Variation in Milk Yield and Composition of West African Dwarf Does fed Cassava Peel based Diets Supplemented with African Yambean Concentrate in the Humid Zone of Nigeria

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ABSTRACT

This study investigated the variation in milk yield and composition of West African Dwarf goats (does) fed cassava peel meal based- diets supplemented with varying levels of African yambean seed meal (AYBM). Four experimental diets designated as T_1, T_2, T_3 and T_4 with 0, 10, 20 and 30% levels of AYBM respectively were used in the feeding trial. A total of twelve does with average weight of 19.6±1.12kg were used in this study. The does which were in their second to third parities were randomly divided into 4 groups of 3 animals each. Each group was assigned to one of the experimental diets in a Completely Randomized Design (CRD) experiment. Each animal was housed separately in cement floored pens measuring 1.85m x 1.70m (3.15m^2). Dry hay material was used as bedding. During the first 4 months of pregnancy, the does were zero-grazed with forage consisting mainly *Penisetum purpureum*, *Pueraria phaseoloides* and *Centrosema pubesens*. Daily dry matter provision for each animal was based on 3% body weight. In the last trimester of pregnancy, each in-doe received 0.5kg of a concentrate diet in the morning (0800hr) and 1.0kg *Penisetum purpureum* in the afternoon (1400hr). This nutritional regime continued through parturition and into the 10th week of lactation for each doe. Water was provided *ad libitum* throughout the study duration. After the 10th day post –partum, the respective does were hand – milked daily and associated milk parameters such as yield and composition (lactose, total solids, butter fat, crude protein, solid–non fats, ash and gross energy) determined accordingly. Correlation coefficients were computed and simple linear regression was used in ascertaining the relationship between the parameters/constituents in goat milk. Results showed significant (P<0.05) differences in weekly variations in milk yield (1.88 – 3.32 kg) and constituents (4.05 – 4.52% lactose, 0.87 – 1.06% ash and 3.89 – 3.53 MJ/kg energy). The Milk yield generally rose with time post- partum and reached peak yield (3.32kg) in week 3 before declining. There were however significant differences (P<0.05) between the peak yield of week 4 and yield obtained in the 7th (2.43kg), 8th (2.43kg), 9th (2.55kg) and 10th (1.88kg) week, respectively. Milk yield was negatively and significantly correlated with total solids (r = -0.59; P<0.05), crude protein (r = 0.71; P<0.01), solid –non fats (r = - 0.87; P<0.01) and milk energy (r = -0.79; P<0.01), but poorly and positively correlated with butter fat (r ~ 0.01; P>0.05), and lactose (r = 0.42; P<0.05). Significantly high (P<0.05) positive correlation existed between BF and TS (r = – 0.55) and CP (r - 0.54), energy and TS (r = - 0.57) while a significantly high (P<0.01) but negative correlation existed between CP and SNF (r = -0.75). Lactose was negatively, poorly and non-significantly correlated with TS (P>0.05; r = -0.22) in this study. The study concludes that dairy goats fed 10% AYBM maintained milk high yield and optimum composition.

Keywords: *Composition, Cassava peel, Milk, Dairy goat, Yambean.*

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1. INTRODUCTION

The majority of milk consumed throughout the world is bovine milk, although in some countries, sheep and goats and even camels are commonly used. Goats are important animals in subsistence agriculture producing meat, milk, skins and hairs on account of their unique ability to adapt and maintain themselves in harsh environments. These locally adapted animals remain very essential to many livestock-keeping livelihoods and contribute to the food security of most households especially as climate change progresses and new challenges arise. In areas of severe milk scarcity, dairy goats could alleviate the scarcity of milk and milk protein in general. Goat milk is highly nutritious and contains a higher proportion of small fat globules which are more easily digestible. Its casein during digestion forms a better constituent and more friable coagulum that cow's milk. Goat milk provides a ready source of nutrient particularly protein, calcium, phosphorus and lactose. However, the over 440 million goats (worldwide) produce an estimated 4.8 million tonnes of milk that is predominantly consumed locally or processed into various milk products. Thus, goats produce considerable amount of milk that contributes to national milk production.

Grass, the predominant forage on natural pasture lands grazed by goats cannot meet the energy and protein requirements of these animals for sustained milk production especially in the dry season. Supplementary grass and other available crop residues with some protein concentrate will definitely improve milk yield, but the challenge of sustainability often arises when cost implications and availability are being considered.

Cassava (Manihot spp.) is one of the most important annual root crops grown widely by tropical and sub-tropical farmers. It is the highest supplier of carbohydrates among staple crops and ranks fourth among food crops in developing countries after maize, rice and wheat [1]. Cassava peels are produced in large qualities in Southern Nigeria, from the processing of Cassava for human, industrial and export purposes. Unfortunately, this enormous feed resource has received any little attention and about 50 million metric tonnes of this peel and is often discarded as waste annually. Cassava peel is rich in metabolizable energy (3.03 Mcal/Kg DM) but low in nitrogen [2].

Generally most fibrous crop residues are poor sources of fermentable nitrogen, as their crude protein is below the level required by rumen microorganisms. Also these crop residues are also low in easily degraded carbohydrates, minerals and other nutrients required to balance the products of digestion to requirements. All these results in limited intake, poor rumen function, increased methane emission and low animal productivity. The use of African yambean (*Sphenostylis stenocarpa*), an under-exploited and often classified minor grain legume that is cheap and readily available protein source in cassava peel meal based diets is a strategy that intends to overcome the nutritional constraints of using cassava peel. It will close the feed deficit gab, reduce feed cost and sufficiently tackle seasonal fluctuations in forage quality and quaintly. This would on the long run encourage increases in flock sizes, provide insurance against external shocks as well as increase the productivity of goats especially in milk production. The quantity of milk produced by various species of dairy animals differs markedly. Within species, individual animals also show wide variation in yield and composition – depending on domestic purpose, breed/genetic factors, environmental conditions, physiological condition and level of management (Animal welfare, wellbeing and handling practices). Also milk production from goats is influenced by several factors such as age, season, parity, litter size, heath and stage of lactation [3, 4]. There is an increasing demand for new dairy products with high added value in sophisticated market niches, which has stimulated goat milk production and trade worldwide [5]. This study therefore evaluated the variation in milk yield and composition of WAD goats (does) fed cassava peel meal based - diets supplemented with varying concentrate levels of African yam bean in the humid high rainforest zone of Nigeria.

2. MATERIALS AND METHODS

2.1. Processing of Cassava Peel and African Yambean Seed Meal

Cassava peels of TMS 30555 variety were collected fresh from the Department of Crop Science commercial "Garri" processing unit of the University of Calabar, Calabar. The peels were from 10–12 months old plants. The peels were properly sun dried for a period of 3–6 days during which they were regular turning to give even drying to a moisture content of 10%. The peels could sometimes have tuber linings as a result of the method of removing the peels. The sun-dried cassava peels were then milled and used in the study as dried cassava peel meal (CPM). African yambean (*SPhenostylis stenocarpa)* seeds (Nsukka brown variety) were purchased from local famers in Obudu and Obanliku Local Government Areas in the Northern parts of Cross River State. The undecorticated brown seeds were boiled for 30 minutes following the method of Ukachukwu and Obioha [6] for Mucuna seeds. Water was made to boil at 100^{o}C in a large (mammoth) cooking pot before the seeds were poured in. The seeds were allowed to boil for 30 minutes. Water was decanted using local baskets and the seeds sun-dried on aluminium roofing sheets for 3 days before being milled and used as yambean seed meal (YBSM) to compound the experimental diets.

2.2. Experimental Diets

Four experimental diets designated T_1, T_2, T_3 and T_4 were formulated as presented in Table 1. Diet A was the control and contained no African yambean seed meal (AYBM). Diet T_2, T_3, and T_4, contained 10, 20, and 30% of AYBM respectively. The diets were allotted randomly to the four animal groups. Each animal within a group was offered 1kg of an assigned concentrate diet daily for 56 days. The concentrate diets were fed at 0800 hour daily. Clean drinking water was provided ad-libitum for each animal within the period. Each animal was provided with salt lick block (TANLICK), a product of SKM Pharma (P) Limited JF-10, City Point, Infantry Road Bangalore – 560001 India. The salt lick had the following composition: Na, 35.96%; Zn, 0.25%; Fc, 0.30%; Mn, 0.20%; I, 0.003%; Co, 0.002%; Cu, 0.10% and Mg, 0.05%.

2.3. Chemical Analyses of Experimental Diet

All the experimental diets ($T_1 - T_4$) including CPM and YBSM were analysed for proximate composition using AOAC [7] methods (Table, 1).

Table-1. Composition of experimental diets (%)

	Diets			
Ingredients	T_1	T_2	T_3	T_4
Cassava peel	46.00	46.00	46.00	46.00
African yambean seed meal	0.00	10.00	20.00	30.00
Wheat offal	33.00	23.00	13.00	3.00
Palm kernel cake	18.00	18.00	18.00	18.00
Bone meal	2.00	2.00	2.00	2.00
Salt	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00

Table-2. Proximate composition of experimental diets, cassava peel meal (CPM) and African yambean seed meal (AYBM)

	Diets					
Parameter (%)	T_1	T_2	T_3	T_4	CPM	AYBM
Dry matter	89.44	89.35	89.42	89.62	90.10	88.50
Crude protein	10.56	10.96	11.36	11.44	3.22	22.10
Crude fibre	12.47	11.05	10.31	10.11	14.73	5.92
Ether extract	4.50	4.61	4.80	4.94	0.91	7.53
N-free extract	51.38	53.61	54.33	54.62	65.67	47.67
Ash	10.35	9.12	8.62	8.49	5.57	5.28
Gross energy (kcal/g)	3.45	3.42	3.31	3.28	3.60	5.23

2.4. Animal Management

Twelve (12) West African Dwarf (WAD) does were selected from the goat herd of the Teaching and Research Farm of the University of Calabar, Calabar and used in this study. The average weight was 19.6±1.12 (18.5-22.7kg). The does which were in their second to third parities were randomly divided into 4 groups of 3 animals each. Each group was assigned to one of the experimental diets (Table 1) in a Completely Randomized Design (CRD) experiment. Each animal was housed separately in cement floored pens measuring 1.85m x 1.70m (3.15m^2). Dry hay material was used as bedding. During the first 4 months of pregnancy, the does were zero-grazed with forage consisting mainly *Penisetum purpureum*, *Pueraria phaseoloides* and *Centrosema pubesens*. Daily dry matter provision for each animal was based on 3% body weight. In the last trimester of pregnancy, each in-doe received 0.5kg of a concentrate diet in the morning (0800hr) and 1.0kg *Penisetum purpureum* in the afternoon (1400hr). This nutritional regime continued through parturition and into the 10th week of lactation for each doe. Prior to parturition routine spraying and deworming programmes were carried out including vaccination against PPR, a viral disease of small ruminants endemic in the locality. Concentrate diets were placed in wooden troughs while water provided *ad libitum* was in plastic containers.

2.5. Milk Measurements

Does were hand-milked daily (morning). However, the total amount of milk yield per day was recorded as the morning daily yield of the doe. The daily milk yield was then estimated for each doe on the assumption that actual daily production of does can be met if the animals were milked twice a day. Thereafter, based on the concept of fixed yield responses to changing milk frequency [8] the constant 0.6596 was used as a weighting factor or the morning milk yield. Each day's milk yield (S) was estimated as: $S = M + 0.6596M$; where, M is the morning milk yield (once-a-day milking).

Prior to each day's milking including the first 4 day period for colostrum sampling, kids were separated from their dams at 1800hr on the evening preceding the day of milking. Within this period of separation, kids were fed milk with the aid of feeding bottles. During colostrum and normal milking, the two halves of the udder of lactating does were hand milked daily from 700 to 0800hr. The quantity of milk harvested from a doe was measured using a graduated glass cylinder (500ml capacity) and weighed back to the nearest gram on a sensitive laboratory scale. Dams were allowed to nurse their kids in the morning after milking and in the afternoon before separation at 1800hr daily.

2.6. Milk Sampling

Lactation length for each doe was based on 135 days. Milk sampling was initiated on the 10th day for each lactating doe and terminated on the 79th day post-partum. Samples from daily milk yield for each doe were analysed daily for lactose content before being bulked and analysed weekly for total solids (TS), butter fat (BF), crude protein (CP), solids - non-fat (SNF), ash and energy. The bulked samples were thereafter stored in a refrigerator (-5^{o}C) until required for analysis. The weekly milk production was a summation of each 7day milk yield per doe while the weekly determinations (analysis) represented each doe milk profile for the week. The weekly lactose contents of milk of a doe was determined as average of daily lactose determinations.

2.7. Analytical Procedure

The milk samples were analysed for lactose, TS, BF, CP (N × 6.38), SNF, ash, and gross energy. TS were determined by drying about 5g of milk sample to a constant weight at 105^{o}C for 24 hours. Lactose content was determined from fresh samples by the Marier and Boulet [9] procedure. BF was obtained by the Roese-Gottlieb method [7]. Milk protein (NX6.38) was determined by the semi-micro distillation method using Kjeldahl and Markham's apparatus. Ash content was obtained by drying and ashing a weighed milk sample (10ml) to a constant weight at 550°C for 48 hours. SNF was determined as the difference between TS and butterfat. Milk energy Y (MJ/kg) was computed using the multiple regression equation. $Y = 0.386F + 0.205\ SNF - 0.236$ [10] where F and SNF represent percentages of fat and solids-not-fat respectively.

2.8. Statistical Analysis

The data on colostrum and milk yield and composition were analysed using the analysis of variance (ANOVA) procedures appropriate for a Completely Randomized Design [11]. Significant means were separated using Duncan's Multiple Range Test [12] as outlined by Obi [13].

3. RESULTS AND DISCUSSION

3.1. Milk Yield and Composition

Table 3a shows the weekly variations in yield and composition of milk of WAD goats. Milk yield generally rose with time post- partum and reached peak yield (3.32kg) in week 3 before declining. There were however significant differences (P<0.05) between the peak yield of week 4 and yield obtained in the 7th (2.43kg), 8th (2.43kg), 9th (2.55kg) and 10th (1.88kg) week. Within treatments (Table 3b), animals fed the control diet (T_1) peaked production in the third week while does on diets T_2, T_3 and T_4 fed AYBM diets recorded peak yields in the 4th week post-partum. Available reports however indicated that indigenous goats in Nigeria attain peak yields within 2-6 weeks of lactation Osinowo and Abubakar [14]; Awgichew, et al. [15]; Erdman and Verner [8]; Akpa [16]. Akinsoyinu [17] and Ahamefule [18] also obtained peak yield in WAD goats within 4-6 weeks post-partum which also agrees with the results of this study. The highest group yield was obtained in the 4th week (3.88kg) by does fed 10% AYBM diet while the least yield was recorded in the 10th week (1.56kg) by does on the control diet. Among AYBM diets, the least yield recorded in the 10th week (1.49kg) was by does fed 10% AYBM (T_2) (Table 3b) which agrees with the findings of Ahamefule [18]. Similarities in production also existed among the does from the 2nd to the 4th week. Goats fed 10% AYBM (T_2) maintained high yield persistently from weeks 1 – 9. This outstanding performance distinguishes diet T_2 (10% AYBM) as the diet of choice for dairy production in this study.

Total solids (TS) generally decreased with time post-partum and were least in week 4 (13.96%) before rising as shown in Table 3a. This trend of variation in TS observed in this study was in line with the report of Ahamefule [18]. TS values compared favourably for all lactating does in weeks 8 (15.08%), 9 (15.06%) and 10 (15.14%), respectively. However, these values differed significantly (P<0.05) from percent values of 14.56, 14.46, 14.70 and 13.96% obtained in weeks 1, 2, 3 and 4 respectively.

Table-3a. Weekly variations in milk yield (kg) and composition of WAD goat

Parameter	1	2	3	4	5	6	7	8	9	10	Mean	SEM
Yield (kg)	2.98^{b}	3.29^{a}	3.32^{a}	3.22^{a}	3.12^{ab}	3.07^{abc}	2.43^{cd}	2.43^{cd}	2.55^{bc}	1.88d	2.83	0.15
TS (%)	14.56^{c}	14.46^{c}	14.70^{c}	13.96^{c}	14.92^{ab}	14.99^{ab}	14.94^{ab}	15.08^{a}	15.06^{a}	15.14a	14.78	0.12
BF (%)	5.15	5.19	4.97	5.00	4.80	4.74	4.84	4.92	4.75	4.84	4.92	0.05
CP (%)	4.76	4.86	4.64	4.53	4.47	4.44	4.59	4.68	4.71	4.72	4.64	0.04
SNF (%)	9.67	9.57	9.30	9.54	9.46	9.65	9.76	9.83	9.78	9.93	9.65	0.06
Ash (%)	0.87^{b}	0.88^{b}	0.89^{ab}	0.90^{ab}	0.91^{ab}	0.92^{ab}	1.04^{ab}	1.01^{ab}	1.05^{a}	1.06a	0.95	0.02
Lactose (%)	4.51^{a}	4.52^{a}	4.39^{ab}	4.32^{b}	4.31^{b}	4.15^{c}	4.16^{c}	4.05^{c}	4.34^{b}	4.39ab	4.31	0.05
Energy (MJ/Kg)	3.53^{c}	3.54^{c}	3.66^{bc}	3.75^{abc}	3.84^{abc}	3.83^{ab}	3.98^{a}	3.89^{ab}	3.89^{ab}	3.89ab	3.75	0.05

^{abcd} Means on the same row with different superscripts are significantly different (P<0.05)

Table-3b. Weekly variation in yield and composition within treatments of WAD goat's milk

Parameter	TRT	1	2	3	4	5	6	7	8	9	10
Yield (kg)	T_1	217	2.89	2.95	2.92	2.86	2.75	2.35	2.34	2.94	1.56
	T_2	3.58	3.75	3.87	3.88	3.72	3.88	2.26	2.23	2.36	1.49
	T_3	3.03	3.38	3.45	3.27	3.18	3.01	2.69	2.71	2.59	2.21
	T_4	3.13	3.16	3.02	2.81	2.74	2.75	2.41	2.42	2.32	2.26
SEM		0.16	0.11	0.12	0.13	0.12	0.13	0.05	0.05	0.08	0.13
TS (%)	T_1	14.79	13.82	14.69	14.69	14.77	14.82	14.87	14.91	14.90	14.93
	T_2	14.26	14.56	14.84	14.39	14.88	14.83	14.76	14.82	14.90	14.80
	T_3	14.53	14.76	14.69	14.93	15.05	15.21	14.97	15.35	15.02	15.42
	T_4	14.66	14.70	14.70	14.84	15.00	15.08	15.57	15.27	15.40	15.41
SEM		0.06	0.11	0.32	0.84	0.05	0.06	0.04	0.07	0.09	0.08
BF(%)	T_1	5.08	5.11	4.90	4.85	5.04	4.90	4.76	4.79	4.62	4.72
	T_2	4.92	5.03	4.82	4.75	3.94	4.22	4.31	4.44	3.85	4.19
	T_3	4.91	5.10	5.12	4.83	4.76	5.02	4.81	4.84	5.01	4.93
	T_4	5.70	5.62	4.99	5.55	5.46	4.84	5.48	5.62	5.52	5.52
SEM		0.10	0.07	0.33	0.10	0.17	4.74	0.13	0.13	0.18	0.14
CP (%)	T_1	4.52	4.45	4.48	4.40	4.24	4.13	4.28	4.33	4.31	4.51
	T_2	4.92	5.15	4.92	4.50	4.59	4.35	4.42	4.32	4.51	4.59
	T_3	4.58	4.58	4.35	4.42	4.37	4.56	4.38	4.95	5.11	4.97
	T_4	5.00	5.27	4.64	4.79	4.68	4.74	4.85	5.12	4.89	4.82
SEM		0.07	0.11	0.70	0.05	0.06	0.07	0.08	0.11	0.09	0.05
SNF (%)	T_1	9.42	9.24	9.09	9.18	9.09	9.24	9.46	9.38	9.40	9.51
	T_2	9.80	9.92	8.80	9.81	10.05	10.05	9.96	10.08	10.08	10.14
	T_3	9.67	9.44	9.46	9.37	9.32	9.38	9.51	9.74	9.54	9.90
	T_4	9.77	9.68	9.86	9.79	9.40	9.92	10.13	10.11	10.09	10.16
SEM		0.05	0.10	0.12	0.08	9.46	0.11	0.04	0.09	0.11	0.08
Ash (%)	T_1	0.78	0.82	0.88	0.86	0.85	0.70	0.93	0.94	0.93	0.90
	T_2	0.89	0.86	0.87	0.88	0.88	0.32	0.93	0.95	0.96	0.97
	T_3	0.89	0.90	0.89	0.92	0.89	1.10	1.07	1.06	1.09	1.09
	T_4	0.87	0.93	0.93	0.94	1.02	0.99	1.21	1.10	1.21	1.26
SEM		0.01	0.01	0.01	0.01	0.02	0.08	0.04	0.02	0.03	0.04
Lactose (%)	T_1	4.49	4.45	4.27	4.28	4.47	4.21	4.15	4.03	4.32	4.40
	T_2	4.54	4.47	4.44	4.31	4.25	4.28	4.15	4.06	4.34	4.25
	T_3	4.49	4.49	4.13	4.29	4.29	4.29	4.16	4.05	4.38	4.42
	T_4	4.53	4.66	4.42	4.41	4.22	4.25	4.16	4.05	4.31	4.40
SEM	0.01	0.04	0.04	0.04	0.03	0.06	0.06	0.02	0.00	0.01	0.02
Energy (MJ/Kg)	T_1	3.34	3.43	3.56	3.73	3.82	3.61	3.72	3.66	3.68	3.69
	T_2	3.68	3.59	3.79	3.75	3.86	3.97	4.09	4.14	4.10	4.10
	T_3	3.42	3.42	3.46	3.77	3.84	3.68	3.76	3.69	3.69	3.69
	T_4	3.69	3.68	3.83	3.75	3.84	3.94	3.98	4.10	4.10	4.10
SEM		0.03	0.03	0.05	0.02	0.01	3.80	0.10	0.06	3.89	0.06

Within treatments (Table 3b), goats fed the control diet (T_1) had the least TS in milk (13.82%) in week 2 and correspondingly in week 1 for goats fed the 10% (14.26%), 20% (14.53%) and 30% (14.66%) AYBM diets. TS have been reported to decrease as lactation progresses [19]. This trend was not observed in this study, as the TS of does tended to be high from the 8-10 week post-partum. However, Akinsoyinu [17] and Ahamefule [18] obtained lowest TS in milk of WAD goat at 4 weeks post-partum which agrees with the result of the present study. Does fed the 30% AYBM diet recorded the highest (15.57%) and lowest (14.66%) TS in milk in the 7th and 1st week respectively.

Butter fat (BF) decreased with time post-partum and was least in week 6 (4.74%) (Table 3a), but weekly values however did not vary significantly (P>0.05). Preston [20] and Ahamefule [18] all reported decrease in milk fat of goats in the first 4 weeks of lactation which agrees with the result of the present study. There was a general tendency for BF values .in milk to decrease with increasing yield and vice versa. This trend confirms the negative correlation between BF and yield which had been reported by several workers [17, 18, 21, 22]. Within treatments

(Table 3b), the least BF value (3.85%) was obtained for diet T_2 in week 9 and for diets T_1 (4.62%), T_3 (4.76%) and T_4 (4.84%) in weeks 9 and 5 (for goats on diets T_1 and T_3) and in week 6 (for goats on diet D) respectively. The highest BF value was recorded in week 1 (5.70%) in the milk of goats fed 30% AYBM while the least was obtained in the 5th week in goats fed 10% (3.94%) AYBM diets. Milk BF values of goats fed 30% AYBM diet (diet T_4) remained persistently higher than others throughout the study. This trend could probably reflect the high ether extract content of diet T_4 (Table 1) which contributed to the high BF of the milk. Preston [20] had reported that in small ruminants about 75% of fatty acids of milk arise from diets which collaborates the findings in this study.

Milk protein tended to decline and rise with time post-partum as presented in Table 3a. The weekly values did not vary significantly (P>0.05) but the highest and lowest values were obtained in weeks 2 (4.86%) and 5 (4.44%) respectively. There was also a tendency for milk protein to increase as milk yield deceased in this study. Within treatments (Table 3b) the highest milk protein value (5.27%) was obtained in week 2 in goats fed diet T_4 (30% AYBM) while the least (4.13%; was obtained in week 6 in goats fed diet T_1 (control). Milk protein also followed a similar trend like milk fat and was persistently high in goats fed 30%) AYBM diets in weeks 2 and 8 respectively.

SNF weekly values did not differ (P>0.05), but declined to a low level in week 3 before rising consistently but slowly to the 10th week (Table 3a). It has been reported from earlier studies [18, 22-24] that SNF content in milk increases as lactation advances, which may have accounted for the same trend, observed in the present study. French [25] reported that the higher the SNF in milk, the higher the buffer value which improves the shelf-life quality of milk. Thus, milk from goats fed diets T_2 and T_4 (Table 3b) are likely to have a better shelf-life quality because of their high SNF contents. Within treatments (Table 3b), the highest and lowest SNF values were obtained in week 7 (10.13%) and week 3 (8.80%) respectively. Goats fed diet T_2 (10% AYBM) produced persistently high SNF in weeks 5 - 6 and weeks 8 – 10 accordingly.

Milk ash values significantly differed (P<0.05) within weeks and were also consistent over the 10 week post-partum period of this study (Table 3a). However, the highest ash value (Table 3b) of 1.21% was recorded in the 7th and 10th week in the milk of goats fed 30% AYBM diet while the least (0.70%) was recorded in week 6 in goats fed the control diet. This result agrees with the report of Ahamefule [18] 'whore milk ash increased as lactation advanced. Boros, et al. [26] had reported higher ash values in milk at the 12th – 18th week post-partum in goats. Also, Akingbade, et al. [27] working with milk of some South African indigenous goats reported that milk ash content iincreases as lactation advanced which agrees with the result of the present study. However, goats fed diet D (30% AYBM) had consistent high ash values in milk all through the lactation period (weeks 1-10).

Lactose concentration in milk differed (P<0.05) significantly with weeks (Table 3a). Akinsoyinu [17] had observed that lactose concentration remained fairly constant within the first 16 weeks of lactation in WAD goats and only declined slightly thereafter. Also in a related study, Ahamefule, et al. [28] and Ahamefule [18] reported that lactose in milk remained fairly constant all through lactation stages in cattle, sheep and goats. The values obtained in this study were, also fairly constant but with an observable trend. In contrast to some reports [18, 27] weekly lactose concentration differed (P<0.05) in this study which agrees with the findings of Akingbade, et al. [27] that lactose content were at maximum in colostrum and early lactation milk yield and declined slightly thereafter. The lactose concentration was high in the first 3 weeks post-partum compared to weeks 4 to 10. The highest lactose concentration of 4.54% was obtained in week 1 (Table 3b) in the milk of goats fed 10% AYBM diet, and least in week 8 (4.03%) in goats fed the control diet. Generally, goats fed 10% AYBM diet maintained superior lactose concentration in milk in the 10 week lactation period of this study.

Milk energy (MJ/kg) did not follow any particular trend but showed a slight increase as lactation progressed (Table 3a).However, milk energy differed significantly (P<0.05) within weeks. Akinsoyinu [17] reported a consistent drop in milk energy up to the 18th week post – partum which runs contrary to the findings of the present study. The moderate milk yields obtained for WAD goat in this study and the associated high BF and SNF may have influenced sudden rise in milk energy from week 4. Ahamefule, et al. [28] had earlier reported fairly constant milk energy values in early and mid-lactation stages in WAD goat which also runs contrary to the findings of this study. The highest milk energy value of 4.14MJ/Kg was recorded in the 8lh week in goats fed diet B (10% AYBM) while the least (3.34MJ/Kg) was obtained in the 1st week in goats fed the control diet (Table 3b). Goats fed 10% AYBM diet produced milk of high energy content which remained persistently high from weeks 1 – 10.

The relationships between yield and constituents of WAD goat milk are summarized in Table 4. Milk yield was negatively and significantly correlated with TS (r = -0.59; P<0.05), CP (r = 0.71; P<0.01), SNF (r = - 0.87; P<0.01) and milk energy (r = -0.79; P<0.01), but poorly and positively correlated with BF (r ~ 0.01; P>0.05), and lactose (r = 0.42; P<0.05). Significantly high (P<0.05) positive correlation existed between BF and TS (r = - 0.55) and CP (r = - 0.54), energy and TS (r = - 0.57) while a significantly high (P<0.01) but negative correlation existed between CP and SNF (r = -0.75). Lactose was negatively, poorly and non-significantly correlated with TS (P>0.05; r = - 0.22) in this study. Ahamefule, et al. [29] and Ahamefule [18] reported similar results in WAD sheep milk and WAD goat milk respectively. To buttress this fact, Rai [30] reported that a decrease in lactose content of milk was associated with an increase in its TS content especially protein which explains the observed negative relationship between lactose and TS even in the present study. However, some relationships between constituents in this study did not follow similar trend as in some reporter studies, this could be generally attributed to the various factors that cause variations in composition of goat milk notably management conditions, parity, season, locality mid breed; differences [31].

Table-4. The relationships between yield and constituents of WAD goat milk

Parameter	Regression Equation	SD	R^2	R	Significance
Yield and TS	Y = 14.98 – 0.54X	0.55	0.30	-0.59	**
Yield and BF	Y = 3.07 – 0.02X	0.59	0.00	0.01	NS
Yield and CP	Y = 5.43 – 1.77X	0.41	0.51	-0.71	***
Yield and SNF	Y = 25.07 – 2.9X	0.29	0.76	-0.87	***
Yield and lactose	Y = 47.53 + 11.21X	0.53	0.18	0.42	NS
Yield and energy	Y = 6.49 – 2.68X	0.36	0.62	-0.79	***
BF and TS	Y = 5.29 + 0.72X	0.32	0.21	0.55	**
CP and TS	Y = 11.63 + 0.47X	0.21	0.20	0.45	NS
Energy and TS	Y = 9.94 –+ 0.44X	0.14	0.33	0.57	**
Lactose and TS	Y = 4.82 – 0.02X	0.02	0.05	-0.22	NS
Energy and BF	Y = 2.40 + 0.22X	0.15	0.20	0.45	NS
CP and SNF	Y = 4.93 – 1.00X	0.16	0.56	-0.75	**
Lactose and SNF	Y = 3.92 + 0.06X	0.02	0.24	0.45	NS
BF and CP	Y = 1.34 + 0.80X	0.30	0.29	0.54	**

** *** = Significant at 5% and 1% respectively.
NS = Not Significant (P>0.05)
SE = Standard error of estimate
R^2 = Coefficient of determination
r = Correlation coefficient

4. CONCLUSION AND RECOMMENDATION

From the findings of this study, it is therefore concluded that goats fed 10% AYBM maintained high milk yield persistently from weeks 1 – 9. This outstanding performance distinguishes 10% AYBM as the diet of choice for dairy production in this study. Does fed the 30% AYBM diet recorded the highest (15.57%) and lowest (14.66%) total solids (TS) in milk in the 7th and 1st week respectively. Goats fed diet 10% AYBM produced persistently high SNF in weeks 5 - 6 and weeks 8 – 10 accordingly. Generally, goats fed 10% AYBM diet maintained superior lactose concentration in milk in the 10 week lactation period of this study. Goats fed 10% AYBM diet produced milk of high energy content which remained persistently high from weeks 1 – 10. Milk yield was negatively and significantly correlated with TS (r = -0.59; P<0.05), CP (r = 0.71; P<0.01), SNF (r = - 0.87; P<0.01) and milk energy (r = -0.79; P<0.01), but poorly and positively correlated with BF (r ~ 0.01; P>0.05), and lactose (r = 0.42; P<0.05). Significantly high (P<0.05) positive correlation existed between BF and TS (r – 0.55) and CP (r - 0.54), energy and TS (r = - 0.57) while a significantly high (P<0.01) but negative correlation existed between CP and SNF (r = - 0.75). Lactose was negatively, poorly and non-significantly correlated with TS (P>0.05; r = -0.22) in this study. Based on the foregoing, 10% AYBM is hereby recommended in diets meant for dairy goats so as to optimize milk yield and composition.

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