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Milk Yield and Composition of West African Dwarf (WAD) Does Fed Pigeon Pea-cassava Peel Based Diets

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Abstract: Twelve lactating West African Dwarf does in early lactation and between 1-3 parity were randomly divided into 4 groups of 3 animals each and housed individually in cement floored pens. The animals selected from the University flock were randomly assigned to 4 experimental diets in a completely randomized design. The diets A, B, C and D were formulated from cassava peel and other feedstuffs and contained 0, 10, 20 and 30% pigeon pea seed meal (PSM) respectively. Each animal received 0.5 kg of the assigned diet for 14 weeks pre and post colostrum period. Drinking water was liberally provided during the period. Daily milk yield was measured and bulked weekly for each animal. Lactose in milk was determined immediately after each day's collection while Total Solids (TS), Butter Fat (BF), Crude Protein (CP), Solids- Not-Fat (SNF), ash and energy contents of milk were determined weekly. Simple linear regression was used to ascertain the degree of relationship between milk yield and constituents and between various milk constituents. Results showed that milk yield, TS, BF, CP, SNF, ash and energy compositions of milk were influenced ($p<0.05$) by dietary treatments. Diet B (10% PSM) promoted the greatest yield (2.33 kg) and the highest concentrations of SNF (9.29%) and energy (2.16MJ kg^{-1}) in milk while the highest TS (15.39%), BF (5.77%), CP (4.52%) and ash (0.93%) values were influenced by diet D (30% PSM). Weekly yield, CP, TS and energy constituents of milk differed significantly ($p<0.05$) among treatment groups. The highest values were obtained for yield in the 4th (2.23 kg), CP and TS in the 10th (4.69; 15.41%) and energy in the 1st(2.08 MJ kg^{-1}) weeks, respectively. Milk yield was negatively correlated ($p<0.05$) with TS ($r = -0.52$), BF ($r = -0.69$) and CP ($r = -0.30$) and positively ($p<0.05$) with SNF ($r = 0.05$), lactose ($r = 0.27$) and energy ($r = 0.33$). Significant ($p<0.05$) positive correlations existed between BF and TS ($r = 0.84$), CP and TS ($r = 0.61$), TS ($r = 0.40$), CP and SNF ($r = 0.32$), lactose and SNF ($r = 0.31$) and BF and CP ($r = 0.42$).

Key words: Milk yield, composition, pigeon, cassava peel, west african dwarf

INTRODUCTION

The West African Dwarf goat is a poor milker. Evidence of low milk production of this breed is well documented[1-3]. Results obtained for the breed on range[4] showed that remarkable improvement can be achieved under favorable or improved conditions of management[1]. The WAD goat is managed extensively in Nigeria by subsistent and rural farmers who keep them. There is little or no effort on part of Government to improve or encourage the production of this breed because she has in the past depended on mass importation of poultry products to bridge the yawning gap between the animal protein need (25 g d^{-1}) and supply (10 g d^{-1}) in the diet of Nigerians[5]. If Nigeria must satisfy the animal protein requirement of her ever increasing population, there is need to promote and encourage production and products of her indigenous animal species. Nutrition is one of the major constraints to goat production in Nigeria. The subsistent farmers who keep these animals believe that the WAD goat should be raised on range[6]. Owing to this, the animals are exposed to severe nutritional stress, especially during the dry months when fodder quantity and quality is low[7]. The dairy characteristics of WAD goat is presently poor probably because the dairy potentials are yet to be exploited. Any targeted approach to the improvement of WAD goat for milk production must first address the issue of nutrition which has a strong influence on milk yield and composition in lactating animals[8]. While genetic improvement of the breed's dairy profile would entail a protracted and systematic breeding effort to maximize inherent potentials, standardized nutrition would however be required presently to realize the full dairy potential of the WAD goat. There is therefore, the need to change or augment the nutrition of these animals with concentrate formulations based on locally available and non competitive feedstuffs.

Cassava peel is a kitchen / industrial waste derived from cassava tuberous root (*Manihot utilisima*) processing. Its nutritional content and limitations in ruminant nutrition have been extensively studied[9].

Due to the prevailing demand on the cassava crop as a staple in Nigeria, the by-products, especially the peels, are largely available but grossly under utilized. Pigeon pea (*Cajanus cajan*) is a grain legume of relatively low human preference and demand in Nigeria. It is only mainly cultivated in the middle belt area as intercrops in cassava and / or yam plots. It grows wild in other parts of Nigeria where little is known of it as a food crop. Consumption is rare even in cultivated areas and occurs only during scarcity of other conventional grain legumes like soya, groundnut and cowpea. It is rich in nitrogen (21-30% CP)[10].

The generally harsh nutritional climate to which the WAD goat is exposed under range has perhaps not given room for full realization of the dairy potentials of the breed. This study therefore is designed to improve the nutritional status of (WAD) in-does by feeding concentrate formulations derived mainly from pigeon pea and cassava peel in an intensive management arrangement. It is hoped that the improved management and nutritional status would enhance milk yield and composition in the WAD goats.

MATERIALS AND METHODS

Processing of Cassava peel and Pigeon pea seed: Cassava peels (variety TMS 30555) from 12-14 month old plants were collected fresh from the commercial 'Garri' processing unit of the National Root Crops Research Institute (NRCRI), Umudike, Abia state, Nigeria. The batch was subsequently sun-dried for 3 days to about 10% moisture content before being milled and used in this study as dried cassava peel meal. Pigeon pea (*Cajanus cajan*) seeds (brown variety) were purchased from a grain market in Aba, Abia State of Nigeria. Known quantities of the seed were boiled in batches in mammoth cooking pots at 100°C for 30 min. Water was decanted, the boiled seeds were then sun-dried for 3 days before being milled and used as pigeon Pea Seed Meal (PSM).

Animal management: Twelve pregnant does of the WAD breed were selected from the University flock and used in this study. The does which were in their first to third parities were randomly divided into 4 groups of 3 animals each and housed separately in cement floored pens. Straw hay was used as bedding. During the first 4 months of pregnancy, the does were fed forage sword consisting mainly *Panicum maximum*, *Calapogonium_mucunoides*, *Stylosanthes gracilis* and *Centrosema pubescens*. Daily dry matter provision for each animal was based on 3% body weight. In the last 4 weeks of pregnancy, each in-doe received 0.5 kg of an assigned concentrate diet in the morning (0800 h) and 1.0 kg *Panicum maximum* in the afternoon (1400 h). This nutritional regimen continued through parturition and into the 10th week of lactation for each doe.

Table 1:The composition of pigeon pea-cassava peel based diets

	Diets			
Ingredients (%)	A	B	C	D
Cassava peel	42	42	42	42
Pigeon pea	0	10	20	30
Brewers dry grain	35	25	15	5
Palm kernel cake	20	20	20	20
Bone meal	2	2	2	2
Common salt	1	1	1	1
Total	100	100	100	100

Experimental diets and design: Four experimental diets designated A, B, C, D were formulated from pigeon pea, cassava peel and other feedstuffs as listed in Table 1. Diet A with 0% PSM inclusion served as the control.

The four experimental diets were allotted randomly to the 4 animal groups. Each animal within a group received 0.5kg of an assigned diet daily for 14weeks. Potable drinking water was liberally provided.

Kid management: For each pregnant doe, each feeder pen also doubled as a maternity pen. At birth, each kid had its umbilical cord cleansed with disinfectant and cut at a distance of about 2 cm away from the naval flap and a tincture of iodine added to aid healing and prevent entry of pathogens. Kid weights were recorded immediately after parturition using a 5 kg capacity sensitive top loading 'Salter' scale. The date of kidding, parity and litter sizes and composition of does were recorded. Thereafter, new born kids were left to suckle their dams freely for the first 7days. Prior to each day's milking, kids were separated from their dams at 1800 h on the evening preceding the day of milking. Within this period of separation, kids were fed milk with the aid of feeding bottle. Dams were allowed to nurse their kids in the morning after milking and in the afternoon before separation at 1800 h daily. The kids were weighed before and after separation from the dam to estimate quantity of milk consumed.

Milk measurements: During milking, the two halves of the udder of lactating does were hand milked daily from 0700 to 0800 h. The quantity of milk harvested from a doe was measured using graduated glass cylinder (500 mL capacity) and weighed back to the nearest gram on a sensitive laboratory scale. The total amount of milk yielded 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 milk yield responses to changing milking frequency[11], the constant 0.6596 was used as a weighting factor on 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).

Milk sampling: Lactation length for each doe was based on 135 days. Milk sampling was initiated on the 8^{th} day for each lactating doe and terminated on the 77^{th} 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, butterfat, crude protein, solids-not-fat, ash and energy. The bulked samples were often stored in a refrigerator (-5°C) until required for analysis. Milk yield and average compositions were determined per doe per week. Weekly lactose concentrations of milk of does were also determined as averages of daily lactose determinations.

Analytical procedure: The milk samples were analysed for lactose, TS, BF, CP (Nx6.38), SNF, ash and gross energy. Total solids were determined by drying about 5g of milk sample to a constant weight at 105°C for 24 h. Lactose content was determined from fresh samples by the[12] procedure. Butterfat was obtained by the Roese-Gottlieb method[13]. Milk protein (Nx6.38) was determined by the Semi-micro distillation method using Kjeldahl and Markhamps apparatus. Solids-not-fat was determined as the difference between total solids and butterfat. Milk energy Y (MJ kg^{-1}) was computed using the multiple regression equation:

$$Y = 0.386F + 0.205\ SNF - 0.236$$ [14]

where F and SNF represent percentages of fat and solids-not-fat respectively. Proximate compositions of the experimental diets were determined according to[15] procedure.

Statistical analysis: The data on milk yield and composition were analysed using the anlaysis of variance (ANOVA) procedures appropriate for completely randomized design. Means and averages were used to determine weekly milk yield and compositions for all treatment groups. Significant means were separated using Duncan's Multiple Range Test[16]. Simple linear regression was used to ascertain the degree of relationships between milk yield and constituents and between the various constituents of milk.

RESULTS AND DISCUSSION

Experimental diets: The proximate constituents of the experimental diets, the cassava peels and pigeon seed meal used in this study are presented in Table 2. The proximate values for the cassava peel were similar to those reported by[9-17]. The proximate constituents of the pigeon pea also fell within the range of values obtained by[10] . The dry matter percent of the PSM diets (B, C, D) compared favorably with that of the control diet (A). The crude protein and crude fibre contents of the PSM diets were also relatively higher than those of the control diet and tended to increase with increasing levels of pigeon pea seed meal in the diets. Ether extract, ash and energy values declined from diets A-D while the nitrogen-free extract values did not show any consistent trend among the diets.

Milk yield and composition: The influence of diets on milk yield and composition of WAD goat is summarized in Table 3. Milk yield (kg) differed significantly ($p<0.05$) among treatment diets. The control diet supported the lowest yield which was similar ($p>0.05$) to the yield obtained for 20% PSM diet. The does fed 30% PSM diet had average yield which did not differ significantly ($p>0.05$) from yield of the group fed 20% PSM diet. Does fed diet B (10% PSM) produced the greatest mean yield which differed significantly ($p<0.05$) from the yield of other treatment groups. When these same diets were used as fattening rations for WAD goats in another experiment, diet B supported the least weight gain.

In raising ruminant livestock either for milk or meat production, there is a fundamental antagonism between milk synthesis and fattening. Diets that would promote efficient weight gain, would most times naturally lead to poor milk synthesis and vice versa[18]. This according to Mathewman[19] is related to the production and metabolism pattern of rumen volatile fatty acids associated with fed diets. For instance, diets that lend themselves more easily to production of propionate

Table 2: Chemical compositions of pigeon pea, cassava peel and pigeon pea-cassava peel based diets (%DM)

Diets	A	B	C	D	CSP	PSM
Dry Matter (DM)	89.32	89.34	89.32	89.30	90.22	88.50
Crude Protein (CP)	13.25	13.30	13.45	13.65	3.05	25.04
Crude Fibre (CF)	9.62	10.94	12.42	12.68	14.50	7.50
Ether Extract (EE)	4.46	4.32	4.28	4.14	0.70	2.33
Nitrogen Free Extract (NFE)	51.57	50.94	50.35	50.87	66.47	50.78
Ash	10.42	9.84	8.82	7.96	5.50	2.85
Gross Energy (GE) (Kcal g^{-1})*	3.44	3.32	3.21	3.09	1.82	3.95

* Calculated CSP = Cassava peel.; PSM = Pigeon pea Seed Meal

Table 3: Effect of diets on yield and composition of milk of WAD goats

	Treatment		Diets		
Parameter	A	B	C	D	SEM
Mean yield (kg)	1.397^{c}	2.33^{a}	1.598^{bc}	1.680^{b}	0.039
Total solids (%)	14.723^{b}	14.77^{b}	14.742^{b}	15.399^{a}	0.064
Butter fat (%)	5.315^{b}	4.821^{c}	5.154^{b}	5.779^{a}	0.047
Crude protein (%)	4.331^{c}	4.494^{ab}	4.416^{bc}	4.525^{a}	
0.09SNF (%)	9.593^{c}	9.929^{a}	9.721^{b}	9.770^{b}	0.11Ash
(%)	0.927^{a}	0.838^{b}	0.929^{a}	0.935^{a}	0.008
Lactose (%)	4.500	4.854	4.699	4.567	0.023
Energy (MJ kg^{-1})	1.7333^{d}	2.165^{a}	1.857^{c}	2.089^{b}	0.004

^{abcd} Means on the same row with different superscripts differ significantly ($p<0.05$).
SEM = Standard Error of the Mean.

than acetate in the rumen would tend to encourage weight gain than milk synthesis in ruminants. The converse is also true.

In this study, diet A promoted the least milk yield and diet B, the highest. This is probably an indication that more propionate than acetate was relatively produced in the rumen of does fed diet A than in other diets. The reverse was probably the case for goats fed diet B.

The present mean yield (1.75±0.35 kg) obtained for WAD goats in the first 10 weeks of lactation is rather low when compared to the value of 3.33±1.07 kg reported by[20] for same breed within same period. The non-concurrent values may be attributed to the influence of parity and perhaps litter size on the lactating does. Nine out of the twelve does used in this study were in their first parity while eight had single births. A greater number of does used by[20] had multiple births and were in their 2nd- 4th parity. Litter size and parity have been identified as very strong factors that influence milk yield and composition in lactating does[21,22]. The higher the parity and litter size the greater the milk production.

Percent TS were higher in the milk of goats fed PSM diets (B, C and D) than in the control group. However, TS of goats fed 10 , 20% PSM and the control diet compared favorably well ($p>0.05$) and were significantly lower ($p>0.05$) than those of goats fed 30% PSM. Butterfat percent was also highest in goats fed 30% PSM diet while values for groups fed diets C and the control, did not differ ($p>0.05$) significantly. Butter fat and TS are generally influenced by yield and dietary regime of lactating animals[23]. Earlier investigations[24-26] observed negative correlations between yield and TS and between yield and BF that were also confirmed in this study.

Except for lactose, the CP and SNF concentrations were significantly higher ($p>0.05$) in the milk of does fed PSM diets than in the control. While milk protein was highest in does fed diet D, SNF and lactose values were highest in goats fed diet B. The CP, SNF and lactose concentrations in milk are also generally influenced by diet quality[23]. The relatively higher values obtained for these constituents in milk of goats fed PSM diets tend to confirm that the PSM diets were of superior quality to the control. However, the mean values of 14.92±0.27; 5.21±0.27 and 4.65±0.13% obtained respectively for TS, BF and lactose for WAD goats, in this 10-week lactation study, were however lower than the corresponding values of 19.21±0.46; 7.31±0.21 and 6.60±0.19% reported by[20] for WAD goats within the same lactation length. Mean milk protein value (4.44±0.07%) in this study was however superior to that reported (4.21±0.02%) by[20]. Differences in dietary planes and compositions have been reported to influence yield and compositions of milk even within animals of the same breed[23].

Milk ash values were also affected by ($p>0.05$) dietary treatments. The PSM diets, except B, supported higher but non significant ($p>0.05$) ash values in milk than the control diet. The ash value of does fed diet B was the least and it differed significantly ($p<0.05$) from the others. The mean value of 0.93 ± 0.08% is higher than 0.55 ± 0.14% reported for WAD goats but compared favorably with the value of 0.94 ± 0.05 obtained for WAD sheep elsewhere[25].

Table 4: Weekly yield and compositions of milk of WAD goat

	Weeks										
Parameter	1	2	3	4	5	6	7	8	9	10	SEM
Yield (Kg)	1.690^{abc}	1.791^{abc}	1.920^{abc}	2.237^{a}	2.080^{ab}	1.931^{abc}	1.741^{abc}	1.535^{abc}	1.371^{bc}.	1.214^{c}	0.02
TS (%)	15.405^{a}	15.163^{ab}	14.387^{c}	14.283^{c}	14.594^{bc}	14.693^{a}	14.894^{abc}	15.129^{ab}	15.382^{a}	15.419^{a}	0.02
BF (%)	5.549	5.589	4.979	4.797	5.019	5.119	5.168	5.372	5.393	5.586	0.03
CP (%)	4.639^{ab}	4.311^{bc}.	4.340^{bc}	4.148^{c}	4.538^{ab}	4.373^{abc}	4.424^{abc}	4.561^{ab}	4.633^{ab}	4.699^{a}	0.004
SNF (%)	9.993	9.875	9.676	9.655	9.609	9.675	9.705	9.801	9.808	9.828	0.005
Ash (%)	0.923	0.954	0.892	0.965	0.927	0.899	0.906	0.939	0.947	0.979	0.001
Lactose (%)	4.453	4.734	4.559	4.699	4.672	4.664	4.632	4.727	4.731	4.755	0.003
Energy (MJ kg^{-1})	2.083^{a}	2.066^{ab}	1.710^{abc}	1.925^{abc}	1.785^{c}	1.881^{bc}	1.939^{abc}	1.969^{abc}	2.014^{ab}	2.019^{ab}	0.006

^{abc}Means on the same row with different superscripts differ significantly ($p<0.05$)
TS=Total Solids; BF=Butter Fat; CP=Crude Protein; SNF=Solids-Not-Fat

Table 5: Effect of diets on weekly yield and milk composition of WAD goats (* Within Treatments)

		WEEKS										
Parameter	Treatment	1	2	3	4	5	6	7	8	9	10	SEM
	1	1.6700^{bc}	1.7200^{ab}	1.8000^{a}	1.7733^{ab}	1.5833^{c}	1.4400^{d}	1.2700^{e}	1.0167^{f}	0.9200^{f}	0.7800^{g}	0.0001
Yield	2	1.7067^{d}	1.7967^{d}	19900^{d}	3.00^{a}	2.9100^{a}	2.7633^{ab}	2.5233^{bc}	2.3500^{c}	2.067^{c}	1.9533^{d}	0.0084
	3	1.6800^{d}	`8600^{bc}	1.9600^{b}	2.1167^{a}	1.9000^{b}	1.7400^{cd}	1.200^{e}	1.3333^{f}	1.200^{g}	0.7533^{h}	0.0024
	4	1.7067^{bc}	1.7900^{ab}	1.9300^{ab}	2.0600^{a}	1.9300^{ab}	1.7833^{ab}	1.6533^{bcd}	1.4400^{cde}	1.1400^{e}	1.3733^{de}	0.0100
	1	14.7600^{c}	13.7500^{c}	14.3100^{e}	14.5000^{d}	14.6900^{c}	147233^{c}	14.8033^{bc}	14.8733^{ab}	14.9033^{ab}	14.9333^{a}	0. 012
TS	2	15.6100^{ab}	15.8133a	14.3900^{ef}	14.1400^{f}	14.1500^{f}	14.2267^{f}	14.5333^{def}	14.7433^{de}	14.8933^{cd}	15.2633^{bc}	0.0210
	3	15.6033^{a}	14.8900^{bc}	13.8900^{e}	13.5500^{e}	14.4333^{d}	14.5933^{cd}	14.7433^{cd}	15.2200^{ab}	15.9233^{a}	15.5933^{a}	0.0146
	4	15.6500^{bc}	15.2000^{d}	14.9600^{e}	14.9433^{e}	15.1033^{de}	15.2300^{d}	15.5000^{c}	15.6800^{bc}	15.8100^{ab}	15.8900^{a}	0.0034
	1	5.0733^{e}	5.0100^{ef}	4.9633^{f}	5.233^{d}	5.1833^{d}	5.4133^{c}	5.4267^{c}	5.5500^{b}	5.6300^{ab}	5.6700^{a}	0.0008
BF	2	5.7833^{a}	6.0200^{a}	4.7733^{bc}	3.9100^{e}	4.3800^{d}	4.4533^{cd}	4.5400^{c}	4.6100^{c}	4.6800^{c}	5.0633^{b}	0.0123
	3	5.7100^{a}	5.6133^{a}	4.5033^{c}	4.4033^{c}	4.8033^{b}	4.8400^{b}	4.9100^{b}	5.4900^{a}	5.6000^{a}	5.6700^{a}	0.0078
	4	5.8300^{bcd}	5.7133^{ef}	5.6800^{fg}	5.6433^{g}	5.7133^{ef}	5.7700^{de}	5.7961	5.8400^{bcd}	5.8833^{bc}	5.9433^{a}	0.004
	1	4.4833^{ab}	4.0433^{e}	4.3300cd	4.080^{e}	4.2500^{d}	4.2233^{d}	4.3200^{cd}	4.4433^{bc}	4.5533^{ab}	4.5900^{a}	0.0018
CP	2	4.6000^{b}	4.3500^{c}	4.3733^{c}	4.0500^{d}	5.3767^{c}	4.5600^{b}	4.5400^{b}	4.6333^{b}	4.6667^{ab}	4.7633^{a}	0.0016
	3	4.6833^{a}	4.5300^{b}	4.2633^{c}	4.1633^{c}	4.1667c	4.2300^{c}	4.2733c	4.5500^{b}	4.6200^{ab}	4.6833^{a}	0.0011
	4	4.7900^{a}	4.3233^{gh}	4.3967^{fg}	4.3000^{h}	4.3600^{gh}	4.4800^{ef}	4.5633^{de}	4.6200^{cd}	4.6933^{bc}	4.7633^{ab}	0.0008
	1	9.6833^{bc}	9.7300^{abc}	9.8200^{a}	9.3100^{f}	9.3033^{f}	9.7600^{ab}	9.5033^{e}	9.6733^{bcd}	9.6100^{cde}	9.5400^{de}	0.0019
SNF	2	9.8200^{b}	10.2900^{a}	9.8600^{b}	10.3500^{a}	9.9033^{b}	9.5933^{c}	9.8433^{b}	9.8467^{b}	9.8767^{b}	9.9133^{b}	0.0036
	3	10.0400^{a}	9.7933^{b}	9.4933^{c}	9.3533^{d}	9.700^{b}	9.7300^{b}	9.7533^{b}	9.7533^{b}	9.7833^{b}	9.8167^{b}	0.0014
	4	10.1900^{cd}	9.6900^{d}	9.5333^{d}	9.5067^{d}	9.5333^{d}	9.6200^{d}	9.7200^{cd}	9.9033^{bc}	9.9633b	10.0433^{ab}	0.053
	1	0.5500^{cd}	0.9533^{b}	0.8100^{d}	1.1100^{a}	0.9200^{bc}	0.8633^{cd}	0.8800^{bcd}	0.9000^{bc}	0.8733^{bcd}	0.9133^{bc}	0.0010
Ash	2	0.8067^{de}	0.8233cd	0.8333^{c}	0.8167^{cde}	0.8533^{b}	0.8233^{cd}	0.800^{e}	0.8533^{b}	0.8700^{b}	0.9033^{a}	0.00003
	3	1.0133^{a}	0.9500^{b}	0.9000^{c}	0.8600^{d}	0.9433^{b}	0.9133^{bc}	0.9033c	0.9233^{bc}	0.9333^{bc}	0.9500^{b}	0.00001
	4	1.0233^{de}	1.0933^{b}	1.0267^{de}	1.0767^{bc}	0.9933^{e}	0.9967^{de}	1.0433^{cd}	1.0800^{bc}	1.1133^{ab}	1.1533^{a}	0.00002
	1	4.2000^{c}	4.700^{a}	4.300^{c}	4.6500^{ab}	4.5533^{ab}	4.5633^{ab}	4.5033^{b}	4.5300^{b}	4.5000^{b}	4.5067^{b}	0.0025
Lactose	2	4.5000^{d}	4.8600^{bc}	4.8033^{c}	5.1633^{a}	4.8333^{c}	4.8100^{bc}	4.8233^{bc}	4.8900^{bc}	4.8833^{bc}	4.9433^{b}	0.0014
	3	4.4333^{c}	4.7433^{a}	4.5633^{b}	4.4033^{c}	4.7000^{a}	4.7133^{a}	4.7400^{a}	4.7800^{a}	4.8033^{a}	4.8100^{a}	0.0013
	4	4.7800^{a}	4.6333^{cd}	4.5700^{e}	4.5800^{e}	4.6033^{de}	4.6333^{cd}	4.6633^{c}	4.7100^{b}	4.7400^{ab}	4.7633^{a}	0.00021
	1	1.9100^{b}	1.8833^{bc}	1.7333^{cd}	1.9500^{a}	1.2500^{e}	1.6333^{d}	1.6333^{d}	1.7433^{cd}	1.8400^{bc}	1.7800^{bcd}	0.0022
Energy	2	2.2000^{bc}	2.3000^{a}	2.2200^{b}	1.9700^{f}	2.1500^{cde}	2.1083^{e}	2.1333^{de}	2.1600b^{cde}	2.1933^{bcd}	2.2233^{b}	0.0004
	3	2.1113^{a}	1.9233^{b}	1.8000^{de}	1.7600^{e}	1.7700^{e}	1.7833^{e}	1.7933^{de}	1.8533^{cd}	1.8800^{bc}	1.8933^{bc}	0.0004
	4	2.1110^{cd}	2.1600^{ab}	2.0900^{d}	2.0200^{e}	1.9733^{f}	2.000^{ef}	2.0900^{d}	2.1233^{bcd}	2.1433^{abc}	2.1800^{a}	0.0001

^{abcdefgh}Means on the same row with different superscripts differ significantly ($p< 0.05$). SEM = Standard error of the mean.
TS = Total solids; BF = Butter fat; CP = Crude protein; SNF = Solids-not fat

Milk energy (MJ kg^{-1}) was significantly higher ($p<0.05$) in does fed PSM diets than the control group. Does fed diet B (10% PSM) promoted the highest energy concentration in milk while the control group had the least. Milk energy is a function of BF and SNF contents of milk[14]. Though the goats fed 10% PSM diet had the least butterfat percent in milk, the group also produced averagely the highest SNF in milk which may be responsible for the comparatively higher milk energy obtained for animals in the group. Meanwhile, the mean energy value of 1.96 ± 0.17 MJ kg^{-1}obtained for WAD goat in this study, compared favorably with 1.92 ± 0.09 and 1.78 ± 0.06 but is lower than 2.31 ± 0.13 MJ kg^{-1} values reported for WAD goat, White Fulani cow and WAD sheep respectively, in an earlier investigation[25].

Table 4 is a summary of the weekly yield and milk composition of WAD goats. Milk yield generally rose with time after parturition, reaching peak production in week 4 before declining. The peak yield did not differ significantly ($p>0.05$) from those of other weeks except for yields obtained in weeks 9 and 10. Within treatments (Table 5), does fed control diet had peak production in week 3 while groups fed diets B, C and D (PSM diets) had peak yields in the 4th week post partum. Available reports indicate that Nigeria's indigenous goats including the WAD, attain peak yields within 2-6 weeks of lactation[27,28,29] . The highest group yield (Table 5) was obtained in the 4th week by does fed 10% PSM diet while the least was recorded in the 10th week by does fed 20% PSM diet. Between treatments (Table 6), milk yield differed significantly ($p>0.05$) between groups except in week 1. Does fed 10% PSM diet maintained highest yield from weeks 3-10.

Total solids initially decreased with time after parturition and was least in week 4 before rising. TS values for weeks 1, 9 and 10 were similarly higher ($p<0.05$) than values obtained in weeks 3, 4 and 5. Within treatments (Table 5), goats fed the control diet had the least TS% in milk in week 3 and correspondingly in week 4 for goats fed 10, 20 and 30% PSM diets. TS have been reported to decrease with advancing lactation[8,30]. Akinsoyinu[20] obtained lowest TS in WAD goat milk at 4 weeks post partum which agrees with the result of the

Table 6. Effect of diets on weekly yield and milk composition of WAD goats (*Between Treatments) Weeks

Parameter	Treatment	1	2	3	4	5	6	7	8	9	10
	1	1.6700^{a}	1.7200^{c}	1.8000^{b}	1.7733^{b}	1.5833^{c}	1.4400^{c}	1.2700^{c}	1.0167^{c}	0.9200^{b}	0.7800^{c}
Yield	2	1.7067^{a}	1.7967^{b}	19900^{a}	3.000^{a}	2.9100^{a}	2.7633^{a}	2.5233^{a}	2.3500^{a}	2.067^{a}	1.9533^{a}
	3	1.6800^{a}	`8600^{a}	1.9600^{a}	2.1167^{a}	1.9000^{b}	1.7400^{b}	1.200^{b}	1.3333^{b}	1.200^{b}	0.7533^{c}
	4	1.7067^{a}	1.7900^{b}	1.9300^{a}	2.0600^{b}	1.9300^{b}	1.7833^{b}	1.6533^{b}	1.4400^{b}	1.1400^{b}	
	SEM	0.007	0.0002	0.0009	0.0114	0.0012	0.0011	0.0021	0.0031	0.0097	0.0249
	1	14.7600^{b}	13.7500^{b}	14.3100^{bc}	14.5000^{b}	14.6900^{b}	147233^{b}	14.8033^{b}	14.8733^{c}	14.9033^{c}	14.9333d
TS	2	15.6100^{a}	15.8133^{a}	14.3900^{b}	14.1400^{c}	14.1500^{d}	14.2267^{c}	14.5333^{c}	14.7433^{c}	14.8933^{c}	15.2633c
	3	15.6033^{a}	14.8900^{b}	13.8900^{c}	13.5500^{d}	14.4333^{c}	14.5933^{b}	14.7433^{bc}	15.2200^{b}	15.9233^{b}	15.5933b
	4	15.6500^{a}	15.2000^{ab}	14.9600^{a}	14.9433^{a}	15.1033^{a}	15.2300^{a}	15.5000^{a}	15.6800^{a}	15.8100^{a}	15.8900^{a}
	SEM	0.0147	0.0366	0.0193	0.0074	0.0054	0.0058	0.0043	0.0044	0.0027	0.0267
	1	5.0733^{c}	5.0100^{d}	4.9633^{b}	5.233^{a}	5.1833^{b}	5.4133^{b}	5.4267^{b}	5.5500^{b}	5.6300^{b}	5.6700^{b}
BF	2	5.7833^{ab}	6.0200^{a}	4.7733^{b}	3.9100^{c}	4.3800^{d}	4.4533^{d}	4.5400^{d}	4.6100^{c}	4.6800^{c}	5.0633^{c}
	3	5.7100^{b}	5.6133^{c}	4.5033^{b}	4.4033^{b}	4.8033^{c}	4.8400^{c}	4.9100^{c}	5.4900^{b}	5.6000^{b}	5.6700^{b}
	4	5.8300^{a}	5.7133^{b}	5.6800^{a}	5.6433^{a}	5.7133^{a}	5.7700^{a}	5.7961^{a}	5.8400^{a}	5.8833^{a}	5.9433^{a}
	SEM	0.0014	0.0002	0.0248	0.0174	0.0007	0.0009	0.0004	0.0041	0.0014	0.0022
	1	4.4833^{b}	4.0433^{c}	4.3300^{ab}	4.080^{b}	4.2500^{b}	4.2233^{b}	4.3200^{b}	4.4433^{b}	4.5533^{b}	4.5900^{c}
CP	2	4.6000^{ab}	4.3500^{b}	4.3733^{ab}	4.0500^{b}	5.3767^{a}	4.5600^{a}	4.5400^{a}	4.6333^{a}	4.6667^{a}	4.7633^{a}
	3	4.6833^{ab}	4.5300^{a}	4.2633^{c}	4.1633^{b}	4.1667^{b}	4.2300^{b}	4.2733^{b}	4.5500^{ab}	4.6200^{ab}	4.6833^{b}
	4	4.7900^{a}	4.3233^{b}	4.3967^{a}	4.3000^{a}	4.3600^{a}	4.4800^{a}	4.5633^{a}	4.6200^{a}`	4.6933^{a}	4.7633^{a}
	SEM	0.004	0.0021	0.0012	0.0016	0.0009	0.0008	0.0003	0.0011	0.0007	0.0004
	1	9.6833^{b}	9.7300^{b}	9.8200^{a}	9.3100^{b}	9.3033^{d}	9.7600^{a}	9.5033^{b}	9.6733^{a}	9.6100^{b}	9.5400^{c}
SNF	2	9.8200^{b}	10.2900^{a}	9.8600^{a}	10.3500^{a}	9.9033^{a}	9.5933^{a}	9.8433^{a}	9.8467^{a}	9.8767^{a}	9.9133^{ab}
	3	10.0400^{a}	9.7933^{b}	9.4933^{b}	9.3533^{b}	9.7000^{b}	9.7300^{a}	9.7533^{a}	9.7533^{a}	9.7833^{ab}	9.8167^{b}
	4	10.1900^{a}	9.6900^{b}	9.5333^{b}	9.5067^{b}	9.5333^{c}	9.6200^{a}	9.7200^{a}	9.9033^{a}	9.9633^{a}	10.0433^{a}
	SEM	0.0042	0.0028	0.0036	0.0038	0.0023	0.0035	0.0016	0.0027	0.0029	0.0033
	1	0.5500^{b}	0.9533^{ab}	0.8100^{c}	1.1100^{a}	0.9200^{b}	0.8633^{c}	0.8800^{c}	0.9000^{bc}	0.8733^{c}	0.9133^{b}
Ash	2	0.8067^{b}	0.8233^{b}	0.8333^{c}	0.8167^{b}	0.8533^{c}	0.8233^{d}	0.800^{d}	0.8533^{c}	0.8700^{c}	0.9033^{b}
	3	1.0133^{a}	0.9500^{b}	0.9000^{b}	0.8600^{b}	0.9433^{b}	0.9133^{b}	0.9033^{b}	0.9233^{b}	0.9333^{b}	0.9500^{b}
	4	1.0233^{a}	1.0933^{a}	1.0267^{a}	1.0767^{a}	0.9933^{a}	0.9967^{a}	1.0433^{a}	1.0800^{a}	1.1133^{a}	1.1533^{a}
	SEM	0.0002	0.0033	0.003	0.007	0.0002	0.0001	0.00001	0.0002	0.00008	0.0004
	1	4.2000^{c}	4.700^{b}	4.300^{c}	4.6500^{b}	4.5533^{c}	4.5633^{d}	4.5033^{d}	4.5300^{d}	4.5000^{d}	4.5067^{d}
Lactose	2	4.5000^{ab}	4.8600^{a}	4.8033^{a}	5.1633^{a}	4.8333^{a}	4.8100^{a}	4.8233^{a}	4.8900^{a}	4.8833^{a}	4.9433^{a}
	3	4.4333^{bc}	4.7433^{ab}	4.5633^{b}	4.4033^{c}	4.7000^{b}	4.7133^{b}	4.7400^{b}	4.7800^{b}	4.8033^{b}	4.8100^{b}
	4	4.7800^{a}	4.6333^{b}	4.5700^{b}	4.5800^{b}	4.6033^{bc}	4.6333^{c}	4.6633^{c}	4.7100^{c}	4.7400^{c}	4.7633^{c}
	SEM	0.0063	0.0001	0.001	0.0026	0.0012	0.0002	0.0001	0.0008	0.0002	0.0005
	1	1.9100^{c}	1.8833^{d}	1.7333^{c}	1.9500^{a}	1.2500^{c}	1.6333^{d}	1.6333^{d}	1.7433^{c}	1.8400^{b}	1.7800^{d}
Energy	2	2.2000^{a}	2.3000^{a}	2.2200^{a}	1.9700^{a}	2.1500^{a}	2.1083^{a}	2.1333^{a}	2.1600^{a}	2.1933^{a}	2.2233^{a}
	3	2.1113^{b}	1.9233^{c}	1.8000^{c}	1.7600^{b}	1.7700^{b}	1.7833^{c}	1.7933^{c}	1.8533^{b}	1.8800^{b}	1.8933^{c}
	4	2.1110^{b}	2.1600^{b}	2.0900^{b}	2.0200^{a}	1.9733^{ab}	2.000^{b}	2.0900^{b}	2.1233^{a}	2.1433^{a}	2.1800^{b}
	SEM	0.006	0.0001	0.0006	0.0011	0.0042	0.0003	0.0001	0.0002	0.0002	0.0007

Table 7: The relationship between yield and compositions and other constituents of WAD milk

Parameter	Regression equation	SE	R^2	r	Sign
Yield and TS	Y = 15 908 – 0.562X	0.494	0.26	- 0.514	*
Yield and BF	Y = 6.534 -0.723X	0.399	0.47	- 0.69	**
Yield and CP	Y = 4.623 – 0.103X	0.203	0.06	-0.258	*
Yield and SNF	Y = 9.634 + 0.068X	0.243	0.02	0.147	*
Yield and Lactose	Y = 4.634 + 0.172X	0.318	0.07	0.273	*
Yield and Energy	Y = 1.722 + 0.136x	0.204	0.11	0.331	**
BF and TS	Y = 10.301 + 0.877X	0.313	0.70	0.840	**
CP and TS	Y = 7.553 + 1.659x	0.458	0.36	0.607	**
Energy and TS	Y= 12.841 + 1.06X	0.528	0.16	0.400	*
Lactose and TS	Y= 15.266 – 0.07X	0.575	0.001	-0.042	NS
Energy and BF	Y= 4.570 + 0.356X	0.546	0.60	0.780	**
CP and SNF	Y= 8.062 + 0.381X	0.232	0.10	0.326	*
Lactose and SNF	Y= 8.663 + 0.235X	0.233	0.09	0.316	*
BF and CP	Y= 3.588 + 0.162X	0.191	0.18	0.424	**

(p<0.05), **(p<0.01) NS= Non Significant

TS = Total Solids; BF = Butter Fat; CP = Crude Protein; SNF = Solids-Not Fat.

present study. Does fed the 20% PSM diet recorded the highest and lowest TS in milk in the 9th and 4th weeks respectively (Table 5) while there were significant differences (p<0.05) in TS content of milk between all treatment groups in weeks 4, 5 and 10 (Table 6). TS in milk remained highest consistently in does fed 30% PSM diet in the 3rd and final week (10th week) of the study.

Butterfat percent like TS also decreased with time and was least in week 4 after parturition, but the weekly values however did not differ significantly (p>0.05). Bath *et al.*[31] reported decrease in milk fat of goats in the first 4 weeks of lactation which agrees with the present result. There was a general tendency for BF values in milk to decrease with increasing yield and vice versa. This observation confirmed the negative correlation between BF and yield in this study which earlier had been reported by[24]. Within treatments, the least BF from the control group was in week 3 while in week 4 for groups fed diets B, C and D. The highest BF value was in week 10 in the milk of goats fed 30% PSM diet while the least was in week 4 in goats fed 10% PSM. Between treatments (Table 6) there were significant differences (p<0.05) in BF content of milk for all treatment groups in week 2 and weeks 5-10. Milk BF values of goat fed 30% PSM diet remained persistently higher over others in week 1 and weeks 3-10.

Milk protein values differed significantly ($p<0.05$) with the highest and lowest obtained in weeks 10 and 4, respectively. There was also a tendency for milk protein to increase as milk yield decreased in this study. Within treatments (Table 5), the highest milk protein value was obtained in week 1 from goats fed 30% PSM while the least was in week 4 from goats fed 10% PSM. As in milk fat, milk protein was remained persistently high in goats fed 30% PSM in week 1 and weeks 3-10 (Table 6).

Weekly values for SNF generally did not differ significantly ($p>0.05$), but was lowest in week 5 before rising slowly to week 10.[32] observed highest SNF values in Beetal goats in the first week of lactation which declined in mid-lactation.[23]had also observed that SNF values increased in the latter part of lactation which tended to agree with the present observation. Within treatments, the highest and lowest SNF values were obtained in week 4 in the milk of goats fed 10% PSM and the control group, respectively. Between treatments SNF values did not differ ($p<0.05$) between treatment groups in weeks 6 and 8, but varied significantly ($p<0.05$) among treatment groups in week 5. Goats fed 10% PSM produced persistently high SNF values in weeks 2-5 and weeks 7 and 9.

Milk ash values also did not differ significantly ($p>0.05$) weekly, however, remained inconsistent over the 10 week period of study. In a recent study Ahamefule[26] observed that ash content of milk of WAD sheep declined generally as lactation advanced. Boros[33] also reported lower and higher ash values in milk on the 6th-12th and 12th – 18th week after parturition in goat, respectively. The highest ash value (Table 5) of 1.15% was recorded in the 10th week in the milk of goats fed 30% PSM diet while the least (0.80%) was recorded in week 7 in goats fed 10% PSM diet. There were significant differences (Table 6) in milk ash content between treatment groups in weeks 6 and 7. However, goats fed 30% PSM had consistently high ash values in milk all through the lactation period (weeks 1-10).

Weekly lactose concentration in milk did not differ significantly ($p>0.05$). Akinsoyinu[20] had observed that lactose concentration remained fairly constant within the first 16 weeks of lactation in WAD goats and only declined slightly thereafter. In a similar study, Ahamefule[25] also reported that lactose in milk remained fairly constant all through the lactation stages in cattle, sheep and goat. The highest lactose concentration of 4.94% was obtained in the 10th week (Table 5) in the milk of goats fed 10% PSM diet and least in week 1 (4.20%) in goats fed the control diet. Lactose concentration differed significantly ($p<0.05$) between treatment groups in weeks 6-10 (Table 6). Goats fed 10% PSM diet maintained superior lactose concentration in milk during the 10-week lactation study.

Milk energy (MJ kg^{-1}) values differed significantly ($p<0.05$) within the weeks. It rose gradually after declining to a low value of 1.78 in week 5. Akinsoyinu[20] reported a consistent drop in milk energy up to the 18th week after parturition which runs contrary to the findings of this study. Ahamefule *et al.*,[25] have earlier reported fairly constant milk energy values in early and mid lactation stages in WAD goat. The highest milk energy values were recorded in the 10th week in does fed10% PSM while the least was obtained in the 4th week, in goats fed the control diet (Table 5). Milk energy differed significantly ($p<0.05$) among treatment groups in week 2, 6, 7 and 10 (Table 6). Goats fed 10% PSM diet produced milk of highest energy content from weeks 1-10.

The relationships between yield and constituents of goat milk are summarized in Table 7. Milk yield was negatively and significantly correlated with TS ($r = -0.51$; $p<0.05$), BF ($r = -0.69$, $p<0.01$) and CP ($r = -0.25$; $p<0.05$) and positively with SNF ($r = 0.14$; $p<0.05$), Lactose ($r = 0.27$; $p<0.05$) and energy ($r = 0.33$; $p>0.01$). Significant positive correlations ($p<0.05$) existed been BF and TS ($r = 0.84$), CP and TS ($r = 0.61$), energy and TS ($r = 0.40$), energy and BF ($r = 0.78$), CP and SNF ($r = 0.32$), lactose and SNF ($r = 0.31$) and BF and CP ($r = 0.42$). Lactose was negatively and non-significantly correlated with TS ($p>0.05$; $r = -0.04$). In a similar study, Ahamefule *et al.* (2004) observed very high positive and significant ($p< 0.001$) correlations between BF and TS ($r = 0.92$), energy and TS ($r = 0.92$), CP and TS ($r = 0.74$) and energy and BF ($r = 0.99$) in (WAD) sheep milk which is consistent with the findings of this study. Rai (1980) observed that a decrease in lactose content of milk was associated with an increase in its TS content especially the protein. This explains the observed negative relationship between TS and lactose, even in this study.

CONCLUSIONS

Nutrition generally had positive influence on yield and composition of milk of WAD goats. The yield in this study appeared slightly lower in comparison with known or existing records and would perhaps have improved if most dams were in their second or third lactation and the study period extended to accommodate full lactation length. The strong maternal affinity between the kid and the dam is a strong factor in the milking of the WAD as most dams would not let down milk freely unless on sighting their kids. Drug induced let down would also have yielded better results. Milk constituents also improved with better management and nutrition. The study has also shown that nutrition can be manipulated to achieve peak results in milk yield or in any of the various milk constituents at some targeted periods during lactation. This observation is valuable for any breeding and improvement programme on WAD goat for milk production. Apart from the obvious advantage of improving the dairy characteristics of the WAD goat, good nutrition would also ensure better kid weight at parturition, enhance resistance against disease and alleviate the high kid and pre-weaning mortality rates associated with this indigenous small ruminant breed.

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