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## Effect of feeding level on production performance of lactating Red Maradi goats and post-natal performance of kids

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### ABSTRACT

Forty pregnant Red Maradi goats were used in Caprine Centre of Maradi (Niger) for two subsequent lactations from day one to day 14 of lactation to evaluate the effect of feeding levels of dams on production performances of dams and post-natal performance of kids; to determine the effect of previous levels of feeding dam on production performances of kid and dam; and to determine the ME intakes of kid and dam and their requirements based on AFRC and NRC systems. One diet was formulated for two kiddings as follows: 38% of crushed and urea-treated of millet stover (CUTMS), 32% of groundnut haulms (GH), 22% of wheat bran (WB) and 8% of cottonseed cake (CSC). For the first kidding until the second kidding, four treatments were constituted, T1, T2, T3, and T4, and formed respectively by four feeding levels 842, 934, 1079 and 1300 g/kg DM corresponding to 200 g, 400 g, 600 g and 800 g of milk production, respectively. A randomized block design was applied on 40 does according to body weight, parity and birth type implying 10 does per treatment, and forty-nine born kids of which thirty-one singles and eighteen twins were fed colostrum and milk using feeding bottles. During the second kidding, dams were fed with T4. Dry matter (DM) intake and ME intake of dams increased linearly ( $P < 0.001$ ) with increasing level of feeding. Kids ME intake (kMEint) increased linearly ( $P < 0.05$ ) during the first lactation with increasing level of feeding while there was no variation ( $P > 0.05$ ) of kMEint at the second lactation. The previous level of feeding, age and birth type affected (at least  $P < 0.05$ ) the final body weight and body weight change of dams. The kMEint observed were similar to ME requirements of AFRC but lower than that of NRC. To overcome the ME requirements of kids and lactating does of Red Maradi goats, the requirements of NRC system should be used.

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**Keywords:** Feeding levels, kids, metabolizable energy, post-natal performance, Red Maradi goat.

### INTRODUCTION

The Red Maradi (Sokoto) goat is widely represented in Southern Niger and is

the most important dual purpose goat breed due to its prolificacy and milk production. According to the 2007 statistics, the goat

population in Niger was about 11 238 268, which constitutes about 36.2% of the livestock (RGAC-Niger, 2007). Breeding activities and diffusion of the Red goat began in 1945. This breed has been part of the traditional farming system and has been selected in Maradi since 1963 in Caprine Centre of Maradi based on its ability to produce meat and milk. Maradi area constitutes the predilected agro-ecological zone of this breed. Nowadays, by efforts of Government, NGOs and Development Projects, Red Maradi goats are widely distributed in Niger and West African countries. The major constraint limiting the productivity of Red Maradi goat is the nutritional management of dams with repercussion on milk production, live weight losses, low post-natal performances of kids (Pamo et al., 2007; Snyman, 2010; Ukanwoko et al., 2012; Petros et al., 2014), and slow growth rate of kids (Nnadi et al., 2007).

Djibrillou et al. (1998) reported a general body weight loss of red Maradi goats fed untreated or urea treated straws supplemented with or without concentrate and attributed this to a negative energy balance. Nnadi et al. (2007) and Snyman (2010) included low birth weight, slow growth rate and insufficient milk production as main causes of kid mortality. The growth performance of kids after kidding and survival rates are the most important factors of animal production but not much work has been done on Red Maradi goats raised under semi intensive system in Southern Niger. Also, very little is known about the metabolizable energy requirements of kids and dams of this breed in early lactation. The Objectives of this study were to (1) evaluate the effect of feeding levels on production performance of dams; (2) determine the effect of levels of feeding of dams on post-natal performance of kids; (3) determine the effect of previous levels of feeding of dams on production performances of dam and kid; (4) determine the ME intakes of kid and dam and their requirements based on AFRC and NRC systems.

## MATERIALS AND METHODS

### Study site

The study took place in the Caprine Centre (1850 ha and 893 animals in 2012) located East of Maradi. It is situated in the sahelo-sudanian zone of Niger with a mean annual rain fall of 350-600 mm, latitude 13°30'N, longitude 7°6'E and an altitude of 347 m above sea level. The climate is relatively dry with the rainy season occurring between June and September. The dry season begins around the 15<sup>th</sup> October with dry and cold weather from November to February. The hot weather occurs from March to June. The mean min/max temperature is 22/36 °C with a peak in April-May (>40 °C); heat decreases when rains begin. The relative humidity from October to June and July to September are < 20% and > 80%, respectively. The natural vegetation is Sahelo-Sudanian woodland dominated by various *Acacia* species, with sparse ground regenerating shrubs and perennial or annual grasses.

### Animals and housing

Forty (40) pregnant does were transferred from the flock of Red Maradi goats breeding centre to the feed research unit towards the end of pregnancy (one to two weeks before kidding). These does weighing 23 kg live weight (SD = 3.65) were used in this experiment. After kidding, does were treated against external and internal parasites with Ivermectin (1%), Limoxin (antibiotic) and one week later, they were vaccinated against pasteurellosis (pastovac). The following variables were recorded on each doe at the beginning of the study: ear-tag number, weight, age, parity, date of kidding, litter size and kid sex. Kids were ear-tagged on the second day of life, separated from their dams at the evening of kidding for 14 days. Does were allocated to four (4) treatments, according to body weight, parity and litter size making a total of ten (10) animals per treatment. Does were allocated to individual pen (2 m x 1.5 m) in the experimental feed unit with free access to a salt lick and potable

drinking water. In this experiment coinciding to the dry season, kid survival rate was 100%.

After weaning kids at 3 months age, does continued on the same diet and oestrus was synchronized to reproduce dams, where 24 over 38 does conceived giving average conception rate of 63% of which T1 and T2 had the lowest (48%) and T3 and T4 the highest (78%) respectively. A similar experiment which was conducted in the rainy season to determine the effect of previous levels of feeding on the growth performance of kids and milk yield of does; where one treatment (T4) which gave the best milk production response at the previous kidding was applied to all the does.

### Feeds

Feeds were chosen based on nutritive value and availability in the study area, and were constituted of crushed millet stover with urea-treatment (38%), groundnut haulms (32%), cottonseed cake (8%), wheat bran (22%) and mineral lick.

#### *Millet stover and groundnut haulms*

Millet stover was purchased (0.25 USD/5 kg bundle) from smallholder farmers immediately after harvesting when feed was available and cheap. Groundnut haulms were purchased from smallholder farmers, packaged in 15 kg bags each costing 2.58-5.16 USD (depending on the dry season or period of feed scarcity). Millet stover and groundnut haulms were crushed through a 10 mm sieve (Made Peruzzo, with electric motor single phase 3 HP - 220 Volts - 2.2 Kw, 5-10 Holes mm, model A/5-R/75, Production: 100/500 kg/hour, <http://www.peruzzo.it/eng/66-hammer-mill-a-5-r-75.html>). Millet stover was treated with urea. Urea treatment was done by dissolving 4kg of urea in 60 liters of water; and the solution was sprinkled onto 100 kg of millet stover, mixed properly, and then stored in polyethylene bags for 40 days in the barn. At the end of treatment, strong smell of ammonia, change in physical characteristics such as brown colour, heat and absence of moulds were observed.

#### *Wheat bran, cottonseed cake, mineral lick and urea*

These ingredients are available at the local Maradi market and from the regional livestock service at subsidised prices where wheat bran and cotton seedcake would cost 8.60 USD/50 kg bag. Mineral salt block (costing 0.68 USD/stone of 2-2.5 kg) and urea (costing 17.21 USD/50 kg bag) were purchased from local dealers. Cottonseed cake was crushed through a 10 mm sieve with the same crushing machine cited above.

### Feeding management

Before entering this experiment, goats were fed on natural grazing based on herbaceous forages dominated by *Schizachyrium exile*, *Eragrostis tremulu*, *Diheteropogon hagerupii*, and shrubs dominated by *Guiera senegalensis*, *Bauhinia rufescens*, and woody plants principally *Acacia nilotica*, *Acacia radianna*, *Acacia albida*, *Piliostigma reticulatum* and *Balanites aegyptiaca*. Feed troughs were made by cutting a barrel in three parts thus 3 feed troughs were made per barrel and pregnant does were transferred to the experimental feed unit. Then an adaptation period of about 14 days was observed, depending on the pregnancy period in order to familiarise animals to the diet comprising of urea treated millet stover (MS), groundnut haulms (GH), cottonseed cake (CSC) and wheat bran (WB).

During adaptation, does were fed T2 which was supposed to meet the requirement for producing 400 g of milk in red Maradi goats known as optimum milk yield of this breed. Feed offered was measured with an electronic balance (Sartorius M-Power Toploader Balance, 6100 x 0.1 g) into plastic bags the previous afternoon just to avoid any delay in feeding the following day. Feed was offered in the morning at 8 o'clock and refusals were collected the following day between 7 and 8 o'clock am. Mineral lick was hung in individual pen permanently per animal as supplementary ingredient. Water was offered *ad libitum*.

### The experimental design

Forty animals were blocked according to weight, parity, litter size, and age, and distributed into four of 10 animals each, which were randomly allocated to four (4) treatments (T1 to T4), making a total of ten (10) does per treatment. Does were allocated to individual pens in the shed during the experimentation. Four groups (10 lactating does/group) received four feeding levels based on one diet from kidding until 14 days post kidding. The diet given in Table 1 was formulated following the AFRC (1993) recommendation and rationed to achieve various milk production targets.

T1: 842 g DM of D<sub>1</sub> for 200 g of milk production

T2: 934 g DM of D<sub>1</sub> for 400 g of milk production

T3: 1079 g DM of D<sub>1</sub> for 600 g of milk production

T4: 1300g DM of D<sub>1</sub> for 800 g of milk production

Treatments one to four were rationed to examine the effect of level of feeding. During the second experiment (lactation), one group of twenty-two (22) lactating does received one treatment (T4) from kidding to 14 days post kidding to determine the effect of previous treatments on milk production and post-natal growth performance of kids.

### Metabolisable energy intake and requirements of dams and kids according to AFRC and NRC systems

The metabolizable energy (ME) intake of dams was derived from proportion of ME in feed intake and ME intake of kids was calculated from ME in colostrum and milk intake (Akinsoyinu et al., 1981). The ME intake of dams was calculated based on ME content of different ingredients. The ME was derived from effective degradability of organic matter of the same feeds (Abdou et al., 2017) based on suggestion by Nsahlai and Apaloo (2007) where  $ME = ED_{OM} * 15.06 / 0.9$ , where 15.06 is a factor suggested by Czerkawski (1986).

The ME intake of kids was calculated as the sum of ME in colostrum plus milk (Akinsoyinu et al., 1981) for Red Sokoto (Maradi) goats. It was assumed after considering losses of energy in digestion, absorption and transportation, that seventy per cent (70%) of milk GE was transformed into ME. The colostrum phase was determined for each doe in order to calculate ME intake derived from colostrum phase.

Metabolizable energy intake of kid

$$(ME_{int}) = SMEC + SMEM$$

Where: SMEC is the sum of ME derived from the quantity of colostrum intake and SMEM is the sum of ME derived from milk intake during the first 14 days of the study. The ME requirement (ME<sub>r</sub>) was calculated according to the AFRC (1993) and NRC (2007) systems as follows:

$$ME_{mr} (AFRC) = MEM + NEg/k_g$$

Where MEM<sub>r</sub> = metabolizable energy requirement; MEM (metabolizable energy for maintenance) =  $0.315 * Kwt^{0.75} / k_m$ ; where  $k_g$  and  $k_m$  are efficiencies with which ME is used for production and maintenance respectively.

$$MEg (NEg, Net energy for gain) =$$

$$EVg * ADG / k_g$$

Where: EVg (energy value for gain) =  $4.972 + 0.3274 * Kwt$ ; and ADG = average daily gain; Kwt = kid weight;  $k_g$  is efficiency of use of ME for gain.

$$MEM_{r} (NRC) = 0.521 * Kwt^{0.75} + 13.4 * ADG$$

(for suckling male kids) and

$$MEM_{r} (NRC) = 0.449 * Kwt^{0.75} + 13.4 * ADG$$

(for suckling female kids)

The ME intake of dams was calculated based on ME content of diets (Table 1) as follows:

$$dMEI = (DI/1000) * MED;$$

$$dME_{r} (AFRC) = 0.315 * dwt^{0.75} - 20 * dADG + MEM_k;$$

$$dME_{r} (NRC) = 0.462 * dwt^{0.75} - 28.5 * dADG + MEM_k;$$

Where dMEI = dam metabolizable energy intake per day; DI = dam intake; MED = metabolizable energy content of diet; dME<sub>r</sub> = dam metabolizable energy requirement; dwt = dam weight; dADG = dam average daily body weight change; MEM<sub>k</sub> = metabolizable energy of milk production.

## **Measurements**

During the experiment, feeds offered and orts were measured daily in order to determine intake. During the period from birth to 14 days of age, daily milk production was recorded during both lactations with an electronic balance (Sartorius 6100 g d=0.1 g). Kids were temporally separated from dams flock during the first 14 days to avoid suckling. Colostrum yield was recorded during the first 1 to 4 days postpartum and then milk yield during the rest of the 14 days post partum. Weaned kids of previous lactation were separated from dams flock to avoid suckling their dams, in order to guarantee colostrum production for the subsequent kidding. Does were milked by hand every day from parturition until day 14. During this period, kids were each fed with colostrum and milk using a feeding bottle. After feeding, kids were allowed with their dams for five to ten minutes to enhance dam-kid relationship and avoid rejection of kid(s) by dam. Everyday, measurements of colostrum and milk yield were recorded thrice: in the morning (8 to 9 o'clock am), afternoon (12 o'clock am to 1 o'clock pm) and evening (6 to 7 o'clock pm). The total daily milk yield was calculated as the sum of three measurements. Feed offered and refusal were measured daily with an electronic balance (KRN5, max=5 kg d=5 g) in order to determine the intake.

Does weight were measured using an electronic balance (Kern CH 50 kg, d=50 g max=50 kg, version 2.7, 2009) during two consecutive days: the day of kidding once the placenta had been expelled and the following morning (6 o'clock am) on day 1 of the study. Does weight was recorded once on day seven (07) and twice at the end of the study (i.e. in the evening (6 o'clock pm) on day 13 and in the morning (6 o'clock am) of day 14).

Kids' weight was measured using an electronic balance Baxtran KRN5 (max=5 kg d=5 g). Kid weight was recorded three times: the day of kidding, seven (7) days and twice at the end of the study, in the evening (6 o'clock pm) on day 13 and in the morning (6 o'clock

am) of day 14. During the experiment, feeds offered and orts were measured daily in order to determine intake.

## **Chemical analyses**

Representative feed samples (10%) of dietary components and refusals were collected daily and at the end of the week, a composite sample (5%) of each was collected and dried (for DM determination) in the oven at 65 °C for 48 h. At the end of the experiment, representative samples of feeds offered and refusals were collected for chemical analyses. Samples of feed offered and orts were analyzed to determine DM, ash, crude protein (Nx6.25), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL). Dry matter was determined by drying samples in an oven at 60 °C for 48h until weight became constant. Ash was determined by combusting 1 g of sample per crucible in a muffle furnace for four hours at 550 °C (method-942.05 AOAC, 1990). Nitrogen content was determined using the Leco TruMac CNS/NS (LECO Corporation USA, 2012). NDF, ADF and ADL were determined in duplicates using ANKOM-A200/2220 (2052 O'Neil Road, Macedon NY 14502) as described by Van Soest et al. (1991). Neutral detergent fibre content was assayed without a heat stable amylase. Both NDF and ADF were expressed inclusive of residual ash. ADL or lignin (sa) was determined by solubilization of cellulose with sulphuric acid. Hemicellulose was obtained by difference of between NDF and ADF and cellulose was calculated as the difference between ADF and lignin (sa). All these analyses were done in the laboratory of Discipline of Animal Science of University KwaZulu-Natal, Pietermaritzburg.

## **Statistical analysis**

Data collected during two lactation periods were cleaned, by removing data when kids died particularly during the 2<sup>nd</sup> experiment, and were analyzed using the General Linear Model of SAS (Statistical Analysis System). Variable included feed

intake, milk yield, metabolizable energy intake, body weight change of does, and birth weight, final live weight, and live weight gain of kids. The model for analysis was as follows:

$$Y_{ijklmno} = \mu + T_m + A_i + B_j + P_k + S_l + W_n + E_{ijklmno}$$

Where  $Y_{ijklmno}$  is the independent variable (feed intake, milk yield, metabolizable energy intake, live weight change and live weight gain of kids),  $\mu$  is the overall mean,  $T_m$  is the effect of treatments,  $A_i$  is the effect of dam ages,  $B_j$  is the effect of birth type,  $P_k$  is the effect of parity,  $S_l$  is the effect of kid sex,  $W_n$  is the effect of initial body weight and  $E_{ijklmno}$  is the residual error. The effect of treatment was tested and the means of dam and kid variables were compared between treatments, statistical significance being declared at  $P < 0.05$ . For the first experiment, linear and quadratic contrasts were used to determine the effect of the treatments. For the second experiment, the effects of the previous level of feeding on these parameters were analysed.

## RESULTS

### Dietary ingredient and chemical composition

The level of feeding differed among T1 to T4 (Table 1). The DM, OM, NDF and ADF contents in refusals were higher than in feeds offered (Table 2).

### Effect of feeding levels on feed intake and production performance of dams

Feed intake varied ( $P < 0.001$ ) among treatments (Table 3). Feed intake increased linearly ( $P < 0.001$ ) but not in a quadratic fashion ( $P > 0.05$ ) with increasing feeding levels. Dams with twins had higher DMI than dams with singles (731 versus 617,  $P < 0.05$ ). The metabolizable energy intake of dams (dMEi) had the same trend like DMI and varied ( $P < 0.001$ ) among treatments (Table 3). Birth type had an influence on dMEi where dam with twins consumed higher ME (6.68 versus 5.60,  $P < 0.05$ ) than with single. Kids' variables did not affect ( $P > 0.05$ ) DMI of dams.

Milk yield did not vary ( $P > 0.05$ ) among treatments (Table 3), though it increased ( $P < 0.01$ ) linearly but not in a quadratic ( $P > 0.05$ ) fashion. The dam initial weight affected ( $P < 0.05$ ) milk yield while other dam and kid variables had no effect. Milk production would increase by 9.42 ml (SE=3.63,  $P < 0.5$ ) per day per unit change (1 kg) in body weight. Dam final live weight (dfwt) and dam weight change (dwtc) were not affected by treatments (Table 3). All kid and dam variables except dam initial weight did not affect ( $P > 0.05$ ) dfwt and dwtc.

### Effect of feeding levels of dams on milk and metabolizable energy intakes and production performances of kids

Milk intake did not vary ( $P > 0.05$ ) among treatments while the metabolizable energy (ME) intake differed ( $P < 0.05$ ) (Table 4). Age, parity, dam initial weight (diwt) and kid sex (ksex) did not affect ( $P > 0.05$ ) kid milk intake. However, birth type affected ( $124.3 \pm 14.75$ ,  $P < 0.001$ ) kid milk intake ( $P < 0.001$ ) and kid ME intake ( $P < 0.001$ ) where single born consumed higher milk and ME than twins (330.83 versus 206.52 g/day,  $P < 0.001$ ) and (0.909 versus 0.584 MJ/day,  $P < 0.001$ ) respectively. Kid initial weight (kiwt) ( $73.12 \pm 25.24$ ,  $P < 0.01$ ) affected also kid milk intake suggesting that every 1 kg change in kid weight would increase milk intake by 73 g. Kid's milk and metabolizable energy intakes increased linearly ( $P < 0.05$ ) but not in a quadratic fashion with feeding levels of dams.

Kid final weight was not affected ( $P > 0.05$ ) by treatments (Table 4), age, parity, dam initial weight (diwt) or kid sex (ksex). However, it was highly affected ( $P < 0.001$ ) by birth type ( $0.38 \pm 0.06$ ,  $P < 0.001$ ) where single born and twins had final weight of 2.39 kg and 1.88 kg respectively. Similarly, kid initial weight (kiwt) strongly affected kid final weight ( $0.98 \pm 0.10$ ,  $P < 0.001$ ).

The kid average daily body weight gain were similar ( $P > 0.05$ ) among treatments (Table 4) and were not affected ( $P > 0.05$ ) by all dam variables and kid variables. However, it was highly affected ( $P < 0.001$ ) by type of

birth (29.07±4.79, P<0.001) where singles gained more weight than twins (54 versus 28 g/d). No other effect was significant (P>0.05).

**Effect of previous feeding levels on production performances of dams**

Feed intake, metabolizable energy intake and daily milk yield were not affected (P<0.05) by previous levels of feeding (treatments), age, parity and birth type (Table 5). However, previous treatments strongly affected (P<0.001) final weight and daily weight change of dam. Age and birth type affected (P<0.05) final live weight of dam whereas live weight change of dam was heavily affected (P<0.001) by age, birth type and parity.

**Effect of previous levels of feeding dams on kids' milk and metabolizable energy intakes**

The previous levels of feeding did not affect (P>0.05) kids' milk intake whereas the metabolizable energy intake varied (P<0.01; Table 6). Kid final weight was affected (P<0.05) by previous treatment while the kid weight gain was not.

**Colostrum phase**

The colostrum period during two subsequent lactations varied from 1 to 4 days with means of 2.83 (RMSE=0.54) (Table 7). The level of feeding, parity, type of birth and the interactions treatment x type of birth did not affect (P>0.05) the duration of colostrum. However, age affected (P<0.05) the duration of colostrum where the colostrum phase increased from primiparous to aged does. Similarly, the parity interacted with birth type to affect (P<0.05) colostrum duration.

**Metabolizable energy intake and requirements of dams and kids according to AFRC and NRC systems**

The ME intake of dams and kids and their ME requirements for two experimental data set are shown in Table 8. The average value of dams' metabolizable energy intake was close to metabolizable energy requirement of AFRC (dMEr\_AFRC) but lower than that of NRC (dMEr\_NRC). Concerning kids, the average value of metabolizable energy intake was similar to metabolizable energy requirement (MEr) of AFRC but much lower than that of NRC.

**Table 1:** Dietary ingredient and chemical composition.

Ingredient (g of DM)	Ration	Diet			
		T1	T2	T3	T4
CUTMS		385	384	385	385
GH		308	307	308	308
WB		230	231	231	231
CSC		77	77	77	77
Total		1000	1000	1000	1000
Chemical composition					
N (g/kg DM)		16.93	16.93	16.93	16.93
ME of diet (MJ/kg DM)		9.24	9.24	9.24	9.24
Rationing					
Target milk production (g)		200	400	600	800
Rationing level (g/day)		842	934	1079	1300
Feeding level		0.65	0.72	0.83	1

T: treatment; CUTMS: crushed and urea treated millet stover; GH: groundnut haulms; WB: wheat bran; CSC: cottonseed cake; ME: metabolisable energy.

**Table 2:** Chemical composition of feeds offered and refusals (g/kg DM).

Parameters	Feed	Diet			
		T1	T2	T3	T4
DM	Offered	822	822	822	822
	refusal	965	965	965	965
OM	Offered	916	916	916	916
	refusal	933	947	940	959
NDF	Offered	613	613	613	613
	refusal	713	715	672	726
ADF	Offered	385	385	385	385
	refusal	510	519	480	531

T: treatment; DM: Dry matter; OM: Organic matter, NDF: Neutral detergent fibre; ADF: Acid detergent fibre.

**Table 3:** Effect of levels of feeding dams on production performance of lactating does.

Treatment	n	Dam initial weight	DM intake MI (g)	ME intake (MJ/day)	Daily milk yield (g)	Final weight (kg)	Daily weight change (g)
T1	10	22.09	501d	4.63b	332a	20.81	-168
T2	10	23.30	606bcd	5.59b	376a	21.41	-125
T3	10	23.02	731ab	6.75a	447a	21.51	-118
T4	10	25.75	824a	7.61a	510a	21.34	-130
Variation sources							
RMSE			116.07	1.06	172.39	1.17	84.20
Treatment			***	***	NS	NS	NS
Age			NS	NS	NS	NS	NS
Parity			NS	NS	NS	NS	NS
Typeb			*	*	NS	NS	NS
diwt			NS	NS	*	***	***
kiwt			NS	NS	NS	NS	NS
ksex			NS	NS	NS	NS	NS
Linear			***	***	**	NS	NS
Quadratic			NS	NS	NS	NS	NS

T: treatment; Typeb: birth type; diwt: dam initial weight; change; kiwt: kid initial weight; ksex; kid sex; DM: dry matter; ME: metabolizable energy; Means in the column with the same lowercase letter are not significantly different at P<0.05; RMSE: Root mean square error; NS (P > 0.05); \* (P < 0.05); \*\* (P<0.01); \*\*\* (P<0.001).

**Table 4:** Effect of levels of feeding dams on post-natal performance of kids.

Treatment	n	Kid initial wt (kg)	Kid milk intake (g)	Kid ME intake (MJ/day)	Kid final wt (Kg)	Kid wt gain (g)
T1	10	1.67	242a	0.683b	2.09a	37.40a
T2	10	1.80	303a	0.846ab	2.42a	51.00a
T3	10	1.61	307a	0.762ab	2.10a	41.63a
T4	10	1.76	305a	0.885a	2.29a	51.24a
Variation sources						
RMSE			70.74	0.32	0.37	19.56
Treatment			NS	*	NS	NS
Age			NS	*	NS	NS
Parity			NS	NS	NS	NS
Typeb			***	***	***	***
diwt			NS	NS	NS	NS
kiwt			**	**	***	NS
ksex			NS	NS	NS	NS
Linear			*	*	NS	NS
Quadratic			NS	NS	NS	NS

T: treatment; n: number of observation; Typeb: birth type; diwt: dam initial weight; change; kiwt: kid initial weight; ksex; kid sex; wt: weight; ME: metabolisable energy; Means in the column with the same lowercase letter are not significantly different at P<0.05; RMSE: Root mean square error; NS (P > 0.05); \* (P < 0.05); \*\* (P<0.01); \*\*\* (P<0.001).

**Table 5:** Effect of previous levels of feeding dams on production performance of lactating does.

Ptreatment	n	Dam initial weight (kg)	DM intake (g/day)	ME intake (MJ/day)	Daily milk yield (g)	Final weight (kg)	Daily weight change (g)
T1	4	22.57	839a	7.75a	408a	21.89c	44a
T2	2	24.31	875a	8.09a	426a	21.74c	-110c
T3	3	29.73	861a	7.96a	371a	26.28a	-160d
T4	8	27.89	837a	7.73a	364a	24.66b	-108c
Variation sources							
RMSE			203.11	1.87	153.12	1.81	0.04
Ptreatment			NS	NS	NS	***	***
Age			NS	NS	NS	*	***
Parity			NS	NS	NS	NS	***
Typeb			NS	NS	NS	**	***

T: treatment; Typeb: birth type; diwt: dam initial weight; Ptreatment: previous treatment; DM: dry matter; ME: metabolizable energy; Means in the column with the same lowercase letter are not significantly different at P<0.05; RMSE: Root mean square error; NS (P > 0.05).

**Table 6:** Effect of previous levels of feeding dams on post-natal performance of kids.

<b>Ptreatment</b>	<b>n</b>	<b>Kid initial wt (kg)</b>	<b>Kid ME intake (MJ/day)</b>	<b>Kid milk intake (g)</b>	<b>Kid final wt (kg)</b>	<b>Kid wt gain (g)</b>
T1	4	1.60	1.168a	167a	2.58a	71.87a
T2	2	1.37	0.392b	133a	1.39b	9.61a
T3	3	1.68	0.572b	145a	2.07a	27.52a
T4	8	1.40	1.049a	158a	2.31a	57.53a
Variation sources						
RMSE			0.342	100.55	0.144	12.82
Ptreatment			**	NS	*	NS
Age			NS	NS	NS	NS
Parity			NS	NS	NS	NS
Typeb			NS	NS	NS	NS
Sex			NS	NS	NS	NS

T: treatment; n: number of observations; Ptreatment: previous treatment; Typeb: birth type; wt: weight; ME: metabolisable energy; Means in the column with the same lowercase letter are not significantly different at P<0.05; RMSE: Root mean square error; NS (P > 0.05); \* (P < 0.05); \*\*\* (P<0.001).

**Table 7 :** Factors affecting the duration of colostrum phase.

<b>Treatment</b>	<b>n</b>	<b>Colostrum phase</b>	<b>Age</b>	<b>n</b>	<b>Colostrum phase</b>
T1	17	2.88 <sup>a</sup>	1	5	2.2c
T2	16	2.50 <sup>a</sup>	2	7	2.85bc
T3	22	2.95 <sup>a</sup>	3	23	2.65bc
T4	27	3.00 <sup>a</sup>	4	35	2.83bc
			7	3	3.67a
Variation sources					
RMSE		0.56			
Mean		2.83			
Treatment		NS			
Age		*			
Parity		NS			
Typeb		NS			
Treatment*Typeb		NS			
Parity*Typeb		*			

T: treatment; n: number of observations; Typeb: birth type; Means in the column with the same lowercase letter are not significantly different at P<0.05; RMSE: Root mean square error; NS (P > 0.05); \* (P < 0.05); \*\* (P<0.01); \*\*\* (P<0.001).

**Table 8 :** Observed metabolisable energy intakes of dams and kids compared with requirements according to AFRC (1993) and NRC (2007) systems.

Experiments	Kidding 1	Kidding 2	Average
n	40	24	-
dMEi (MJ/d)	6.128	7.518	6.478
dMEr_AFRC (MJ/d)	5.768	6.724	6.009
dMEr_NRC (MJ/d)	7.697	9.022	8.030
kME intake (MJ/d)	0.794	0.822	0.808
kMEr_AFRC (MJ/d)	0.827	0.802	0.814
kMEr_NRC (MJ/d)	1.540	1.500	1.520
kMEint (KJ/kg BW <sup>0.75</sup> )	440	551	495.5

n: number of observations; dMEi: dam metabolisable energy intake; dMEr\_AFRC: dam metabolisable energy requirement according to Agricultural and Food Research Council; dMEr\_NRC: dam metabolisable energy requirement according to US National Research Council; kME: kid metabolisable energy; kMEint: kid metabolisable energy intake; kMEr\_AFRC: kid metabolisable energy requirement according to Agricultural and Food Research Council; kMEr\_NRC: kid metabolisable energy requirement according to US National Research Council.

## DISCUSSION

The linear increase of dry matter intake from treatments T1 to T4 may be explained by increasing levels of feeding. Similar findings were observed by others (Malau-Aduli et al., 2004; Greyling et al., 2004; Kinuthia et al., 2007) who reported increased dry matter intake (DMI) when goats were offered more feeds. DMI of goats is influenced by several factors, namely feed quality, coarseness, palatability of feed, roughage concentrate ratio, animal behaviour and physiological stage of goats. The increase of dams' metabolizable energy intake (dMEi) with increasing level of feeding may be attributed to DMI of dams since the dMEi was related to dry matter of feeds. This is the reason why the dMEi increased similarly to DMI which is similar to others (Kinuthia et al., 2007). These dMEi were above the minimum requirement of maintenance estimated at 4.52 MJ/d (Sahlu et al., 2004) for goats weighing 23 kg.

The lack of treatment effect on milk yield despite the linear increase in dry matter and metabolizable energy intakes may be explained by the energy mobilized from body tissue for milk production at the early stage of lactation. However, Greyling et al. (2004)

reported effect of level of nutrition on milk production of indigenous and Boer goats in South Africa. Results on milk yield in the present study are similar to those obtained by others (Zahraddeen et al., 2009a; Otaru et al., 2011) on the same breed. However, Malau-Aduli et al. (2004) reported lower (270 g/day) and higher (620 g/day) milk yield values than the present study with unsupplemented and supplemented (with concentrate) treatments, respectively. Additionally, Sangaré and Pandey (2000) reported higher values (700-850 g/day) in early lactation (two first weeks) on Sahelian goats in Mali.

Although only the effect of treatment on kMEint was significant, the linear effect of T1 to T4 was not significant for milk intake. This variation of kMEint can be attributed to both birth type and variation in kid initial weight among treatments which would impact on kid milk intake or the kMEint derived from milk intake in the present study. This linear effect of treatments on kMEint may also be due to differences in duration of colostrum phase which had higher ME content than normal milk and kid which consumed colostrum during more days may consume

more energy than the one which had less days on colostrum.

The influence of previous levels of feeding on dams' final weight and body weight change could be explained by increased feed intake and body weight gain of does in the previous experiment before subsequent kidding where does gained more weight with graded levels of feeding during the last three months of pregnancy. It has been recognized that the body condition scores and stage of lactation influence the energy value of body weight change of lactating animals especially in early and late lactation where body weight change can be large. Thus, during early lactation in accordance with the present study, does might mobilize fat and protein from their body reserves to satisfy milk production and this has repercussion on body weight and body weight change that were observed.

The observed metabolizable energy intake of kids in the present study was close to ME requirements of AFRC system whereas the ME requirements of NRC were greater than that observed. Using the NRC requirements will satisfy requirement for more animals in a herd but may overfeed more animals. Similar results were observed with metabolizable energy requirements for dams, where the ME requirements based on AFRC system were closer to ME values observed compared with NRC system which were greater than ME observed. The differences between ME intake and required could be attributed to type of breed, type of production, feeding system, and age or stage of animals. Observed mean values of ME intake of kids in experiment 1 (1<sup>st</sup> kidding of the study) and experiment 2 (the subsequent kidding) were 440 and 551 kJ/kwt<sup>0.75</sup> respectively, but overlapped results (485 kJ/kwt<sup>0.75</sup>, 13.4 KJ/ADG) of Luo et al. (2004) on suckling kids. However, values of ME<sub>int</sub> observed were lower than those obtained by Sahlou et al. (2004) on suckling kids (1.424 MJ/d) of 50g average daily gain (ADG). It is important to note that in some studies, dietary ME was calculated based on feed digestibility through

fecal collection whereas others used markers to estimate fecal output. In the present study, ME intake was based on milk intake and feed intake of nursing kids and their dams, respectively. Nonetheless, according to their similarities, to estimate the metabolizable energy requirements of suckling kids and does of Red Maradi goat, it appears rationing based on the NRC system would be more generous than based on AFRC system.

The high DM, OM, NDF and ADF contents of refusals may be explained by differences in physical and chemical characteristics of feeds (Abdou et al., 2017) due to feeding behaviour of goats known to select feeds based on prehension ease, nutrient content and post-ingestive effects. This is in agreement with other works (Provenza et al., 2003; Basha et al., 2009; Glasser et al., 2012; Tshibangu et al., 2014).

The influence of birth type on DMI could be attributed to high demand of energy by dam with twins compared with those with single to satisfy kids' milk intake and their maintenance. The significant effect of birth type on milk yield is similar to the findings of other researchers (Zahraddeen et al., 2009a; Sanogo et al., 2012). However, Akpa et al. (2001) reported that birth type did not influence milk yield. The effect of dam initial weight on milk yield is similar to the findings of Sangaré and Pandey (2000) on Sahelian goats. The variation in milk yield compared with other studies could be due to differences in nutritive value of diets, breed, parity, body weight of does, frequency and milking methods.

All groups of lactating does during the first two weeks postpartum lost body weight in agreement with Greyling et al. (2004) using indigenous and Boer goats in South Africa. The significant effect of dam initial weight (diwt) on both dam final weight (dfwt) and dam weight change (dwtc) is in agreement with other studies (Fedele et al., 2002; Otaru et al., 2011; Casals et al., 2006). This loss of body weight corrects for the lower feed intake after kidding and therefore does mobilize own energy reserves to satisfy the extra energy

requirement for milk production at this particular stage of lactation. Djibrillou et al. (1998) attributed body weight loss of lactating does to the unbalanced energy requirement and energy provided in the diet, whereas Casals et al. (2006) attributed this to the decrease of DMI.

The significant effect of dam's age on kid metabolizable energy intake (kMEint) could be explained by the duration of colostrum phase which differed according to dam's age or the ME in colostrum is higher than that of the normal milk. Thus, kid born by aged dam could consume more ME than kids of young does. The influence of birth type on kid milk intake and kMEint may be due to the fact that dam's milk is shared between twins born kids. This was the reason why kid milk and ME intakes of single borns were higher than those of twins which would have repercussions on kids' final weight and body weight gain in spite of the superiority of milk yield of dam giving twins. This similarity of trend is due to the fact that kMEint derived from milk intake. Furthermore, single born kids were heavier than twins born kids at kidding, and the present study showed the effect of kid initial weight (kiwt) on kid milk intake. Both of these results are in agreement with Sangaré and Pandey (2000) where kid initial weight affected milk intake and consequently the final live weight. Kids' birth weights in the present study were close to those reported by Muktar et al. (2011) on the same breed. However, lower values were obtained by Malau-Aduli et al. (2004) on the same breed in Nigeria and higher values by Sangaré and Pandey (2000) on Sahelian goats in Mali, by Mahmoud et al. (2012) on Damascus goats' kids in Sudan and by Castro et al. (2009) on Majorera goat kids in Spain. This variation in kid birth weight could be attributed to differences in livestock system, diets and breeds. The effect of kid initial weight (kiwt) on kid final weight (kfw) is in agreement with other works (Sangaré and Pandey, 2000; Al-Shorepy et al., 2002; Andries, 2013). The influence of birth type on kfw may be due to the kiwt and kid milk intake (as explained

above), where a single born kid was heavier than twins and consumed more milk than twins which had repercussion on kfw during early lactation. The influence of birth type on kid weight gain (kwtg) corroborates the findings of Zahraddeen (2009b).

The influence of age and birth type on body weight and body weight change of dam at the subsequent lactation may be explained by the characteristic of Red Maradi goat which is reputed as a prolific breed in West Africa (Djariri, 2005) of which prolificacy is influenced by parity (age). According to Marichatou et al. (2002), 36.48% of twins born were observed with Red Maradi goat. As parity is highly correlated with age and naturally multiparous does are heavier than young ones. This analogy may be explained by the influence of age and birth type on body weight and body weight change.

The length of colostrum phase (1 to 4 days) is in agreement with some works on other breeds (Gajdusek et al., 2001; Kracmar et al., 2002; Kráčmar et al., 2003; Argüello et al., 2004). These authors stipulated that variations in minerals contents of colostrum occurred between 48 and 96 hours and in this present study, distinction between colostrum and milk was based on the yellowish colour characteristic of colostrum. In the present study, the parity interacted with birth type to affect colostrum duration/production which is also supported by Romero et al. (2013).

## **Conclusion**

The levels of feeding dams did not affect the production performance of lactating Red Maradi goat and their kids during the first 14 days postpartum. The previous levels of feeding dams had impacted on body weight of dams and kids. The metabolizable energy intake of kids was closer to ME requirements based on AFRC compared with that of NRC system. Kids nurse by does on increasing feeding levels consumed more milk and tended to have a better body weight. To overcome the ME requirements of kids and lactating does of Red Maradi goats, the requirements of NRC system should be used.

## COMPETING INTERESTS

The authors declare that they have no competing interests.

## AUTHORS' CONTRIBUTIONS

NA: Implementation of experiments, laboratory analysis, writing manuscript; ASG: Assistance on field work, observations on manuscript; IVN: Assistance on laboratory analysis and statistical analysis, contribution to improve the language of the manuscript and editing the manuscript.

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