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Effect of Varying Concentrate Levels on Milk Yield and Composition of West African Dwarf Does Fed *Bambusa vulgaris* Leaves

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Abstract

The effect of varying concentrate levels on milk yield and composition of West African Dwarf (WAD) does fed *Bambusa vulgaris* leaves as basal diet were evaluated in this study. Nine lactating WAD does in their 3rd to 4th parity nursing single kids were placed in three dietary regimens in a completely randomized design. Dams on Treatment 1 were fed forages at 7% body weight (BW) and concentrate at 0 % BW, dams on Treatment 2 received forages at 6% BW and concentrate at 1% BW, while dams on Treatment 3 received forages at 5% BW and concentrate diet at 2% BW. Ingredients used to formulate the concentrate diet were wheat offal, palm kernel cake, brewers' dried grains, bone meal, vitamins/trace minerals, premix and salt. The result of proximate composition indicated that *Bambusa vulgaris* leaves contained 16.63% crude protein and 6.84% crude fibre. Milk yield was significantly ($p<0.05$) highest (220.74g) for dams fed concentrate at 1% body weight (Diet 2) and lowest (149.04 g) for dams fed the control diet (Diet 1) of forages only. Butterfat contents was significantly ($p<0.05$) highest (3.99%) in the milk of dams fed concentrate at 2% body weight (Diet 3), followed by (2.63%) the milk of dams fed concentrate at 1%, then by the milk of dams fed the control diet (2.60%). Feeding concentrate at 2% body weight significantly ($p<0.05$) affected Iron concentration (0.20 mg/100g). Thus, WAD does fed *Bambusa vulgaris* leaves basal diet should be fed concentrate at 1% BW for maximum milk yield and concentrate at 2% body weight if higher butter fat and optimal milk composition is desired.

Keywords: *Bambusa vulgaris* Leaves, Concentrate, Proximate, Milk Yield, Milk Constituents, Butterfat.

Introduction

One major problem of ruminant production in Nigeria is the scarcity of fodder grasses and legumes in the dry season (Andriarimalala *et al.*, 2019; Sasu *et al.*, 2023). Those available are highly lignified, have low contents of protein and of poor quality (Tona *et al.*, 2014; Ekanem *et al.*, 2019). A few of the grasses are available all year round. One of such grasses is the African bamboo, *Bambusa vulgaris* (Okoruwa *et al.*, 2016; Andriarimalala *et al.*, 2019; Sasu *et al.*, 2023). Bamboo is regarded to as a wonder grass with a woody stem or culm.

Bambusa vulgaris, one of the many species of bamboo belongs to the class Liliopsida, to the subclass Commenlinidae, to the order Cyperales, to the tribe Bambusinae, to the family Poaceae and to the sub-family Bambusoideae, (Okoruwa *et al.*, 2016; Sasu *et al.*, 2023). The various uses of the different parts of bamboo (stems, leaves, roots and extracts) include construction, electrification pole, staking, fencing, decoration, furniture, feeding of livestock such as cattle, sheep and goats, erosion control, other environmental purposes, carbon sequestration, chemicals, pharmaceuticals, etc. (Okoruwa *et al.*, 2016; Andriarimalala *et al.*, 2019; Sasu *et al.*, 2023).

Bamboo leaves are rich in nutrients. The chemical composition of nine bamboo species reported by Andriarimalala *et al.* (2019) include 44.50 – 64.60 % dry matter, 6.68 – 18.50 % ash, 25.90 – 32.60 % crude fibre, 7.71 – 15.40 % crude protein, 43.80 – 55.10 % acid detergent fibre, 10.40 – 15.20 % acid detergent lignin and 72.40 % - 79.30 % neutral detergent fibre. Bamboo leaves has served as an alternate feedstuff for ruminants in the dry season, with increased productivity recorded in carcass yield of rams (Okoruwa *et al.*, 2016) and milk yield of cattle (Andriarimalala *et al.*, 2019). A more appropriate method of utilizing fibrous feeds is to supplement with leguminous leaves and concentrate. Mixture of forages and supplementing with concentrate have been used in improving ruminant production in Nigeria (Malau-Aduli *et al.*, 2001; Tona *et al.*, 2014; Okoruwa *et al.*, 2016; Ahamefule *et al.*, 2019; Ekanem *et al.*, 2022).

Milk composition and quality are important attributes that determine the nutritive value and consumer acceptability. Factors affecting goat milk yield and composition include breed, age, stage of lactation, season and plane of nutrition (Malau-Aduli *et al.*, 2001; Ahamefule *et al.*, 2012; 2017; Anya *et al.*, 2019; Ekanem *et al.*, 2024). *Bambusa vulgaris* is always available in the dry season and all year round for the feeding of livestock. No information is available on the milk yield and composition of any breed of goats fed *Bambusa vulgaris* leaves. The aim of this experiment therefore was to assess the milk yield, lactose, proximate and mineral composition in the milk of West African dwarf (WAD) does fed a basal forage of *Bambusa vulgaris* alone or supplemented with varying dietary concentrate levels.

Materials and Methods

Experimental Site

The research work was carried out at an out station Teaching and Research Farms located at Ikot Ambang Ibiono Ibom Local Government Area. Ikot Ambang is about three kilometers from the city centre of Uyo, the state capital and is within Uyo Capital City territory. The Global Positioning System (GPS) value of the farm location as read in an android phone application, "GPS Test", is N 5°03′44.292″; E 7°52′38.478″. Uyo is located between latitudes 4°59^{1} and 5°04^{1}N and longitudes 7°52^{1} and 8°00^{1}E of the equator. Uyo is located within the South South tropical rainforest agro-ecological zone of Nigeria. The annual rainfall in Uyo ranges from 800 mm – 3,200 mm per annum, average relative humidity is 80% (74 – 85%) and average temperature is 26°C (23 – 28 °C). Rains begin in

March and continue till October with peaks in June and September and two weeks of break in August (August break), then followed by dry season from November till February (University of Uyo Meteorological Station).

Experimental Animals and Management

A total of 9 lactating West African Dwarf (WAD) does were randomly divided into three treatments with 3 replicate per treatment in a completely randomized design. The does were in their 3rd or 4th parity. The nine animals weighed on an average 16.50±0.67 kg. *Bambusa vulgaris* leaves were fed as the basal diet. Other feed ingredients (wheat offal, palm kernel cake, brewers' dried grain, bone meal, vitamins/trace minerals, premix and salt) were used to formulate a concentrate diet as shown on Table 1.

Table 1: Ingredients composition of concentrate diet

Ingredients	% inclusion
Wheat offal	60
Brewers' dried grain	10
Palm kernel cake	27
Bone meal	2.0
Vitamin/trace mineral premix	0.50
Salt	0.50
Total	100
Calculated nutrients (%)	
Crude protein	15.12
Crude fibre	10.65
Ether extract	4.63

The lactating animals were offered the forage and concentrate diets at 7 % body weight. Animals on Diet 1 received no concentrate supplementation while does on Diets 2 and 3 received concentrate supplementation at 1 and 2 % body weight respectively. The dietary treatments were:

Treatment 1: 0 % concentrate: 7 % forage

Treatment 2: 1 % concentrate: 6 % forage

Treatment 3: 2 % concentrate: 5 % forage

Data were collected on daily feed intake, milk yield and composition.

Milk Measurements and Sampling

Milk measurement was carried out using the kids' weight difference procedure described by Ekanem *et al.* (2024). Prior to the day of milk sampling, kids were separated from their dams over night for 10 hours (9.00 p.m. – 07.00 a.m.). Kids were weighed on a sensitive electronic compact scale (Atom –A 120) to obtain the weight of the kids before suckling and allowed to suckle their dams for 5 to 15 minutes. The kids were removed from the dams and weighed again to obtain the weight of the kids after suckling. The amount of milk produced was obtained by subtraction. The total amount of milk yield per day was recorded as the morning daily yield of the does. The daily milk yield was 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 (Erdman and Verner, 1995), the constant 0.6596 was used as a weighting factor on the morning milk yield. Each day's milk yield (S) was estimated as follows:

$$S = M + 0.6596\,M$$

Where M is the morning milk yield (once-a-day milking).

To obtain milk samples for laboratory analyses, the two halves of the udder of lactating does were hand milked once a week from 07:00 to 08:00 hour. The quantity of milk harvested from each doe was measured using a graduated glass cylinder (100 ml capacity) and weighed back to the nearest gram on a sensitive electronic compact scale (Atom –A 120). Milk samples from does on the same dietary treatment were bulked and sub sample of 50 -100ml taken, analyzed immediately for lactose content and stored for chemical analyses. Samples were then analyzed every two weeks for total solids, butterfat, crude protein, ash and minerals. The bulked samples were stored in a deep freezer (-10 ˚C) until required for analyses. Average daily milk yield and compositions were determined for each treatment.

Milk Analyses

The milk samples were analyzed for lactose, total solids (TS), Butter fat (BF), protein, ash, and gross energy. Solids-not fat (SNF) was calculated. Total Solids were determined by drying about 5 g of milk sample to a constant weight at 105 °C for 24 hours. Lactose content was determined from fresh samples by the Marier and Boulet (1959) procedure. Butter Fat was obtained by the Roese-Gottlieb method (AOAC, 2000). Milk protein (N x 6.38) 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 (10 ml) to a constant weight at 550 °C for 48 hours. Solids-not-fat was determined as the difference between TS and butterfat. Milk energy (MJ/kg) was computed using the multiple regression equation. $Y = 0.386F + 0.205\ SNF – 0.236$ (MAFF, 1975).where F and SNF represent percentages of fat and solids-not-fat respectively.

Data Analysis

Data obtained were subjected to analysis of variance using the Statistical Analysis System (SAS, 1999) software. Treatment means were separated using Duncan's multiple range test of the same software.

Results and Discussion

The proximate composition of *Bambusa vulgaris* leaves and the concentrate diet fed to the lactating WAD does is as shown on Table 2.

Table 2: Proximate composition (%) of *Bambusa vulgaris* leaves and concentrate diet

Parameters	*Bambusa vulgaris*	Concentrate diet
Dry matter	61.89	85.55
Crude Protein	16.63	17.15
Crude fibre	6.84	5.24
Ether extract	3.37	6.89
Ash	8.54	6.29
Nitrogen Free Extract	64.80	64.43

The *Bambusa vulgaris* leaves contained a crude protein (CP) of 16.63 % while the CP of the concentrate diet was 17.15 %. The CP value obtained here for *Bambusa vulgaris* leaves was higher than the 15 % reported by Andriarimalala *et al.* (2019) but lower than the 19.02 % reported by Koura *et al.* (2021). This might be due to varietal differences among species, soil type, climatic conditions and stage of development of the grass (Koura *et al.*, 2021). Even if fed alone as the sole diet, the range of CP contents in *Bambusa vulgaris* leaves was above the minimum of 8 % reported as necessary to provide the minimum ammonia levels required by rumen micro-organisms to support optimum rumen activity (Norton, 1998). The CP content range of 16.63 – 17.15 % present in the leaves of *Bambusa vulgaris* and in the concentrate diet was within the range of 14 – 18 % recommended by NRC (1981) for lactating goats.

The influence of varying levels of dietary concentrate on the feed intake and milk yield of WAD does fed a basal diet of *Bambusa vulgaris* leaves is as shown on Table 3.

Table 3: Forage intake, concentrate intake and milk yield (g/day) of WAD does fed *Bambusa vulgaris* leaves and graded levels of dietary concentrate

Parameter	Treatment 1	Treatment 2	Treatment 3	SEM
Forage intake	1978.13^{a}	1573.81^{b}	908.55^{c}	73.40
Concentrate intake	0.00	278.01	239.24	11.89
Milk yield	149.04^{b}	220.74^{a}	152.11^{b}	11.52

^{a,b,c} Means on the same row with different superscripts are significantly different (p<0.05). SEM= standard error of mean, Treatment 1= 0 % concentrate. Treatment 2 = 1 % concentrate. Treatment 3 = 2 % concentrate.

There were significant differences (p<0.05) observed across the forage intake of does and milk yield while there was no significant difference (p>0.05) observed in the concentrate intake. Dams fed Diet 1 had a forage intake of 1978.13g, while dams on Diet 2 had a forage intake of 1573.81 g/day and dams on Diet 3 had a forage intake of 908.55g/day. Dams on Diet 1 had no record of concentrate because they were not fed any. Dams on Diet 2 had a concentrate intake of 278.01g while dams on treatment 3 had a concentrate intake of 239.24g. Highest concentrate intake for does on Diet 2 favoured increased milk yield.

Milk yield (220.74 g) was significantly highest ($p<0.05$) for dams fed Diet 2 (1% concentrate). The milk yield of dams fed Diets 1 (149.04 g) with 0 % concentrate and 3 (152.11g) did not differ ($p>0.05$) from each other. Ahamefule and Ibeawuchi, (2005) obtained 122g daily milk yield for WAD goats placed on forage regimen. Ekanem *et al.* (2024) fed a total mixed concentrate ration containing *Enterolobium cyclocarpum* to WAD does and obtained a milk yield of 101.79 – 196.10 g/day. Factors ranging from nutrition, parity, season and environment of study could be implicated for the variations in milk yield within these small ruminants (Ibeawuchi and Dagut, 1996; Ahamefule *et al.*, 2012). Highest milk yield obtained in this study was likely due to parity (does were in their 3^{rd} – 4^{th} parity while does used by Ekanem *et al.* (2024) were in their 1^{st} parity) and the high dietary concentrate intake.
The milk composition of WAD goats fed *Bambusa vulgaris* leaves and different levels of concentrate are summarized on Table 4.

Table 4: Milk composition (%) of does fed *Bambusa vulgaris* leaves and different levels of concentrate

Composition	Treatment 1	Treatment 2	Treatment 3	SEM
Total solids	18.67	17.29	18.83	0.47
Butter fat	2.60^{b}	2.63^{b}	3.99^{a}	0.26
Solids-not–fat	16.07	14.66	14.84	0.39
Lactose	4.93	5.06	4.88	0.10
Protein	5.29	5.64	4.94	0.18
Ash	$0..95^{a}$	0.70^{b}	0.83^{ab}	0.05
Energy (MJ/Kg)	4.06	3.79	4.34	0.13

$^{a, b}$ Means on the same row with different superscripts are significantly different ($p<0.05$).
SEM= standard error of mean

There was no significant difference ($p>0.05$) observed across the total solids (TS) contents of the milk of does. Milk of does on Treatment 1 had a TS value of 18.67 %, while the milk of does on Treatment 2 had a TS value of 17.29 % and milk of does on Treatment 3 had a TS value of 18.83 %. The values obtained for TS was higher than the 12.99 %, 14.78 % and 16.63 % reported for total solid by Ahamefule *et al.* (2017), Anya *et al.* (2019) and Zahraddeen *et al.* (2008) respectively for WAD does but comparable to the range of 15.05 – 22.39 reported by Ekanem *et al.* (2024) for WAD does fed the browse plant, *Enterolobium cyclocarpum*. Variation in TS might be due to various dietary compositions.
Butter fat (BF) composition of milk (%) differed significantly ($p< 0.05$). Milk of dams on Treatment 1 had a BF content of 2.60 %, while milk of dams on Treatment 2 had a butterfat content of 2.63 % and milk of dams on Treatment 3 had a butterfat content of 3.99 %. Butter fat values obtained in this study were higher than the 1.45 – 2.57 % BF reported by Ekanem *et al.* (2024) for WAD does fed *Enterolobium cyclocarpum* leaves. However, BF concentrations obtained in this study were quite lower than the values of 4.21 %, 4.74 % and 4.92 % reported by Ahamefule *et al.* (2017), Zahradden *et al.* (2008) and Anya *et al.*

(2019) respectively for WAD does. The disparities in values may be due to differences in diet and individuality of the animals.

There was no significant difference (p>0.05) observed in the solids-not-fat (SNF) composition of milk. Milk of dams on Treatment 1 had SNF composition of 16.07 %, milk of dams on Treatment 2 had SNF composition of 14.66 % and milk of dams on Treatment 3 had SNF composition of 14.84 %. The values for SNF obtained here were within the range of 12.48 – 20.57 % obtained by Ekanem *et al.* (2024). Solids-no-fat values obtained were higher than the range of 8.78 – 9.93 % reported (Anya *et al.*, 2019; Ahamefule *et al.*, 2017).
The lactose composition of milk had no significant difference (p>0.05) across treatments. Milk lactose remained fairly constant and ranged from 4.88 % in Treatment 3 to highest numerical value of 5.08 % in Treatment 2. Values obtained for lactose in this study were higher than the 4.49 % reported by Zahradden *et al.*, (2008). This work corroborated the research of other authors who reported fairly constant but lower values of lactose concentration. Lactose contents reported were 3.88 - 4.13 (Ahamefule *et al.*, 2017), 4.05 – 4.52 % (Anya *et al.*, 2019), 4.42 – 4.60 % (Ahamefule *et al.*, 2012) and 4.08 – 4.81 % (Ekanem *et al.*, 2024).
Values for milk protein were also similar (p>0.05) among treatment groups and ranged from 4.94 - 5.64 %. The values obtained in this study was comparable to the values of 3.34 – 5.64 % reported by Ekanem *et al.* (2024) but lower than the range of protein concentration (4.44 – 4.86 % and 3.73 - 4.08 %) reported by Anya *et al.* (2019) and Ahamefule *et al.* (2017) respectively. Protein concentration in milk is generally influenced by diet quality.
Ash composition of milk differed significantly (p<0.05) across treatment. Milk of dams fed Treatment 1 had an ash composition of 0.95 % while Treatment 2 had an ash composition of 0.70 % and Treatment 3 had an ash content of 0.83 %. Ash contents obtained in this study is in line with similar values of 0.88 – 0.95 % reported (Ahamefule *et al.*, 2017; Anya *et al.*, 2019; Ekanem *et al.*, 2024).
Milk energy (MJ/kg) had no significant difference (p>0.05) across treatments. Milk of dams on Treatment 1 had an energy content of 4.06 MJ/kg while milk of dams on Treatment 2 had an energy content of 3.79 MJ/kg and milk of dams on Treatment 3 had an energy content of 4.34 MJ/kg. Values obtained for energy in this study is similar to 3.53 – 3.98MJ/kg reported by Anya *et al.* (2019) and 3.27 – 4.68 MJ/kg reported by Ekanem *et al.* (2024).

Milk Mineral Concentration

Minerals in milk constitute less than 1 % of the total composition. However, they are an important influence on the functional properties of milk. Presented in Table 5 is the mineral composition of milk from WAD does fed *Bambusa vulgaris* leaves and different levels of concentrate.

Table 5: Mineral constituent (mg/100g) of does fed *Bambusa vulgaris* leaves and different levels of concentrate

Constituents	Treatment 1	Treatment 2	Treatment 3	SEM
Calcium	40.13	38.76	40.46	1.07
Phosphorus	5.43	5.26	5.27	0.19
Potassium	5.81	5.57	5.87	0.12
Magnesium	19.38	19.44	20.09	0.53
Sodium	13.98	13.93	14.95	0.35
Iron	0.13^{b}	0.10^{b}	0.20^{a}	0.02

$^{a, b}$ Means on the same row with different superscripts are significantly different (p<0.05); SEM= standard error of mean

There was no significant difference (p>0.05) among treatment groups in the calcium (Ca) content of milk. Milk of dams fed Treatment 1 had a Ca content of 40.13 mg/100g, while milk of dams fed Treatment 2 had a calcium content of 38.76 mg/100g and Treatment 3 had a Ca content of 40.46 mg/100g. The milk calcium concentration (38.76 - 40.46 mg/100g) obtained in this study were comparable to the concentrations of 39.82 – 46.30 mg/100g reported by Ekanem *et al.* (2024), but higher than the concentrations of 14 - 26 mg/100g reported by Ahamefule *et al.* (2017) for WAD goats.

There was also no significant difference observed (p>0.05) in the phosphorus (P) composition. Milk of dams on Treatment 1 had a phosphorus content of 5.43 mg/100g, while milk of dams on Treatment 2 had a phosphorus content of 5.26 mg/100g and Treatment 3 had a phosphorus content of 5.27 mg/100g. Values for P recorded in this research were lower than the 4.80 – 11.59 mg/100g reported by Ekanem *et al.* (2024) for WAD does.

Potassium (K) constituent had no significant difference (p>0.05). Treatment 1 had a K content of 5.81 mg/100g while Treatment 2 had a K content of 5.57 mg/100g and Treatment 3 had a K content of 5.87 mg/100g. These values collaborated the 4.93 – 6.12 mg/100g K reported by Ekanem *et al.* (2024) for lactating WAD goats.

There was no significant difference (p>0.05) among treatment groups in the magnesium (Mg) constituents of milk. Milk of dams on Treatment 1 had a Mg content of 19.38 mg/100g, milk of dams on Treatment 2 had a Mg content of 19.44 mg/100g, while Treatment 3 had a Mg content of 20.09 mg/100g. Similar range of values (18.87 – 24.00 mg/100g) for Mg was reported (Ekanem *et al.*, 2024). However, the Mg contents obtained in this research was higher than 11.00 – 17.00 mg/100g reported by Ahamefule *et al.* (2017) for WAD does at early, mid and late lactation.

Sodium (Na) constituent also did not differ significantly (p>0.05) among treatment groups. Milk of dams on Treatment 1 had a Na content of 13.98 mg/100g, dams on Treatment 2 had a Na content of 13.93 mg/100g and milk of dams on Treatment 3 had a Na content of 14.95 mg/100g. Contents of Na obtained in this study corroborated the report of Ahamefule *et al.*

(2017) and Ekanem *et al.* (2024) who obtained 8.00 – 22.00 mg/100g and 11.88 – 20.06 mg/100g respectively for WAD does fed forages and concentrate mix.

There was a significant difference ($p < 0.05$) among treatment groups in the iron (Fe) concentration of milk. Milk of dams on Treatment 1 had Fe contents of 0.13 mg/100g while Treatment 2 had a Fe content of 0.10 mg/100g and Treatment 3 had Fe contents of 0.20 mg/100g. The Fe contents here were in line with what was reported (0.05 – 0.14 mg/100g) by Ekanem *et al.* (2024) for WAD does. Variations in mineral supplementation may be due to season, environmental conditions, and genetic makeup of individual WAD does (Ahamefule *et al.*, 2012; 2017; Anya *et al.*, 2019; Ekanem *et al.*, 2024). This experiment was conducted in the dry season. *Bambusa vulgaris* is available all year round.

Conclusion

It can be concluded that feeding of lactating WAD does with *Bambusa vulgaris* forages and 1% concentrate resulted in highest milk yield and lactose contents. Also, lactating WAD does fed a basal diet of *Bambusa vulgaris* forages should be fed 2 % concentrate as this resulted in highest butter fat contents of milk. Furthermore, feeding of lactating WAD does with *Bambusa vulgaris* forages and 2 % concentrate resulted in higher concentration of milk minerals.

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