± 0.06	3.26 ± 0.06	3.42 ± 0.01	3.52 ± 0.03	3.90 ± 0.03	0.08
Total Solid (mg/l)	10.80 ± 0.14	11.25 ± 0.07	11.65 ± 0.21	12.10 ± 0.00	12.95 ± 0.21	0.25
Lactose (%)	3.85 ± 0.01	4.15 ± 0.02	4.45 ± 0.04	4.57 ± 0.04	4.69 ± 0.01	0.1
Vitamin A(IU/100 g)	45.30 ± 0.14	46.50 ± 0.00	50.55 ± 0.70	50.85 ± 0.70	54.50 ± 0.28	1.1
Vitamin B2 (mg/100 g)	1.61 ± 0.01	1.72 ± 0.01	1.81 ± 0.01	2.16 ± 0.00	2.39 ± 0.01	0.09
Vit B12 (µg/100 g)	0.07b ± 0.00	0.08b ± 0.00	0. 09b ± 01	0.11a ± 0.01	0.13a ± 0.00	0.01
Vitamin D(IU/100 g)	54.25 ± 0.07	54.65 ± 0.07	55.10 ± 0.14	55.70 ± 0.14	58.65 ± 0.07	0.52
Specific gravity	0.97^{b} ± 0.01	0.96^{b} ± 0.00	1.02^{a} ± 0.00	1.03^{a} ± 0.01	1.05^{a} ± 0.00	0.01

Note: ^{ab} Means on the same row with different superscripts are significantly different (P<0.05). Diet 1: 0% cocoa pod, 60% cassava pulp and 40% acacia leaf; Diet 2: 5% cocoa pod, 55% cassava pulp and 40% acacia leaf; Diet 3: 10% cocoa pod, 50% cassava pulp and 40% acacia leaf; Diet 4: 15% cocoa pod, 45% cassava pulp and 40% acacia leaf ; Diet 5: 20% cocoa pod, 40% cassava pulp and 40% acacia leaf.

Table 5. *Effects of combinations of cocoa pod, cassava pulp and acacia leaf silage on mineral composition of west African dwarf does.*

Parameters (ppm)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Sem
Na	47.80 ± 0.42	50.45 ± 0.21	60.65 ± 0.21	65.65 ± 0.35	68.40 ± 0.28	2.72
Ca	161.70 ± 0.28	166.45 ± 0.21	172.35 ± 0.21	202.55 ± 0.07	210.45 ± 0.07	6.63
K	244.65 ± 0.07	252.70 ± 0.14	270.20 ± 0.28	275.30 ± 0.14	280.55 ± 0.21	4.57
Mg	13.42 ± 0.00	16.32 ± 0.01	16.73 ± 0.03	17.21 ± 0.01	18.08 ± 0.04	1.66
Ph	126.37 ± 0.01	126.52 ± 0.01	127.04 ± 0.12	128.20 ± 0.02	131.65 ± 0.01	2.06
Fe	0.07^{c} ± 0.00	0.06^{c} ± 0.00	0.08^{b} ± 0.00	0.08^{b} ± 0.00	0.09^{a} ± 0.00	0.01
Mn	0.04^{c} ± 0.00	0.05^{b} ± 0.01	0.06^{b} ± 0.01	0.07^{a} ± 0.00	0.08^{a} ± 0.01	0.02
Cu	0.03^{b} ± 0.00	0.03^{b} ± 0.00	0.03^{b} ± 0.01	0.04^{a} ± 0.00	0.05^{a} ± 0.00	0.01
Se	0.01^{c} ± 0.00	0.02^{b} ± 0.00	0.03^{b} ± 0.00	0.04^{a} ± 0.00	0.06^{a} ± 0.00	0.02
Zn	0.31 ± 0.01	0.43 ± 0.01	0.48 ± 0.01	0.58 ± 0.01	0.62 ± 0.01	0.11

Note: ^{abc} Means on the same row with different superscripts are significantly different (P<0.05). Diet 1: 0% cocoa pod, 60% cassava pulp and 40% acacia leaf; Diet 2: 5% cocoa pod, 55% cassava pulp and 40% acacia leaf; Diet 3: 10% cocoa pod, 50% cassava pulp and 40% acacia leaf; Diet 4: 15% cocoa pod, 45% cassava pulp and 40% acacia leaf; Diet 5: 20% cocoa pod, 40% cassava pulp and 40% acacia leaf.

Figure 1. *Suckling kid and doe.*

Figure 2. *Milk collection.*

Discussion

The present study corroborates the findings of Ayizanga *et al*.,[19] who reported on behavioural interactions between West African dwarf goats does and their kids, he affirmed that normal birth weight start from 1.20 kg. Gardner also affirmed that most animal species have optimum birth weight in which non complicated natural parturition occurs and neonatal survival is increased [20]. It was also confirmed that low birth weight was associated with increased neonatal mortality whilst too high birth weight was associated with dystocia and sometimes, maternal death. The birth weight recorded in this study was also in agreement with the report of Baffour *et al*.,[21,22] who reported birth weight of 1.18 kg for West african dwarf goats between 1997 and 2001 and records from the same station between 1998 to 2007 of the same breed of WAD goats revealed a higher birth weight of 1.31 kg [23]. The difference in birth weight may be due to differences in the nutritional status of the does during pregnancy, age or parity of doe as well as management practices during the reference periods. The age at weaning and hence weaning weight varies with the management system under which animals are kept. Studies have indicated that in goats, weaning can take place from 35 days after birth or any time the kid attains a 25% increase in its weight at birth. In this study, weaning weight at 90 days corroborates the finding of Ayizanga *et al*.,[24] who reported similar weaning weight at Kintampo. The little differences in weaning weight could be as a result of feeds and management practices.

The values obtained for total solid and fat in this study were comparable to the reports of Zahraddeen for West African Dwarf does. Lactose composition was fairly comparable in milk of both does on Diet 4 and 5 groups. Unlike fat, the concentration of lactose in milk cannot be easily altered by nutrition. This affirmed the findings of Ahamefule *et al*.,[25] and Odoemelam who recorded similar values for total solid, fat, protein and lactose concentrations in early, mid and late lactation stages in West african dwarf goat and confirmed the relative consistency of lactose in milk. Lactose is a disaccharide synthesized in the udder. It is composed of a molecule of galactose joined to a molecule

of glucose. Milk protein was also in agreement with Ahamefule report who recorded similar protein values in milk in early, mid and late lactation stages. The results of this study support the reports of Ahamefule but higher than 3.27% reported by Zahraddeen and lower than values of 5.06-5.37% and 4.30% reported by Ukpabi who used Mucuna seed-based diets for lactating WAD does. Crude protein concentration in milk is generally influenced by diet quality.

Many of the minerals, particularly Ca, P and Na had been reported by Ghazanfar *et al*.,[26] as essential minerals for small ruminants to attain optimum productivity. Mineral in milk constitute less than 1% of the total milk composition. However, they are an important influence on the functional properties of milk as reported by ANON. The result of 20% cocoa pod-based diets was also in agreement with Odoemelam who reported that lactating does fed 20% Bambara nut meal concentrate had higher milk Calcium than those fed 0, 10 and 30%. Phosphorus (P) and Sodium (Na) concentration in milk also followed similar trend with Calcium. The Phosphorus, Magnesium and Iron (Fe) in milk also corroborates the reports of Olaniyi as part of mineral requirements for lactating goats was shown in Figure 3.

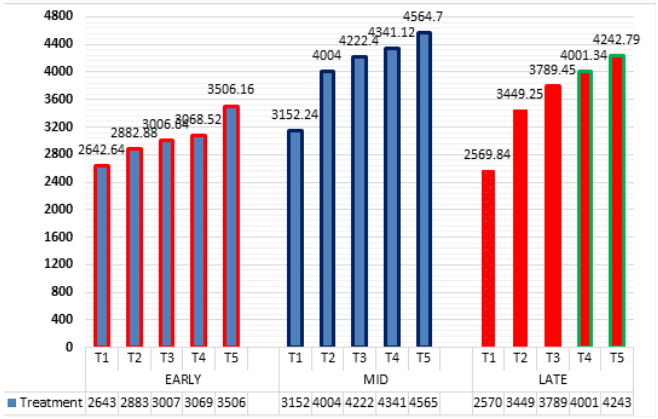

Figure 3. *Monthly milk yield (ml/animal/month) of west African dwarf does fed graded levels of combinations of cocoa pod, cassava pulp and acacia leaf.*
Note: *Diet 1: 0% cocoa pod, 60% cassava pulp and 40% acacia leaf;Diet 2: 5% cocoa pod, 55% cassava pulp and 40% acacia leaf;Diet 3: 10% cocoa pod, 50% cassava pulp and 40% acacia leaf;Diet 4: 15% cocoa pod, 45% cassava pulp and 40% acacia leaf;Diet 5: 20% cocoa pod, 40% cassava pulp and 40% acacia leaf; EARLY-Early monthly milk yield from T1-T5(ml/animal/month);MID- Middle monthly milk yield from T1-T5(ml/animal/month); LATE- Late monthly milk yield from T1-T5(ml/animal/month).*

Moreover, Potassium concentration in milk was observed to be higher than Calcium; this was in consonance with existing report by Idamokoro that potassium concentration could be higher than calcium. Ahamefule reported that calcium is essential for bone and teeth formation, likewise in steady heartbeat maintenance, nerve impulses transmission, muscle growth, contraction and cramps. Potassium was also reported to be essential in healthy nervous system and steady heart rhythm, good muscle contraction, body water balance. Magnesium is also essential for enzymes activity, potassium uptake, bone formation, carbohydrates and mineral metabolism. He affirmed that phosphorus is also essential for bone and tooth formation, cell development, heart muscle contraction, vitamins utilization and feed to energy conversion. Generally, results obtained in this study indicated that combinations of cocoa pod, cassava pulp and acacia leaf enhanced the mineral content of milk of WAD does at 20% cocoa pod inclusion level.

The milk yield was in agreement with the findings of Ahamefule and Ibeawuchi who obtained 122 g daily milk yield for WAD goats placed on forage and forage-concentrate regime. Available reports of Anya *et al*.,[27] however indicated that indigenous goats in Nigeria attained peak milk yields within 2-6 weeks of lactation (Mid-lactation) which affirmed the reports from this study that does attain peak milk yield at 4-6 weeks (Mid-lactation) while the least milk yield was recorded at the 12th. Overall, does on 20% cocoa pod inclusion level maintained high milk yield persistently from weeks 1–9. This outstanding performance distinguished Diet 5 (20:40:40) as the diet of choice for dairy goat production in this study.

Conclusion

It can be concluded from this study that does on Diet 5 (20:40:40) had increased doe weight, birth weight and weaning weight. No mortality was recorded in all the groups. The Fat, Total Solid, Protein, Lactose, Vitamin A, B2, B12, D and Specific gravity constituents of the milk of does on Diet 5 (20:40:40) was high compared to other groups. Sodium, calcium, potassium, magnesium, phosphorus, manganese, copper, selenium, iron and zinc were high in the milk of does on Diet 5 (20:40:40). Likewise, does on 20% cocoa pod inclusion had high monthly milk yield at the early, mid and late stages of production. Therefore, farmers can incorporate up to 20% cocoa pod in the diets of WAD goats, particularly during the dry season for sustainable and profitable goat production. Further studies are hereby recommended to reveal the economic value and farmers' affordability and acceptability of cocoa pod in goats' diet.

Availability of Data and Materials

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare that there is no conflict of interest.

Declarations of Funding

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Author's Contributions

COR and AAA suggested the study. Both authors participated in its design and coordination. COR carried out the feeding trial, sample collection, and analysis. COR carried out statistical data analysis and interpreted the results. COR searched for pieces of literature. COR prepared the first draft of the manuscript. Both authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

The right to conduct the research granted by the Research Committee of the Department of Animal Production, authorized by the Vice chancellor of Landmark University, Omu Aran, Kwara State, Nigeria. The animals were managed following the recommendation and guidelines for applied nutrition experiments in goats.

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