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Milk Yield, Composition and Growth of Kids of West African Dwarf Does Fed *Enterolobium Cyclocarpum* Leaves

Ekanem, N.J.[1*], Mbaba, E.N.[1], Ikwunze, K.[2], Ahamefule, F.O.[2], Okah, U.[2]
[1]Department of Animal Science, Faculty of Agriculture, University of Uyo, Uyo, Akwa Ibom State.
[2]Department of Animal Production and Livestock Management, College of Animal Science and Production, Michael Okpara University of Agriculture, Umudike, Abia State.

ABSTRACT: The aim of this experiment was to determine the milk yield, composition and the growth performance of kids of West African dwarf (WAD) does fed varying levels of *Enterolobium cyclocarpum* (EC) leaves. Twelve lactating goats at their first parity were used in a completely randomized design. The does were divided into 4 groups and fed diets containing 0 %. 07.50 %, 15.00 % and 22.50 % *Enterolobium cyclocarpum* leaves in a concentrate diet respectively. The experiment commenced at the fourth month of pregnancy till the 56th day post-partum. Milk yield was significantly (p<0.05) highest (196.10 g) for does fed Diet 2 with 07.50 % EC leaves. Milk yield for does fed other diets followed this order: 184.35 g (Diet 1) > 104.13 g (Diet 3) > 101.79 g (Diet 4). Milk protein composition ranged from 3.34 – 5.97 % and was significantly (p<0.05) highest (5.97 %) in the milk of does fed Diet 3 (15.00 % EC leaves). Milk magnesium concentration ranged from 18.87 mg/100g (Diet 1) to 24.00 mg/100g (Diet 2) while sodium ranged from 11.88 mg/100g (control) to 20.06 mg/100g (Diet 2). The concentrations of magnesium (24.00 mg/100g) and sodium (20.06 mg/100g) were thus significantly (p<0.05) highest in the milk of does fed Diet 2 (07.50% EC leaves). Diet 2 also supported maximal growth weight (4,858.50 g) of kids at the 9th week. Thus WAD does should be fed 07.50% *Enterolobium cyclocarpum* leaves for maximal milk yield and kids growth.

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KEYWORDS: *Enterolobium cyclocarpum*, milk yield, milk minerals, WAD goats, milk composition, kids' growth.

Corresponding Author:
Ekanem, N.J.

INTRODUCTION

The animal protein (meat and milk) consumption of an average Nigerian is low due to the unavailability and high cost of these products from cattle. Goat production will help to increase animal protein consumption. Goat milk is the most complete food known (Getaneh *et al.,* 2016). It is highly nutritious, with gross composition higher than bovine milk except for lactose which is low. Like other mammalian milk, goat milk contains lactose, fat, protein, vitamins, mineral salts and enzymes. Goat milk also differs from human or cow milk in higher digestibility, buffering capacity and alkalinity and possesses certain therapeutic uses in medicine and human nutrition (Getaneh *et al.,* 2016).

The fat content of goat milk is lower and smaller than its contents in cow milk (Getaneh *et al.,* 2016). Goat milk fat lacks the protein agglutinin, which causes fat molecules to clump together. The relative smaller size globules of goat milk fat make it highly digestible by persons with compromised liver or digestive system or by those allergic to cow milk. The small fat molecules also allow goat milk to stand for a long time before separating into serum and cream (Getaneh *et al.,* 2016). Goat milk fat also contains the precursor to vitamin A that allows it to be readily available for use by the body. Goat milk fat is also very rich in the medium chain fatty acid/triglycerides (MCT) - caproic, caprylic and capric acid. The MCT in goat milk is twice (35 versus 17 %) as cow's milk. MCT is reported to lower cholesterol deposition in the arteries, dissolving and preventing cholesterol deposition in the arteries and treatment of a variety of conditions such as mal-absorption syndrome, coronary diseases, cystic fibrosis, intestinal disorders, pre-mature infant nutrition, gallstones, steatorrhoea, chyluria, hyperlipoproteinaemia, infantile pyloric stenosis and childhood epilepsy. The MCTs also help to fight harmful microbes, thus boosting the immune system (Aina (2012; Getaneh *et al.* 2016).

Goat milk is closer in composition to human milk and it is easily digestible especially by the infants and elderly ones. The low content of lactose in goat milk is also believed to have contributed to its high digestibility (Getaneh *et al.*, 2016). The major milk protein, casein, of goat milk is easily digestible compared to bovine casein. Amino acids (especially tryptophan) of Caprine milk are utilized with ease by the human body. The distinct alkaline nature of goat's milk neutralizes the stomach pH, thus preventing gastric ulcers (Aina, 2012). Goat milk has only 2 % curd, which enhances precipitation, compared with 10% curd in cow's milk. Goat milk does not form mucous (phlegm), but rather neutralizes mucous; it soothes the digestive tracts, thus being better tolerated by persons suffering from allergy to cow's milk, asthmatic, bloating and diarrhea (Aina, 2012; Getaneh *et al.* 2016).

Goat milk contents of vitamins, minerals, electrolytes, trace elements, enzymes, protein and fatty acids are utilized by the human body with ease. Calcium, chlorine, fluorine, silicon, vitamin A, niacin, choline and inositol are present more in goat milk than other domestic livestock (Getaneh *et al.*, 2016). Chlorine and fluorine are natural germicides and fluorine assists in preventing diabetes. Goat milk is rich in selenium, which antioxidant effect strengthens the body immune system. Goat milk is equally free or rare of the tuberculosis bacteria. The enzyme xanthise oxidase is less in goat milk compared to cow's milk. When xanthise oxidase enters the blood stream, it causes scar on the heart, resulting in the liver secreting more cholesterol to protect the heart (Aina, 2012; Getaneh *et al.* 2016).

The productivity of livestock is generally low in the dry season due to reduced forage quantity and quality. Browse plants including *Enterolobium cyclocarpum* are available all year round, are less expensive and have high nutritive value. Feeding of browse plants help to improve the animal diets and productivity (Olorunnisomo, 2013; Delgado *et al.*, 2014). Elephant-ear tree (*Enterolobium cyclocarpum*) is a species of flowering tree belonging to the pea family Fabaceae (Feedipedia, 2017). *Enterolobium cyclocarpum* leaves contain the following nutrients: 15.59 – 22.05 % crude protein (CP), 3.10 – 48.2 % crude fibre (CF), 2.21 – 11.00 % ether extract (EE), 4.40 – 11.80 % ash, 66.57 % nitrogen free extract; 51.4 – 63.94 % neutral detergent fibre (NDF); 31.90 – 42.99 % acid detergent fibre (ADF), 8.6 – 14.83 % acid detergent lignin (ADL) (Babayemi, 2006; Aderinboye *et al.*, 2016; Ekanem, *et al.*, 2020).

Factors affecting milk yield and composition in dairy animals include genetic and environmental factors such as parity (lactation number), stage of lactation (Williams *et al.*, 2012). age of animals, live-weight, age at first parturition, udder and teat dimensions, litter size, season/year of parturition, lactation length, climatic conditions (Ahamefule *et al*., 2017) and nutrition (Ahamefule and Ibeawuchi, 2005; Olorunnisomo, 2013; Anya *et al.*, 2019).

Information on the lactation performance of cows fed *Enterolobium cyclocarpum* forage is scanty (Olorunnisomo, 2013). No information is available on the milk production potentials of West African dwarf (WAD) goats fed *Enterolobium cyclocarpum* leaves. The main aim of this investigation therefore was to assess the milk yield, compositions and kids growth of lactating WAD does fed concentrate diet containing varying levels of *Enterolobium cyclocarpum* leaves.

MATERIALS AND METHODS

The study was carried out at the Teaching and Research Farms, University of Uyo, Uyo, Akwa Ibom State, Nigeria. Uyo is located between latitudes 4˚59´ and 5˚04´ N and longitudes 7˚52´ and 8˚00´ E. The android phone application "GPS Test" recorded the following GPS values for the farm site: N $5^0$03′44.292″; E $7^0$52′38.478.″ Uyo is located within the tropical rainforest zone which characterizes the South South 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 26^0C (23 – 28 ^{0}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 (The Meteorological station, University of Uyo).

Animal management

Sixteen (16) young does that have not yet kidded were purchased; estrous was synchronized using the buck effect and the buck served all the does. Fifteen (15) of the does kidded at the same time and a total of 12 lactating does in their first parity were selected and used in a completely randomized design. Prior to their mating, the does were quarantined and treated against endo and ecto parasites using Kepro oxytet 20% LA injection (Oxytetracycline) and Jay Ivermec 1% (Ivermectin injection). They were also injected with albion multivitamin injection to boost their immune system. The animals were also vaccinated against *Peste des Petits Ruminants* (PPR). The in-does were randomly divided into 4 groups of 4 goats per group and fed the experimental diets. They were housed individually in cement floored pens. Wood shavings were used as bedding materials. During the first 4 months of pregnancy, the animals were fed mainly on forages and a supplement concentrate made up of wet brewers' spent grains and other ingredients (wheat offal, palm kernel cake, bone meal, salt and vitamin/trace mineral premix) that were later used to formulate the experimental concentrate diet. In the last month of pregnancy, *Enterolobium cyclocarpum* (EC) leaves were harvested and wilted in shade for two days, shredded and mixed with other ingredients (brewers' dried grains, wheat offal, palm kernel cake, bone meal, salt and vitamin/trace mineral premix) to formulate 4 diets containing 0.00, 7.50, 15.00 and 22.50 % EC leaves inclusion. The ingredients composition of the diets is as shown on Table 1. The does were fed at 5% of their body weight

(BW). Weighed but *ad libitum* quantity of the experimental concentrate diet was fed at 3% BW while forage sward comprising mostly *Panicum maximum* was fed at 2% BW The weight of the dams were taken weekly. Drinking water was provided *ad libitum*. This feeding regime started from the last month of pregnancy and continued through the parturition and into the 56th day of lactation for each doe.

Table 1: Ingredients composition of experimental diets

INGREDIENTS	DIET 1 (0%)	DIET 2 (7.5%)	DIET 3 (15%)	DIET 4 (22.5%)
Enterolobium cyclocarpum	0.00	7.50	15.00	22.50
Wheat offal	60.00	60.00	60.00	60.00
Brewers' Dried Grain	10.00	10.00	10.00	10.00
Palm Kernel Cake	27.00	19.50	12.00	4.50
Bone meal	2.00	2.00	2.00	2.00
Salt	0.50	0.50	0.50	0.50
Vitamins/Trace Mineral premix	0.50	0.50	0.50	0.50
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated nutrient composition				
% Crude protein	14.75	14.82	14.89	14.97

Kids management

The individual pen of each pregnant doe served as the maternity pen. At birth, each kid umbilical cord was severed from the naval flap, cleansed with disinfectant and a tincture of iodine applied to aid healing. Birth weight was recorded immediately after parturition. Kids were allowed to freely suckle their dams until the 7th day. Milk collection commenced 8 days after kidding to allow kids access to colostrum. Does were milked three days in a week. Prior to each milking day, kids were separated from their dams at 21.00 hour (9.00 p.m.) on the evening proceeding the day of milking. Within this period of separation, kids were creep fed. Kids were allowed to suckle their dams in the morning at 07.00 hour.

Milk measurements and sampling

Lactation length for each doe was based on 135 days. Milk samples collection commenced on the 8th day and terminated on the 56th day post-partum. Milk measurement was carried out using the kids' weight difference method with slight modification according to the procedures described by Ochepo *et al.* (2015) and Ahamefule *et al.* (2012). 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 during the separation period (10 hours) 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 the 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 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. The bulked samples were stored in a deep freezer (-10 ˚C) until required for analyses. Samples were then analyzed every two weeks for total solids, butterfat, protein, ash and minerals. Average daily milk yield and compositions were determined for each treatment.

Analytical procedures

Milk samples were analyzed for their contents of lactose, total solids (TS), butterfat (BF), protein, ash and minerals composition. Solids-not-fat and energy contents were calculated.

Lactose was determined by the Marrier and Boulet (1959) method. Total solid was determined by the method of AOAC (1990). Butterfat (BF) was determined by the Roese-Gotlieb method (AOAC, 1990). Protein was determined by the micro Kjedahl method. The percentage nitrogen content was calculated and the value multiplied by the factor 6.38 to obtain the percentage protein contents. Ash was determined by drying a known weight of milk on a water bath, heated over a hot plate to char and then placed in a muffle furnace set at 540 ^{0}C to ash for about 2 hours (AOAC, 1990). Solids-not-fat (SNF) was calculated as the difference between total solids (TS) and butterfat (BF) while milk energy Y (M/kg) was calculated using the multiple regression equation:

Y = 0.386F + 0.205 SNF – 0.236 (MAFF, 1975);

Where

F = fat,

SNF = solids-not-fat.

Milk mineral composition analyses

The milk mineral composition (calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K) and sodium (Na)) was analyzed according to the methods of AOAC (2005). Calcium and Mg were burnt off in an atomic absorption spectrophotometer (AAS) and the intensity of their flame was measured at the appropriate wavelength, current and pressure. Potassium and sodium were read off in the flame photometer while phosphorus was measured calorimetrically using the vanadomolybdate reagent (AOAC, 2005).

Statistical analysis

Data obtained were subjected to the analysis of variance (ANOVA) using the General Linear Model (GLM) of SAS software (SAS, 1999). Simple correlations on milk yield and constituents were analyzed using the same software. Treatment means were separated by Duncan option of the software.

RESULTS AND DISCUSSION

Proximate composition of experimental diets

The proximate composition of diet containing graded levels of EC fed to WAD does are presented in Table 2. The crude protein (CP) concentration was significantly different (p<0.05) across treatment. The CP which ranged from 13.30% in the control diet to 20.53% in diet 4 (22.50% EC) was within the range reported in literature for lactating WAD does (Ogunbosoye and Babayemi, 2010; Ahamefule *et al.*, 2012; Tona *et al.*, 2015). The range of CP contents in this diet 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 range of CP concentrations (13.30 – 20.53%) in this diet was in conformation with the range of 14 – 18% recommended for lactating goats (NRC, 1981).

Table 2: Proximate composition of concentrate diet containing graded levels of *E*nterolobium *cyclocarpum* leaves fed to lactating WAD does

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Dry matter	98.65^a	95.23^b	94.87^c	94.11^d	0.53
Crude protein	13.30^d	14.88^c	18.01^b	20.53^a	0.85
Crude fibre	3.89^c	5.13^b	5.99^a	6.00^a	0.26
Ether extract	1.33^d	2.32^c	2.80^b	3.06^a	0.20
Ash	5.63^c	7.58^b	8.86^a	8.92^a	0.40
Nitrogen free extract	75.85^a	70.09^b	64.34^c	61.49^d	1.66

$^{a-d}$ Means in the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

Feed intake, milk yield and composition

Table 3 shows the feed intake, milk yield and composition of WAD does fed concentrate diet containing graded levels of *Enterolobium cyclocarpum* leaves. There was no significant difference (p>0.05) in feed intake of lactating does fed diet 2 (7.50% EC; 359.42g/d) and the control diet without EC leaves (371.79g/d). Similarly, there was no significant difference (p>0.05) in feed intake by lactating does fed diet 3 (244.19g/d) and diet 4 (247.96g/d). The feed intake of does fed diets 1 and 2 were significantly different from the intakes of does fed diets 3 and 4.

The milk yield followed similar pattern as feed intake, recording values of 184.35, 196.10, 104.13 and 101.79g/d for does fed diets 1, 2, 3 and 4 respectively. Milk yield by does fed diet 2 was significantly different (p<0.05) and higher than yield for does fed diets 3 and 4. Milk yield decreased with increased EC in the diet. This was due likely to the increased amount of anti-nutritional factors with increased EC leaves in the diet. The range for milk yield (101.79 – 196.10g/d) obtained in this study was higher than the values of 92.5 g/d and 97.34 g/d reported by Ahamefule *et al.* (2012; 2017), within the range of 40.00 - 205.00g/d and 119.17 – 134.99 g/d reported by Tona *et al.* (2015) and Ukanwoko and Ibeawuchi (2014) respectively, but lower than the mean milk yield of 253 g/d reported by Ahamefule and Ibeawuchi (2005) for WAD goats. The variation in milk yield values with other reports may be due to diet (Ukanwoko and Ibeawuchi, 2014; Okunlola *et al.*, 2015) and method of milking (Ahamefule *et al.*, 2012; Ochepo *et al.*, 2015; Tona *et al.*, 2015).

Table 3: Effect of concentrate diet containing graded levels of *Enterolobium cyclocarpum* leaves on the feed intake, milk yield and milk composition of WAD does

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Feed intake (g/d)	371.79[a]	359.42[a]	244.19[b]	247.96[b]	6.73
Milk yield (g/d)	184.35[a]	196.10[a]	104.13[b]	101.79[b]	5.22
Total solids (%)	15.05[c]	15.69[c]	22.39[a]	18.66[b]	0.90
Lactose (%)	4.39[ab]	4.08[b]	4.34[ab]	4.81[a]	0.11
Protein (%)	4.83[ab]	3.34[b]	5.97[a]	5.80[a]	0.34
Butter fat (%)	2.57[a]	1.57[b]	1.82[b]	1.45[b]	0.14
Solids-not-fat (%)	12.48[d]	14.12[c]	20.57[a]	17.21[b]	0.93
Ash (%)	0.83	0.91	0.90	0.87	0.02
Carbohydrate (%)	10.73[b]	9.78[b]	13.61[a]	10.58[b]	0.46
Energy (MJ/kg) *	3.39[c]	3.27[d]	4.68[a]	3.85[b]	0.12

[a – d] Means in the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrates diet. Diet 3 = 15% EC leaves inclusion concentrates diet. Diet 4 = 22.50% EC leaves inclusion concentrates diet. SEM = Standard error of mean.
*Calculated

Milk lactose concentration was slightly significant (p<0.05), ranging from 4.08% in the milk of does fed diet 2 to 4.81% in the milk of does fed diet 4. Lactose concentration obtained in this study was within the same range of 4.20 – 4.53% reported by Ogunbosoye and Babayemi (2010), 4.18 – 4.30% reported by Ukanwoko and Ibeawuchi (2014), 4.22 – 4.41% reported by Tona *et al.* (2015) and 4.05 – 4.52% reported by Anya *et al.* (2019) for the milk of WAD does. Milk lactose contents are thus influenced by the diet.

The milk protein concentrations ranged from 3.34% in diet 2 (7.50% EC) to 5.97% in diet 3 (15.00% EC). Protein contents of the milk of does fed diet 2 was significantly lower than milk of does fed the control diet (4.83%), diet 3 (5.97%) and diet 4 (5.80%). Concentrations of protein did not differ significantly (p>0.05) between the milk of does fed diets 3 and 4. Milk protein concentration increased with increased EC contents in the diet, with optimal concentration in the milk of does fed diet 3. This corroborates the findings of Ogunbosoye and Babayemi (2010), Ukanwoko and Ibeawuchi (2014), Tona *et al.* (2015) and Anya and Ozung (2018) who reported protein concentrations of 3.00 – 3.80%, 3.39 – 3.68%, 3.47 – 3.76% and 5.09 – 5.41% respectively for the milk of WAD does fed varying diets. Okunlola *et al.* (2015) also reported an increased milk protein concentration (3.50, 3.98, 4.28 and 4.06%) with increased (0, 10, 20 and 30%) baobab (*Adansonia digitata L.*) fruit meal supplementation in the diets of Red Sokoto does.

Butter fat (BF) concentrations in the EC supplemented diets were low and non-significant (p>0.05). The BF concentration in the milk of does fed the control diet (2.57%) was significantly higher (p<0.05) than in the milk of does fed diets 2 (1.57%), 3 (1.82%) and 4 (1.45%). The fat content (ether extract; Table 4.24) of the diets was generally low. Higher concentrations of butter fat than what is obtained in this study were reported in literature; 4.33 – 4.53% (Ahamefule and Ibeawuchi, 2005), 4.44 – 5.49% (Anya and Ozung, 2018) and 4.74 – 5.19% (Anya *et al.*, 2019). However, these authors reported that the milk concentration of BF was influenced by the diet composition and milk yield. The results obtained in this study corroborate their assertion on diet composition.

The solids-not-fat (SNF) contents of the milk of does fed concentrate diets with or without EC leaves differed significantly (p<0.05) across treatment. The SNF values were 12.48, 14.12, 20.57 and 17.21% in the milk of does fed diets 1, 2, 3, and 4 respectively. Concentrations of SNF were higher in milk of does fed EC diets than the control, with milk of does fed diet 3 (15.00% EC) recording the highest SNF value. Concentrations of SNF obtained in this study were higher compared to 9.59 – 9.93% reported by Ahamefule and Ibeawuchi (2005) and 9.30 – 9.93% reported by Anya *et al.* (2019). These authors reported that SNF contents in milk are influenced by diet quality. The higher SNF concentrations in the milk of does fed these diets testified to the high quality (especially CP) of the diets (Table 4.24). Milk concentrations of SNF obtained in this study corroborate the findings of Okunlola *et al.* (2015) who reported a higher milk SNF content with increased (0, 10, 20 and 30%) baobab (*Adansonia digitata L.*) fruit meal (higher CP concentration) supplementation in the diets of Red Sokoto does.

The ash contents of the milk of does fed the EC diets ranged from 0.83 – 0.91% and did not differ significantly (p>0.05). The ash concentrations were numerically higher in the milk of does fed the EC leaves containing diets. Okunlola *et al.* (2015) reported ash contents of 0.80 – 0.90% in the milk of Red Sokoto does fed high crude protein diets. Ash contents of 0.73 – 0.97 were reported by Ogunbosoye and Babayemi (2010) for the milk of WAD does fed forage (*Leucaena leucocephala, Gliricidia sepium, Albizia odoratissima, Spondias monbim, Ficus thoningii* and *Panicum maximum*) based diets. Similar ash contents of 0.88 – 1.04% was also reported by Anya and Ozung (2018) for the milk of WAD does.

The milk energy contents differed significantly (p<0.05) across treatment and ranged from 3.27 MJ/kg in diet 2 to 4.68MJ/kg in diet 3 (15.00% EC). It has been reported that milk energy is a function of the milk contents of BF and SNF (Ahamefule and Ibeawuchi, 2005; Anya and Ozong, 2018; Anya *et al.*, 2019). Although the BF concentrations of the diets were low, their correspondingly higher contents of SNF gave milk with high energy contents. Energy contents were highest in the milk of does fed diet 3 (15.00% EC). Milk energy contents obtained in this study were within the range 3.62 - 3.91MJ/kg and 3.53 – 3.98MJ/kg reported by Anya and Ozung (2018) and Anya *et al.* (2019) respectively for WAD does. However, energy values obtained in this study were higher than the values of 1.73 – 2.17MJ/kg and 1.77 – 1.82MJ/kg reported by Ahamefule and Ibeawuchi (2005) and Ukanwoko and Ibeawuchi (2014) for WAD does.

Milk mineral composition

The effect of concentrate diets containing graded levels of EC leaves on the milk mineral composition of WAD does are shown in Table 4. Concentrations of Ca were higher in the milk of does fed the EC containing diets than the milk of does fed the control diet, with the highest concentrations (46.30mg/100g) in the milk of does fed diet 3(15.00% EC). The least Ca concentrations of 39.82mg/100g were in the milk of does fed the control diet without EC leaves. The range (39.82 – 46.30mg/100g) of milk Ca obtained in this study was lower than the range of 120.98 – 131.97mg/100ml and 94.33 – 102.33mg/100g reported by Bawala *et al.* (2006) and Olaniyi *et al.* (2018) respectively for the milk of WAD does fed diets fortified with different mineral sources.

Table 4: Effect of feeding concentrate diet containing graded levels of *Enterolobium cyclocarpum* leaves on the milk mineral compositions (mg/100g) of WAD does

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Calcium	39.82^{b}	42.91^{ab}	46.30^{a}	40.86^{ab}	1.08
Magnesium	18.87^{c}	24.00^{a}	21.82^{b}	22.74^{b}	0.59
Phosphorus	7.17^{b}	7.49^{b}	11.59^{a}	4.80^{c}	0.78
Potassium	5.70^{a}	4.93^{b}	5.80^{a}	6.12^{a}	0.15
Sodium	11.88^{c}	20.06^{a}	16.21^{b}	15.62^{b}	0.88
Iron	0.12^{a}	0.14^{a}	0.14^{a}	0.05^{b}	0.01

$^{a-d}$ Means in the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

Milk magnesium (Mg) concentrations obtained in this study were significantly different (p<0.05) and ranged from 18.87 – 24.00mg/100g, with the lowest concentrations in the milk of does fed diet 1 and the lowest in the milk of does fed diet 2 (7.50% EC). Milk contents on Mg did not differ significantly (p>0.05) in the milk of does fed diets 3 (15.00% EC) and 4 (22.50% EC). The range for milk Mg (17.10 – 17.90mg/100ml) reported by Ojoawo and Akinsoyinu (2014) for WAD does as influenced by lactation stages were within the range obtained in this study. Contents of Mg obtained in this study were also within the range of 18.90 – 47.61mg/100ml reported for the milk of WAD does fed diets supplemented with Calcium Phosphate and Magnesium Sulphate (Bawala *et al.*, 2006). However, Mg contents obtained in this study were lower than the range (9.40 – 10.73mg/100g) reported by Olaniyi *et al.* (2018) for the milk of WAD does fed diets with varying mineral sources.

Milk Phosphorus (P) contents ranged from 4.80 – 11.59mg/100g. Phosphorus contents in the milk of does fed diet 2 did not differ (p>0.05) from the milk of does fed the control diet. There were significant differences (p<0.05) in the contents of P in the milk of does fed diets 2 (7.49 mg/100g), 3 (11.59 mg/100g) and 4 (4.80 mg/100g). Milk concentrations of P obtained in this study were lower than the concentrations of 84.50 – 94.08mg/100ml and 54.67 – 62.00mg/100g reported by Bawala *et al.* (2006) and Olaniyi *et al.* (2018) respectively for the milk of WAD does fed diets fortified with mineral from varying sources.

Milk Potassium (K) contents ranged from 4.93 – 6.12mg/100g. There was no significant difference (p>0.05) in K contents in the milk of does fed the control diet, diet 3 and diet 4. Contents of K were lowest in the milk of does fed diet 2. Concentrations of K obtained in this study were quite lower, compared to the range of 145.20 – 150.40mg/100ml and 158.43 – 165.03 mg/100ml reported by Ojoawo and Akinsoyinu (2014) and Bawala *et al.* (2006) for WAD does milk.

Sodium (Na) concentration was highest (20.06mg/100g) in the milk of does fed diet 2 (07.50% EC leaves) and lowest in the milk of does fed the control. There were significant differences ($p<0.05$) in Na contents in the milk of does fed diets 1, 2, and 3. Milk contents of Na did not differ significantly ($p>0.05$) between milk of does fed diets 3 (16.21mg/100g) and 4 (15.62mg/100g). Contents of Na obtained in this study were also lower than the range of 85.3 – 90.70 mg/100ml for WAD does milk (Ojoawo and Akinsoyinu, 2014).

The contents of Iron (Fe) in WAD does milk obtained in this study did not differ significantly ($p>0.05$). Iron contents ranged from 0.05 – 0.14mg/100g. Concentrations of Fe obtained in this study were higher than the range of 0.02 – 0.05mg/100g reported by Olaniyi *et al.* (2018) for WAD does fed diets with varying mineral sources.

Minerals found in milk are derived from digested mineral present in feed. Variations in milk mineral composition which differed from previous reports may be due to the deficiency of these mineral in the leaves of *Enterolobium cyclocarpum* fed the animals. Variations in milk mineral composition may be as a result of the season of the study; tropical forages differ in nutritional composition in the different seasons of the year. Other factors that may be responsible for the observed variations in milk composition include genetic makeup and environmental conditions (Ahamefule *et al.*, 2012).

Weight of kids at birth, weekly weight gain and weight at weaning

The weight of kids at birth, weekly weight gain and weight at weaning of kids fed the various diets are as shown on Table 5. The birth weight ranged from 958.50g for kids of dams fed diet 4 (22.50% EC) to 1302.35g for kids of dams fed diet 3 (15% EC). There were significant gain ($p<0.05$) in weight in most of the week. Weekly weight increased significantly ($p<0.05$) from birth to week 4 for the kids of does fed diet 1, up to week 6 for the kids of does fed diet 2, up to week 3 for the kids of does fed diet 3 and till week 9 for the kids of does fed diet 4. Thereafter, there were numerical increases in weight gain of kids. Kids on diets 1 and 2 doubled their birth weight before week 4 while kids fed diets 3 and 4 doubled their birth weight at week 5. The weaning weight was highest (4858.50g) for the kids of does fed diet 2 (07.50% EC), followed by the weaning weight (3538.10g) of kids fed the control diet, for kids (3410.40g) of does fed diet 3 and finally for kids (2292.60g) of does fed diet 4. Increases in weight gain are a function of milk yield/quantity (Robinson, 1990). Does fed diet 2 produced more milk, followed by does fed diets 1>3>4 (see Table 3). Linear increases in weight gain by kids from birth till the end of the study corroborate the report of Tona *et al.* (2015).

Table 5: Birth weight, weekly weight gain and weaning weight (g) of kids fed the various EC containing diets

Day/Weeks	DIET 1	DIET 2	DIET 3	DIET 4
Day 1	1228.55^{g}	1131.75^{g}	1302.35^{g}	958.50^{i}
Week 2	1871.30^{f}	1767.60^{f}	1903.75^{f}	1459.80^{h}
Week 3	2188.05^{e}	2198.70^{f}	2275.20^{e}	1677.10^{g}
Week 4	2544.15^{d}	2721.75^{e}	2423.30^{de}	1826.70^{f}
Week 5	2747.95^{cd}	3572.90^{d}	2611.45^{cd}	1926.30^{e}
Week 6	2993.10^{bc}	4028.70^{c}	2664.30^{bc}	2050.60^{d}
Week 7	3224.95^{ab}	4353.70^{bc}	2881.40^{b}	2110.20^{c}
Week 8	3375.70^{a}	4629.30^{ab}	3250.50^{a}	2233.70^{b}
Week 9	3538.10^{a}	4858.50^{a}	3410.40^{a}	2292.60^{a}
SEM	143.34	252.22	122.69	78.25

$^{a-i}$ Means on the same column with different superscripts differ significantly ($p<0.05$). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

Relationship between milk yield and constituents

The relationship between milk yield and constituents of WAD does fed diets containing EC leaves are presented on Table 6. Milk yield was significantly and positively correlated with TS ($r = 0.69$; $p<0.05$), CP ($r = 0.39$; $p<0.05$), SNF ($r = 0.74$; $p<0.05$) and energy ($r = 0.67$; $p<0.05$). Milk yield was non-significantly and positively correlated with BF ($r = 0.08$; $p>0.05$) and lactose ($r = 0.17$; $p>0.05$). Non-significant ($p>0.05$) negative correlation existed between BF and TS ($r = -0.01$), lactose and TS ($r = -0.02$) and BF and CP ($r = -0.09$), while non-significant ($p>0.05$) but positive correlation existed between CP and TS ($r = 0.17$), energy and TS ($r = 0.90$) and CP and SNF ($r = 0.20$). Significant ($p<0.05$) negative correlation existed between energy and BF ($r = -0.06$) and between lactose and SNF ($r = -0.08$). Some of the relationship in milk yield and constituents obtained in this study is in tandem with the findings of Ahamefule *et al*. (2005) and Anya *et al*. (2019). However variations in relationship with previous reports may be due to diet quality, season and parity.

Table 6: The relationship between yield and constituents of WAD goats' milk

Parameter	Regression equation	SE	R^2	r	Significance
Yield and TS	Y = 370.10 – 12.45X	2.48	0.72	0.69	*
Yield and BF	Y = 76.31 + 37.96X	27.52	0.16	0.08	NS
Yield and CP	Y = 248.96 – 20.52X	7.28	0.44	0.39	*
Yield and SNF	Y = 346.20 – 12.40X	2.17	0.77	0.74	*
Yield and Lactose	Y = 408.26 – 59.41X	32.64	0.25	0.17	NS
Yield and Energy	Y = 398.32 – 66.29X	13.68	0.70	0.67	*
BF and TS	Y = 2.67 – 0.05X	0.05	0.09	-0.01	NS
CP and TS	Y = 0.79 + 0.23X	0.13	0.24	0.17	NS
Energy and TS	Y = 0.61 + 0.18X	0.02	0.91	0.90	NS
Lactose and TS	Y = 3.81 + 0.03X	0.04	0.07	-0.02	NS
Energy and BF	Y = 4.23 – 0.23X	0.37	0.04	-0.06	*
CP and SNF	Y = 1.14 + 0.24X	0.12	0.27	0.20	NS
Lactose and SNF	Y = 4.04 + 0.02X	0.04	0.04	-0.08	*
BF and CP	Y = 1.98 – 0.03X	0.10	0.01	-0.09	NS

*Significance at 5%; NS = Not significant ($p<0.05$); SE = Standard error of estimate; R^2 = Coefficient of determination; r = Correlation coefficient. TS = Total solids; BF = Butter fat; CP = Crude protein; SNF = Solids-not-fat.

CONCLUSION

Does fed diet 2 (7.50% *Enterolobium cyclocarpum* leaves) consumed more feed and produced more milk than does fed the control diets and other diets containing EC leaves. The milk was rich in nutrient, with the highest concentration of protein in the milk of does fed diets 3 (15% EC leaves). Magnesium and sodium concentrations was highest in the milk of does fed diet 2 (7.50% *Enterolobium cyclocarpum* leaves). Kids fed diet 2 (7.50% *Enterolobium cyclocarpum* leaves) also had the highest growth weight.

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