IJAS Iranian Journal of Applied Animal Science

Reproductive and Lactation Characteristics of West African Dwarf Goats Offered *Moringa oleifera* Herbage Supplement

Research Article

O.T. Ojoawo[1*], J.A. Akinlade[1], A.A. Akingbade[1], O.A. Aderinola[1] and D.O. Okunlola[2]

[1] Department of Animal Production and Health, Ladoke Akintola University of Technology, Ogbomoso, Nigeria
[2] Department of Animal Nutrition and Biotechnology, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

Received on: 7 Sep 2020
Revised on: 4 May 2021
Accepted on: 15 May 2021
Online Published on: Dec 2021

*Correspondence E-mail: otojoawo47@lautech.edu.ng

Online version is available on: www.ijas.ir

ABSTRACT

Nutrition improvement with multipurpose trees could be a means of increasing milk yield. The present study was conducted to evaluate the effect of *Moringa oleifera* supplementation on the productive and reproductive performance of goats. The *Panicum maximum* was replaced by *Moringa oleifera* at the level of 0, 25, 50, 75, and 100% of group T_1, T_2, T_3, T_4, and T_5, respectively. Data recorded on conception rate, kids' birth weight; dry matter intake (DM), average daily gain, and milk yield; and kids' DM intake of West African Dwarf (WAD) goats. The highest value for conception rate (50%), DM intake (3.08%), average daily gain (44.30 g/day), and milk yield (0.5 kg/day) were observed in the does fed T_4 diet, except for kids birth weight (1.70 kg) at T_3. The does fed T_5 diet had the least values. Kids from T_4 diet had significantly (P=0.05) the highest DM intake (152.33 g/day). *M. oleifera* herbage supplementation at 25 % with 75 % *P. maximum* based diet improved reproductive and lactation characteristics of WAD goats.

KEY WORDS lactation characteristics, *Moringa oleifera* herbage supplement, reproduction, West African Dwarf goats.

INTRODUCTION

Humans have identified milk (product from female mammary gland) as a major source of protein and have recommended it for all ages. Humans have relied heavily on livestock, especially ruminants for intake. Among these ruminants, milk from cattle has been most used and researched into. Small ruminants (sheep and goat) also produce milk and are of growing interest recently. Among goats, the Saanen breed has been the "New Jersey" with about 3 liters of milk yield daily (Gőkdai *et al.* 2020). West African Dwarf goat is the predominant breed in Southern Nigeria. It produces a low quantity of milk when compared with other goat breeds (Devendra and Burns, 1983; Adebambo *et al.* 1994; Ojoawo and Akinsoyinu, 2014). Valerie (1996) reported that West African Dwarf (WAD) goats produce low milk when compared with other nonseasonal breeds with milk yield of 0.3 kg/day and had contributed to the low growth rate in the offsprings. However, it had been observed that remarkable improvement can be achieved under improved nutrition and management conditions (Milerski and Mares, 2001). Nutrition plays a major role in milk quantity and quality. One of the identified ways of assessing milk yield has been to assess the nutrition of the dairy ruminants (Milerski and Mares, 2001). This has usually been done with concentrate diets. However, ruminants depend on forage for survival (Banerjee, 2013). The response of ruminants in terms of performance and reproductive characteristics is being assessed using multipurpose trees. One of such trees of global interest is *Moringa oleifera*. *Moringa oleifera* leaf meal has been reported to increase feed intake, nutrient digestibility, reduced worm load, re-

placed conventional mixed concentrate and did not pose a health threat when included in diets of growing goats and sheep (Sultana *et al.* 2015; Yusuf *et al*. 2016; Zaher *et al.* 2020). Therefore, there is a need to assess the response of these goats to *Moringa oleifera* herbage supplementation before and after kidding; during lactation, and its corresponding effects on the progeny.

MATERIALS AND METHODS

Ethical statement and experimental site

The Ladoke Akintola University of Technology, Ogbomosho's guidelines and ethics for use of animals for the experiment were observed and approval was granted. The experiment was conducted at the Sheep and Goat Unit of the institution's Teaching and Research Farm. Ogbomoso is located at 8˚ 7' North of the equator and 4˚ 15' East of Greenwich meridian, in the derived savannah zone, Southern Nigeria. The temperature ranges between 28 ˚C and 34 ˚C and humidity ranges of 50 to 80 % (NASA, 2016).

Experimental design and duration

The study involved four experimental groups and one control group, which made a total of five treatments. A completely randomized design was used for the experiment, in which nine West African Dwarf goats (sexually matured 8 does and 1 buck) were balanced for weights and then randomly assigned to the five treatments and tagged. The experiment lasted for ten months (1 month for pre-experimental period, 5-6 months for gestation period, and three months for lactation/kid weaning).

Experimental animals and management

Sexually matured 40 does and 5 bucks of about 1-1.5 years of age and weight range of 19.5-21 kg were acquired from Ogbomoso community and kept in individual experimental pens. The pens measured 1.5 m^2 (1.7 m×0.9 m) and were disinfected with Morigard solution before being stocked with the goats. On-farm quarantine was done for the goats; sick ones were isolated and treated. The initial weights of the goats were measured using a digital hanging scale. Two weeks of adaptation/adjustment to the new environment was observed. During the two weeks adjustment period, all the goats were dewormed with Albendazole and Ivermectin (0.5 mL/10 kg body weight) against internal and external parasites. Antibiotics (oxytetracycline L.A. (20%) was administered at 5 mL/10 kg body weight, multivitamins (5 mL/10 kg body weight), iron D (5 mL/10 kg body weight) and Vitamin B. Co (1 mL)) were also administered to ensure that the goats were of good health status. During this period, goats were fed with the likes of cassava peels, *Panicum maximum* leaves, *Gliricidia sepium* herbage, and corn grits.

The animals were however gradually exposed to *Moringa oleifera* leaves. Water and salt licks were provided *ad libitum*. The experimental diets that were offered to the animals in varying proportions were:

T_1: concentrate mixture 200 g + *Panicum maximum* 100% + *Moringa oleifera* 0% (control)
T_2: concentrate mixture 200 g + *Panicum maximum* 75% + *Moringa oleifera* 25%
T_3: concentrate mixture 200 g + *Panicum maximum* 50% + *Moringa oleifera* 50%
T_4: concentrate mixture 200 g + *Panicum maximum* 25% + *Moringa oleifera* 75%
T_5: concentrate mixture 200 g + *Panicum maximum* 0% + *Moringa oleifera* 100%

The does were synchronized with estradiol injection to terminate the activity of the corpus luteum and to induce oestrus. The does were hand mated within the experimental pen at the ratio of eight does to one buck in each of the five treatments. Immediately conception was established through blood test, the goats were fed concentrate diet as sustenance ration (cassava flour -73.1%, wheat bran -20%, urea -5%, salt -0.5%, oyster shell -0.2% and mineral/vitamin premix -0.2%). 200 g of the concentrate diet was offered to each of the animals in the morning and they were allowed to do exercise till 12 noon. The goats were thereafter exposed to the experimental diets. They were then managed until kidding and the weights of the pregnant does were measured using a digital scale fortnightly.

Experimental outcomes

(i) After the does had kidded, the respective birth weights of the kids and litter sizes were recorded. The kids were allowed to suck milk from the dam for two weeks after which they were gradually exposed to the experimental diet of their respective dams. The sexing of the kids was done in the fourth week. The kids were kept separately in a pen of 0.18 m^2 (0.6 m×0.3 m) size. (ii) Conception rate was evaluated by dividing the number of pregnant does by the number of times for mating and then multiplied by 100. Assigns of parturition were observed, a birthing kit that contained iodine solution, a soft towel, a pair of scissors was made available. The kidding was normal in all the goats. The cords of the kids after being cut with scissors were dipped in iodine solution. The kidding pen was then cleaned and disinfected. Litter size was recorded. The birth weights of the kids, placenta weights, and weight of the dams were measured with a digital scale and also recorded.
During the lactation, the feed intake (on a dry matter basis) of the does was estimated by measuring the feed offered in the morning and the refusals that were collected the follow-

ing morning. The weight change was also estimated. The efficiency of feed utilization for milk production of the lactating does was also evaluated by dividing daily milk yield with daily dry matter intake.

The lactation characteristics of the does as the feed was supplemented with *Moringa oleifera* herbage were evaluated. Milk yield from each of the animals that were assigned to each experimental diet was estimated by the weigh-suckle-weigh method. The kids were separated from the dam by 6 pm. In the morning, the weights of the kids were measured with digital scale before and after suckling the dam for 3 hours, and the measurements were recorded. The hand milking method was used to extract the remaining milk from the udder and then weighed. The difference in the weights of the kids before and after sucking the dams was added to the weight of the milk that was hand-milked, and it was estimated as the daily milk yield. These steps were done by 9.00 a.m. and 3 p.m. All measurements were recorded. The kids were separated from the dams between 12 p.m. and 3 p.m. and the milk that was extracted manually from the dams was given to the kids in a feeding bottle. Milk yield determination was done twice a week and the average was recorded as the weekly milk production. The average milk production for 8 weeks was recorded as the milk yield of the WAD goats. Average daily milk yield was evaluated from the total milk yield for 56 days.

Flow rate, fat corrected milk, and net energy efficiency

The average of the daily milking period (in seconds) used by the kids to suck for both morning and evening sessions erewere recorded. Flow rate (g/s) for each of the dams in each treatment was determined by dividing the average daily milk yield by the average daily milking period. Fat corrected milk (FCM) at 4% was evaluated using this formula [0.4 × milk yield (kg)] + [15 × fat yield] (Akpa *et al.* 2004). The FCM/kg W was calculated by dividing FCM with the average body weight of the dams in each treatment. The FCM/Kg MW was estimated as FCM/day divided by $W^{0.75}$. Net energy efficiency (NEE, %) was calculated as 750 × FCM/day × 100 (750×FCM/day) + 70 $W^{0.75}$ where 750= kilocalories of energy/kg of FCM and 70= basal metabolic rate.

Milk intake of the kids

The weights of the kids were measured using a digital measuring scale before and after sucking the dam in the morning and evening. The average of the differences in weight was estimated as the daily milk intake.

Kid Feed intake

This is the amount of feed an animal consumes. It was estimated on a dry matter basis. The average dry matter content of the feed was estimated as 100 g of feed sample was weighed after being oven-dried. An adjustment period of seven days was observed. Forages were offered to the animals at a stipulated time (9.00 h and 16.00 h) for seven days to determine the feed intake. The feeds (3%, in respect to the bodyweight of the animal/day) on DM basis were weighed in the morning by 9.00 h and the residues/leftovers were collected the next morning by 9.00 h and weighed. The feed intake was thus evaluated by subtracting the average dry matter refused daily from the average dry matter offered daily. The total feed intake was estimated by adding the milk intake and the forage intake on DM basis.

Weight change

The weights of the goats were measured using a digital measuring scale immediately after birth and subsequently once every week for eight weeks after parturition. The weekly weights were recorded. Weight change was estimated as the difference between the initial weight and final weight at the eighth week. The final weight at the end of the experiments was estimated as the pre-weaning weight. The average daily gain and Feed Conversion Ratio of the kids were estimated.

Laboratory procedures and analysis

The feeds at the various inclusion levels were analyzed for crude protein (CP), crude erfiber (CF), ether extract (EE), moisture, and Ash using the outline of AOAC (2002). Total nitrogen (N) was determined by micro-Kjeldahl technique using the Markham's distillation apparatus while the crude protein content was calculated by multiplying % N with a factor of 6.25. Nitrogen free extract (NFE) was obtained by subtracting the sum of the percentage of protein, ash, ether extract, and crude erfiber from dry matter.

Statistical analysis

Data generated were subjected to one-way analysis of variance procedure of SAS (2001) and significant means were separated using Duncan's new multiple range test of the same package.

RESULTS AND DISCUSSION

It was observed in Table 1 that there were significant differences in all the nutrient contents across all the experimental diets except the EE content. The CP values of these diets (8.75-25.85%) were higher than the 8% recommended value for the optimum microbial activity of the rumen (Norton, 1994). The CP values of T_2 (13.70%) and T_4 (10.85%) fell within the 11-14% recommended value by NRC (2007) for body maintenance and growth of the growing WAD goats.

Table 1 Chemical composition of the experimental diets (% DM basis)

Chemical composition	T_1	T_2	T_3	T_4	T_5	SEM
Dry matter (DM)	91.78^{a}	91.40^{b}	90.96^{b}	91.20^{b}	92.21^{a}	0.12
Organic matter (OM)	87.00^{ab}	89.00^{a}	83.00^{c}	85.00^{bc}	82.94^{c}	0.10
Crude protein (CP)	8.75^{d}	13.70^{b}	17.70^{a}	10.85^{c}	25.85^{a}	0.09
Crude fibre (CF)	35.00^{a}	24.90^{b}	29.70^{b}	33.60^{ab}	13.84^{c}	0.17
Ether extracts (EE)	4.40	4.00	4.40	4.60	4.15	0.10
Ash	13.00^{c}	11.00^{c}	17.00^{a}	15.00^{b}	17.06^{a}	0.10
Nitrogen free extract (NFE)	30.63^{ab}	33.80^{a}	22.16^{c}	27.15^{b}	31.31^{a}	0.13
Neutral detergent fiber (NDF)	62.14^{a}	33.71^{c}	44.21^{b}	49.21^{ab}	34.00^{c}	0.07
Acid detergent fiber (ADF)	38.57^{a}	12.34^{c}	25.45^{b}	27.63^{ab}	15.17^{b}	0.09

T_1: concentrate mixture 200 g + *Panicum maximum* 100% + *Moringa oleifera* 0% (control); T_2: concentrate mixture 200 g + *Panicum maximum* 75% + *Moringa oleifera* 25%; T_3: concentrate mixture 200 g + *Panicum maximum* 50% + *Moringa oleifera* 50%; T_4: concentrate mixture 200 g + *Panicum maximum* 25% + *Moringa oleifera* 75% and T_5: concentrate mixture 200 g + *Panicum maximum* 0% + *Moringa oleifera* 100%
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

CP values for T_3 (17.7%) and T_5 (25.85%) exceeded the range while that of T_1 (8.75%) which was the least did not meet up with the required value. It was also observed that as the *M. oleifera* inclusion in the diet decreased, there was a significant decrease in CP values. The DM content of T_5 and T_1 diets were significantly higher (P<0.05) than T_2, T_3, and T_4.

The NDF and ADF values of the five experimental diets were low to moderate except for T_1 (*Panicum maximum* only) diet which was on the high side. The fiber fraction analysis of the experimental diets revealed that T_2 diet had the highest predictor of forage intake (lowest NDF) with 33.71 % and the highest predictor of forage digestibility (lowest ADF of 12.34%).

The reproductive performance of WAD goats fed varying levels of *Moringa oleifera* herbage supplement is presented in Table 2. The number of services per pregnancy did not differ significantly among the treatment diets. It was observed that goats fed 25% *Moringa oleifera* and 75% *Panicum maximum* (T_4) diet had the highest number of services and lowest conception rate while those in 75% *Moringa oleifera* and 25% *Panicum maximum* (T_2) diet had the least number of services per pregnancy and the highest conception rate. This implied that conception rate was influenced by the diet. Feeding WAD goats at 75% *Moringa oleifera* and 25% *Panicum maximum* inclusion rate of herbage would increase the conception rate. This finding was observed to contrast with the report of Adeboyejo and Odeyinka (2011) who reported that feeding more than 50% of *Moringa oleifera* improved the conception rate among WAD goats fed *Gliricidia sepium* basal diet. The type of forage being combined with *M. oleifera* herbage could have been responsible.

Litter size did not differ significantly (P>0.05) among the goats fed the treatment diets. Thus the lower the conception rate, the higher the litter size. However, it was observed that the goats in T_5 and T_4 diet groups had twinning while others had just one.

The diet, weight of the pregnant goats, species, and parity could have been responsible for the variation as it was reported by Adebambo *et al*. (1994) that twinning is common in WAD goats and most especially in their second or third parity.

Birth weights of the kids, placenta weight and postpartum weight of does as presented in Table 2 are significantly different (P<0.05) among the treatment diets. All the goats that were exposed to *M. oleifera* herbage from 25% to 100% had high values which ranged from 1.46 kg-1.70 kg. This implied that *M. oleifera* herbage increased birth weight of kids, placenta weight and postpartum weight of does. The kids from goats fed guinea grass diet alone had a low birth weight of 1.09 kg. The highest kid birth weight and placenta weight were observed in goats fed T_2 diet. The twinning that occurred in T_5 and T_4 diets resulted in lower kid birth weights and correspondingly the lower placenta weight.

The size of the dams could have influenced birth weight of the kids and the placenta weight. This result was found to be similar to the report of Mellado *et al*. (2005) who reported that the higher postpartum weight of goats indicated higher birth weight of the kids. Sultana *et al*. (2012) also reported similar findings in Black Bengal goats. There was no significant difference among the treatment diets for the postpartum weight of the does.

The lactation characteristics of the WAD goats fed *Moringa oleifera* herbage in terms of dry matter intake (DMI, g/day), weight change, average daily gain (ADG), feed conversion ratio (FCR), flow rate (g/s), total milk yield (kg), daily milk yield (kg/day), fat corrected milk (FCM) at 4% (kg), FCM/day (kg), and efficiency of feed utilization for milk production are shown in Table 2. All the parameters measured varied significantly among the treatment diets except the initial weight of the lactating does.

The *M. oleifera* herbage intake on a dry matter basis was highest among animals in the T_5 diet group. The intake increased as *M. oleifera* inclusion increased.

Table 2 Lactation characteristics of West African Dwarf goats fed *Moringa oleifera* herbage

Parameters	T_1	T_2	T_3	T_4	T_5	SEM
Reproductive parameters						
Number of services per pregnancy	3	2	4	5	3	0.01
Conception rate (%)	33.33^{ab}	50.00^{a}	25.00^{b}	20.00^{b}	25.00^{b}	1.00
Gestation length (days)	160	155	155	151	153	1.15
Litter size	1	1	1	2	2	0.01
Birth weight of kids (kg)	1.09^{c}	1.70^{a}	1.62^{a}	1.46^{b}	1.52^{b}	0.08
Placenta weight(g)	178.5^{b}	240^{ab}	315^{a}	316^{a}	298^{ab}	10.00
Post partum weight of does (kg)	21.00	21.44	21.80	20.75	21.20	0.50
Lactation characteristics						
Dry matter intake (g/day)						
Moringa oleifera	-	145.64^{d}	262.06^{c}	403.75^{b}	530.12^{a}	3.00
Guinea grass	520.00^{a}	436.91^{b}	260.18^{c}	137.25^{d}	-	2.28
Total dry matter intake (DMI) (g/day)	520.00^{c}	582.55^{a}	522.20^{bc}	541.10^{ab}	530.12^{b}	2.25
Total DMI/kgw$^{0.75}$	59.88^{b}	66.82^{a}	62.44^{b}	64.92^{ab}	62.79^{b}	0.01
DMI (% of body weight)	2.76^{c}	3.08^{a}	2.91^{b}	3.00^{a}	2.91^{ab}	0.02
Live weight change						
Initial weight (kg)	21.00	21.44	21.80	20.75	21.20	0.01
Final weight (kg)	22.91^{c}	23.92^{a}	23.85^{b}	23.03^{c}	23.19^{b}	0.09
Weight change (kg)	1.91^{c}	2.48^{a}	2.05^{c}	2.28^{b}	1.99^{c}	0.08
Average daily gain (g/day)	34.11^{b}	44.30^{a}	36.62^{b}	40.70^{a}	35.52^{b}	1.00
Feed conversion ratio	15.30^{a}	13.15^{c}	14.17^{bc}	13.25^{c}	14.92^{b}	1.12
Lactation parameters						
Milk yield (g/day)	250^{c}	500^{a}	420^{ab}	330^{b}	431^{ab}	0.05
Total milk yield (kg)	14.75^{d}	29.25^{a}	23.51^{b}	18.45^{c}	24.14^{b}	2.00
Feed efficiency for milk production	2.09^{a}	1.16^{d}	1.24^{c}	1.64^{b}	1.25^{c}	0.13
Flow rate (g/s)	0.05^{b}	0.16^{a}	0.05^{b}	0.08^{ab}	0.09^{b}	0.01
Fat corrected milk (4%), (kg)	8.03^{d}	18.60^{a}	14.05^{b}	8.54^{c}	8.27^{c}	1.12
Fat corrected milk/day (4%), (g/day)	143.00^{d}	320.00^{a}	250.00^{b}	150.00^{c}	147.70^{c}	0.04
Milk energy (MJ/kg)	3.02^{b}	3.16^{a}	3.14^{a}	3.01^{b}	3.12^{a}	0.05

T_1: concentrate mixture 200 g + *Panicum maximum* 100% + *Moringa oleifera* 0% (control); T_2: concentrate mixture 200 g + *Panicum maximum* 75% + *Moringa oleifera* 25%; T_3: concentrate mixture 200 g + *Panicum maximum* 50% + *Moringa oleifera* 50%; T_4: concentrate mixture 200 g + *Panicum maximum* 25% + *Moringa oleifera* 75% and T_5: concentrate mixture 200 g + *Panicum maximum* 0% + *Moringa oleifera* 100%
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Also, guinea grass intake on DM basis was highest among animals in T_1 diet. This implied that the DM intake of the herbages was affected by the quantities offered to the lactating does. The total DMI (g/animal/day) ranged from 522.2-582.55 g/animal/day in this study. This is lower when compared with the range of 0.66-0.80 kg/day reported by Bawala *et al*. (2006). The authors offered *Panicum maximum*, isonitrogenous (15% CP), and isocaloric formulated concentrate diet to the WAD goats. However, it was lower when cows were fed *M. oleifera* herbage with *Brachiara brizantha* hay. The variation could be attributed to the type of livestock used and the study area (Reyes-Sanchez *et al*. 2005). The composition of the diet, type of livestock, and study area was responsible for the variations with the finding in this study. The diets that were supplemented with *Moringa oleifera* herbage (T_2, T_3, T_4 and T_5) had higher DM intake than those offered *Panicum maximum* only (T_1). Meanwhile, the highest DM intake was observed among goats in the T_2 diet with 582.55 g/animal/day. It was followed by T_4, T_5, T_1, and T_3 with 541.00, 530, 522.20, and 520.00 g/animal/day respectively.

A similar trend was observed in total DMI/ kg $w^{0.75}$ and DMI (% of body weight) with the goats in the T_2 diet group having the highest value. The nutritional contents in terms of CP and Acid detergent fiber (ADF) contents of the diet (Table 2) could have been responsible for this finding. The DMI expressed as a percentage of body weight ranged from 2.76%-3.08% among the goats offered the different diets. This falls within the range of 1.9%-3.0% recommended by NRC (2007) for goats. The lactating goats had enough DM intakes. The *M. oleifera* herbage supplement was palatable to the goats and it had a positive effect on the rate of growth of the lactating WAD goats as it was seen among goats in T_2 diet which had a high value of ADG and least FCR. T_2 diet could be rated best in terms of DMI, weight change, and FCR of the lactating WAD goats.

The weights of the goats increased during the experiment which lasted for 56 days. The highest weight change and ADG were observed among the goats offered T_2 diet. Also, the does were the most efficient user of the feed for maintenance (FCR) with 13.15 and efficiency for milk production (1.16).

The goats in the T_2 diet had the highest total milk yield and daily milk yield (29.25 kg and 500 g/day), followed by T_5 (24.14 kg and 431 g/day), T_3 (23.51 kg and 420 g/day), and T_4 (18.45 kg and 330 g/day), while the goats in T_1 diet had the least value of 14.75 Kg and 250 g/day. The highest value of the milk yield of 500 g/day in this study is higher than the 206-374 g/day) of Bengal does fed concentrate supplement (Sultana *et al*. 2012), the 102-122 g/day reported by Ahamefule *et al*. (2007) when WAD goats were fed concentrate diet in addition to guinea grass basal diet and in which some were kept intensively in the university farm and some extensively in the village; and the mean value of 25 g/day reported by Ahamefule and Ibeawuchi (2005) when pigeon pea-cassava based diets were fed to lactating WAD does.

This implied that forage-based diet for lactating does with *M. oleifera* herbage supplement improved milk yield of WAD does. Similarly, the daily milk yield was higher for cows offered *M. oleifera* supplement than for those of *B. brizantha* hay only (Reyes-Sanchez *et al*. 2005). The milk yield of Red Sokoto goats was however higher than the values in this study. The non-concurrent values in these reports could be due to the influence of breed, management systems, litter size, and level of parity. It is thereby inferred that nutrition influences milk yield and that *Moringa oleifera* herbage supplement improved milk production of WAD does.

Similar trend was observed in flow rate, the total fat corrected milk (FCM, at 4%), and the daily fat corrected milk with the highest values among goats in T_2 diet group. The milk energy values (3.01-3.12 MJ/kg) reported in this study were higher than the range of values of 1.41-1.84 MJ/kg reported by Ahamefule and Ibeawuchi (2005) and Ahamefule *et al*. (2007). The milk energy value from this study is similar to the energy in the milk of lactating Anglo-Nubian goats (Morsy *et al*. 2015) that were fed *Moringa oleifera* leaf as a protein source where milk energy and milk yield linearly increased ($P< 0.001$). The optimum performance in terms of DMI, live weight and lactation characteristics observed in goats fed T_2 diet is traceable to the quality of the feed (low ADF and NDF, and high CP values (Table 1). The low NDF in the diet accounted for the forage effectiveness in milk production. The reports of Fulgueira *et al*. (2007) and Oba and Allen (2005) corroborated this finding.

The weekly milk yield of the goats for the 8 weeks of lactation is shown in Figure 1. Milk yield increased steadily from the first week of lactation to the sixth week, then dropped for T1, T2, T3, and T5 diets, whereas T1 declined from the third week (Figure 1). The peak for the weekly milk yield was recorded at the 6th week of lactation for all the treatments except for the control (T_1) diet.

The trend of lactation curve (Figure 1) of WAD in this study is similar to the report of Ahamefule and Ibeawuchi (2005), Okunlola *et al*. (2015), Marete *et al*. (2014), and Banda *et al*. (1992) for WAD, Red Sokoto, Kenyan Alpine, and Malawi goats. Thus, higher inclusion of *Moringa oleifera* in diets of lactating goats resulted in decreased DMI, weight change, ADG, milk yield, flow rate and FCM when compared with animals fed T_2 diet. Lactating goats performed optimally in those parameters when offered 25% *Moringa oleifera* herbage and 75% guinea grass mixture.

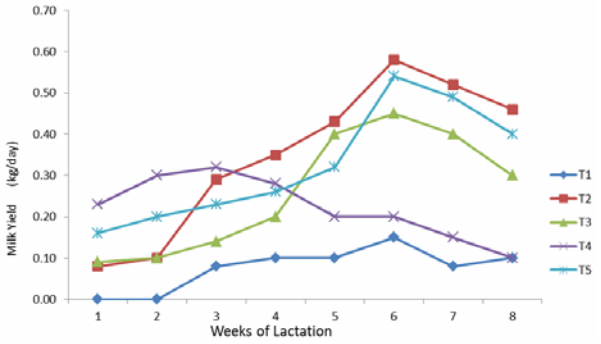

Figure 1 Lactation curve for WAD goats were fed *M. oleifera* and *Panicum maximum* herbage

Table 3 showed the performance of the kids fed the corresponding experimental diets of their dams. All the parameters were significantly different ($P<0.05$) among the goats in the experimental diet groups except total forage intake, FCR and pre-weaning weight. The highest *M. oleifera* herbage intake was observed in the T_5 diet group with 41.20 g/animal/day and the highest *Panicum maximum* intake was observed in T_1 diet (40.48 g/animal/day). The *M. oleifera* herbage intake increased among the treatment diet groups as *M. oleifera* inclusion increased. A contrary trend was observed in the *Panicum maximum* intake. Thus, intake on DM basis is influenced by the amount of forage made available to the goats. The total forage intake ranged from 40.48-53.25 g/animal/day. The highest total forage intake (53.25 g/animal/day) was observed among kids fed T_2 diet while the least (40.48 g/animal/day) was observed among kids fed T_1 diet. The milk intake by the kids ranged from 82.71-99.14 g/animal/day. The total DMI ranged from 123.19-152.39 g/animal/day with kids from T_2 diet group having the highest value. This implied that supplementing kids' diet with *M. oleifera* herbage below 50% improved daily milk intake, forage intake and the total DM intake. The high nutritive value could have informed the high DMI observed in the kids. After the experiment, there were significant changes in the total live weight, weight gain and ADG. The DMI values when expressed as % of body weight and the metabolic weight fell within the recommended range of 2-3% (NRC, 2007).

Table 3 Effects of *Moringa oleifera* herbage supplementation on performance characteristics of the progeny of West African Dwarf goats

Parameters	T_1	T_2	T_3	T_4	T_5	SEM
DMI, g/animal/day						
Milk intake	82.71	99.14^{a}	88.73^{b}	87.67^{b}	88.17^{b}	2.20
M. oleifera intake	-	21.81^{c}	21.58^{b}	28.53^{b}	41.20^{a}	1.80
Panicum maximum intake	40.48^{a}	31.44^{ab}	19.58^{b}	12.18^{c}	-	1.50
Total forage intake	40.48	53.25	41.15	40.71	41.20	1.70
Total dry matter intake	123.19^{c}	152.33^{a}	129.88^{ab}	128.38^{b}	129.37^{ab}	0.08
DMI (% of body weight)	1.89^{c}	2.83^{a}	2.57^{bc}	2.64^{b}	2.63^{b}	0.03
Dry matter intake (kg/w$^{0.75}$)	52.13^{b}	55.42^{a}	52.58^{b}	54.17^{a}	53.90^{a}	2.00
Live weight changes						
Initial (kg)	1.09^{c}	1.70^{a}	1.62^{a}	1.46^{b}	1.52^{b}	0.08
After (kg)	4.22^{c}	5.99^{a}	5.05^{a}	4.87^{ab}	4.92^{ab}	0.08
Weight change (kg)	3.13^{c}	4.29^{a}	3.43^{b}	3.41^{b}	3.40^{b}	0.03
Average daily gain (g/day)	55.92^{bc}	76.58^{a}	61.25^{ab}	60.89^{ab}	60.71^{b}	1.90
Feed conversion ratio	2.20	1.99	2.12	2.11	2.13	0.08
Pre weaning weight (kg)	5.97	6.64	6.51	6.48	6.35	0.05

T_1: concentrate mixture 200 g + *Panicum maximum* 100% + *Moringa oleifera* 0% (control); T_2: concentrate mixture 200 g + *Panicum maximum* 75% + *Moringa oleifera* 25%; T_3: concentrate mixture 200 g + *Panicum maximum* 50% + *Moringa oleifera* 50%; T_4: concentrate mixture 200 g + *Panicum maximum* 25% + *Moringa oleifera* 75% and T_5: concentrate mixture 200 g + *Panicum maximum* 0% + *Moringa oleifera* 100%
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

The weight change and ADG of animals offered T_2 diet had the highest values of 4.29 kg and 76.58 g/day.

These results were higher than the reports of Bunmi *et al.* (2004) in which ADG of 53.88 g for Red Sokoto goat kids that were exposed to crop residue supplementation; and that of Tona *et al.* (2015) in which palm kernel cake (PKC) was included in the concentrate diet. The result from this study was however low when compared with the ADG of Boer goats in Namibia (218-240 g/day) and 182- 257 g/day of Boer goats in Germany (Lu, 2002). The type of feed and species of goats used in these studies could have been responsible for these variations.

The kids in T_2 diet group were the most efficient use of the feed with 1.99. This was followed by 2.11, 2.12, 2.13, and 2.20 for goats in T_4, T_3, T_5, and T_1 diet group respectively.

There was no significant difference among the treatment diets. It was observed that non – supplementation of the goats' diets with *M. oleifera* herbage brought about the high feed conversion ratio (FCR) recorded in the T_1 diet.

The FCR values reported in this study are lower when compared with the reports of Lu (2002) and Rahman *et al.* (2014). The type of diet (forage or concentrate), species of the goats, season, location of the study, and the weather of the study area could have informed these variations.

The pre-weaning weights at eight weeks ranged from 5.97-6.64 kg and it varied significantly among the treatment diets. The kids in the T_2 diet group had the highest weight of 6.64 kg followed by T_3, T_4, T_5, and T_1 respectively. The pre-weaning weight of these kids when supplemented with *M. oleifera* herbage compared favorably with the weaning weights of WAD goat kids reported by Ogunbosoye (2013) at the 4th month.

The high live weight gain of these kids within 8 weeks could be attributed to the increased milk yield and good nutrient composition of the milk and *M. oleifera* herbage. The pre-weaning weights in the study were found to be higher than the weaning weights of Bengal goat kids in which different levels of concentrates were offered to the goats (Sultana *et al.* 2012). The variation could be traced to the quality of feed, milk composition, and milk intake of the kids. Thus, for a high growth rate, the feed of kids could be supplemented with *M. oleifera* herbage at 50% or below. The pre-weaning weight reported in this study falls within the range reported by Ebozoje *et al.* (1995) – (4.1-7.56 kg) for WAD goats for a 90-day growth trial.

CONCLUSION

Moringa oleifera herbage supplement increased the weight of dams and the birth weight of kids. The dietary treatments had no effect on gestational duration or litter size. During lactation, *M. oleifera* herbage increased weight change and improved feed conversion ratio when the does were fed at 25% *M. oleifera* and 75% guinea grass ratio. Daily and total milk yield, efficiency for feed for milk production, fat corrected milk (FCM), FCM/day and milk energy were also optimum for goats fed 25% *M. oleifera* and 75% guinea grass ratio. The highest birth weight of kids was observed in dams fed 25% *M. oleifera* and 75% Guinea grass diet. It is thereby concluded that *Moringa oleifera* herbage supplement improved the reproductive and lactation efficiency of WAD goat and thus should be recommended to farmers to increase goat production. Subsistent farmers should incorporate *Moringa oleifera* herbage as supplement in the West African dwarf goat diet to increase milk production

and thus increase human protein intake.

ACKNOWLEDGEMENT

I specially thank Professor Samson O. Ojoawo for his encouragement, financial and moral assistance. He also assisted in the editorial aspect of the manuscript.

REFERENCES

Adebambo O.A., Samuel A.O. and Onakade A.D. (1994). Causes of variation in reproductive performance of West African Dwarf goat. *Nigerian J. Anim. Prod.* **21,** 29-36.

Adeboyejo F. and Odeyinka S. (2011). Reproductive Performance of WAD Goats Fed *Moringa oleifera.* University of Bremen Publications, Bremen, Germany.

Ahamefule F.O. and Ibeawuchi J.A. (2005). Milk yield and composition of WAD does fed pigeon pea-cassava peel based diets. *J. Agric. Vet. Adv.* **4,** 991-999.

Ahamefule F.O., Ibeawuchi J.A. and Nwachinemere G.C. (2007). Comparative evaluation of milk yield and composition of West African dwarf goats raised in the village and university environment. *J. Anim. Vet. Adv*. **6(6),** 802-806.

Akpa G.N., Edino O.O. and Yashim S. (2004). Influence of milking frequency on lactation characteristics of Red Sokoto goats. *Anim. Res. Int*. **1(3),** 140-143.

AOAC. (2000). Official Methods of Analysis. 17th Ed. Association of Official Analytical Chemists, Gaithersburg, MD, USA.

Banda J.W., Steinbach J. and Zerfas H.P. (1992). Composition and yield of milk from non dairy goats and sheep in Malawi. Pp. 461-483 in Proc. 1st Biennial Conf. African Small Rumin., Kenya, East Africa.

Banerjee G.C. (2013). A Textbook on Animal Husbandry. Oxford and IBH Publishing Company Pvt. Ltd., New Delhi, India.

Bawala T.O., Isah O.A. and Akinsoyinu A.O. (2006). Studies on milk mineral composition of lactating West African dwarf goats. *J. Anim. Vet. Adv*. **6(12),** 1458-1463.

Bunmi M.A., Lawrence E., Clarence L. and Aduli E.O. (2004). Crop-residue supplementation of pregnant does influences birth weight and weight gain of kids, daily milk yield but not the progesterone profile of Red Sokoto goats. *Reprod. Nutr. Dev*. **44(2),** 111-121.

Devendra C. and Burns M. (1983). Goat Production in the Tropics. Commonwealth Agricultural Bureaux Publisher, Willingford, United Kingdom.

Ebozoje M.O., Ngere L.O. and Nwosu I.C. (1995). An analysis of the pre-weaning body weight in WAD goats and their crosses. *Nigerian J. Anim. Prod*. **22(2),** 125-129.

Fulgueira C.L., Amigot S.L., Gaggiotti M., Romero L.U. and Basilica J. (2007). Forage quality: Techniques for testing. *Fresh Prod*. **1,** 121-131.

Gőkdai A., Sakarya E., Contiero B. and Gottardo F. (2020). Milking characteristics, hygiene and management practices in Saanen goat farms: A case of Canakkale province, Turkey. *Italian J. Anim. Sci*. **19(1),** 213-221.

Lu C.D. (2002). Boer Goat Production: Progress and Perspective. Available at: www.hilo.hawaii.edu.

Marete A.G., Mosi R., Amino J. and Janga J. (2014). Characteristics of lactation curves of the Kenyan Alpine dairy goats in smallholder farms. *Open J. Anim. Sci*. **4,** 92-102.

Mellado M., Mellado J., Garcia J. E and Lopez R. (2005). Lifetime reproductive performance of goats as a function of growth traits and reproductive performance in early life. *J. Appl. Anim. Res*. **27,** 113-116.

Milerski M. and Mares V. (2001). Analysis of systematic factors affecting milk production in dairy goat. *Acta Univ. Agric. Silvic. Mendel. Brun*. **1,** 43-50.

Morsy T.A., Kholif A.E., Gouda G.A., Salem A.Z.M., Kholif S.M. and Kholif A.M. (2015). Blood chemistry, milk yield and composition and milk fatty acids profile of lactating Anglo-Nubian goats fed *Moringa oleifera* leaf as a protein source. *J. Anim. Sci*. **93,** 248-250.

National Aeronautic and Space Administration (NASA). (2016). Average Weather in Ogbomoso. https://www.nasa.gov Accessed May. 2020.

Norton B.W. (1994). Tree legume as dietary supplements for ruminants. Pp. 202-215 in Forage tree legumes in tropical Agriculture. R.C. Guttendge and P.M. Shelton, Eds. CAB International, Wallingford, United Kingdom.

NRC. (2007). Nutrient Requirements of Small Ruminants, Sheep, Goats, Cervids, and New World Camelids. National Academy Press, Washington, D.C., USA.

Oba M. and Allen M. (2005). *In vitro* digestibility of forages. Pp. 81-92 in Proc. 3rd State Dairy Nutr. Conf. Fort Wayne, India.

Ogunbosoye D.O. (2013). Correlation between milk composition and kid's growth of West African Dwarf goat fed forage based diet in Southwest Nigeria. *Glob. Vet.* **11(2),** 155-159.

Ojoawo O.T. and Akinsoyinu A.O. (2014). Sodium, potassium and magnesium in milk of West African Dwarf Does as influenced by lactation stages. *J. Agric. Environ. Sci.* **3(2),** 333-343.

Okunlola D.O., Olorunnisomo O.A., Aderinola O.A., Nuga H.A. and Balogun N.O. (2015). milk yield and composition of Red Sokoto goats fed varying levels of Baobab pulp sand seed meal. *J. Biol. Agric. Health.* **5(13),** 186-191.

Rahman M.M., Abdullah R.B., Wen-Khadijah W.E., Nakagawa T. and Akashi R. (2014). Feed intake and growth performance of goats offered Napier grass supplemented with concentrate pellet and soy waste. *Sains Malaysiana*. **43(7),** 967-971.

Reyes-Sanchez N., Sporndly E.S. and Ledin I. (2005). Effect of feeding different level of foliage of *Moringa oleifera* to Creole dairy cows on intake, digestibility, milk production and composition. *Livest. Sci*. **1001,** 24-31.

SAS Institute. (2001). SAS®/STAT Software, Release 8.2. SAS Institute, Inc., Cary, NC. USA.

Sultana N., Alimon A.R., Huque K.S., Sazili A.Q., Yaakub H., Hossain J. and Baba M. (2015). The feeding value of Moringa (*Moringa oleifera*) foliage as replacement to conventional concentrate diet in Bengal goats. *Adv. Anim. Vet. Sci*. **3(3),** 164-173.

Sultana N., Khan M.J., Hassan M.R. and Khondoker M.A.M.Y. (2012). Effects of concentrate supplement on growth, reproduction and milk yield of Black Bengal goats (*Capra hircus*).

Bangladesh Vet. **29(1),** 7-16.

Tona G.O., Adewumi O.O. and Olaniyi E.O. (2015). Milk yield (offtake), composition, dam and kid weight changes of West African Dwarf goats fed dietary levels of palm kernel cake. *IOSR J. Agric. Vet. Sci.* **8(12),** 29-34.

Valerie P. (1996). Goats of the World. Farming Press, Ipswich, United Kingdom.

Yusuf A.O., Iposu S.O., Sanwo K.A., Akinde K.T., Owolabi A.J., Omotosho O.O., Adedayo O.A. and Okwelum N. (2016). Influence of *Moringa* leaf meal (MOLM) supplementation on growth performance, hematological parameters and faecal egg count of West African dwarf sheep *Nigerian J. Anim. Sci.* **(2),** 492-506.

Zaher H.A., Alawaash S.A., Amir I., Tolba M., Ayman L., Swelum A., Mohamed E., Abd El-Hack E., Taha A.E. and Abdelnour S.A. (2020). Impacts of *Moringa oleifera* foliage substituted for concentrate feed on growth, nutrient digestibility, haematological attributes, and blood minerals of growing goats under Abu Dhabi conditions. *Sustainability*. **12,** 6096-6072.