



Feeding *Moringa olifeira* Meal to Sudanese Desert Goats and its impacts on Milk Yield and Composition in North Kordofan, Sudan

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ABSTRACT

This study was conducted in North Kordofan State, Sudan with the objective of studying impacts of feeding *Moringa oleifeira* meal (MOM) feed intake, milk production, composition and weight of Sudanese Desert goats and kids. Four groups at second parity, weighing 25 ±0.750 kg each with single kid were individually penned with feeding and drinking troughs. The first group was fed cut natural grazing (NG) while the second, third and forth groups were supplemented with 300, 400g MOM and 250g of a ration respectively. The milk was measured daily in the morning and evening from one teat and the kids suckled the other. Supplementation increased feed intake significantly (P<0.01). The goats consumed 1100, 1250, 1260 and 1000g DM when they were offered NG alone, supplemented with 300g, 400g MOM and 250g of the ration, respectively. Milk yield also significantly (P<0.01) increased upon supplementation. Daily production was 0.500, 1.775, 2.012 liter for NG, supplemented with 300, 400 g MOM and 250g ration, respectively. Milk had higher fat from goats supplemented with a ration; higher milk protein from consuming NG alone and higher lactose when goats were offered 300 or 400g MOM. Non-fat solids content was similar in milk from all groups. Live body weight was the highest in the group supplemented with 400g MOM followed by those on 300g MOM, 250 g ration and finally those on the NG only. The respective daily weight gain was 152.6, 145, 130 and 10g. Kids' weight gain was 23.24g in the group of NG, 55, 67.9 and, 95.5g for those on 300, 400g MOM and a ration respectively. It was concluded that supplementation with *Moringa olifeira* meal positively affected feed intake, weight gain and milk yield of goats. More studies are needed to determine best levels of MOM supplementation

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INTRODUCTION:

North Kordofan State lies within the savanna zone of Sudan and covers about 185,302 square Kilometers. It is the

major Gum Arabic and livestock production area in Sudan (Fadl *et al.*, 2009). Integration of trees in farm land proved to have positive effects on soil

physical and chemical properties, protecting the farm against soil erosion, improve the microclimate and satisfying farmer's needs from fuel wood and fencing materials (Fadl and Gebauer, 2004). Studies on alleviation of draught effects and environmental preservation have shown that the rationale in resources utilization entails shifting from traditional crop production that involves illicit tree cutting and burning grasses and herbs to livestock production (Hassan, 2008; Hemidan, 2008; and El Hag *et al.*, 2001). Small ruminants were recommended as most suitable Livestock species. Goats in particular were reported being the most adapted species to the harsh environmental conditions of North Kordofan. Because the species mainly depend on trees for feed, it entails integration of forestation with livestock production and introduction of new tree species specially those known for their large biomass production and high nutritive value. Recently, *Moringa olifeira* was introduced and used for different uses in Sudan. Empirical observations have shown that the tree fodder is palatable to goats and there are reports of increased milk production of does fed *M. olifeira*. No studies were conducted to evaluate effects of feeding *M. olifeira* to goats on milk production and weight changes in Sudan in general and Kordofan in particular.

Overall objectives of the studies in this field were to improve the local Desert goats' production in Northern Kordofan State through improving and providing green fodder alternatives. The objectives of the current study were to evaluate the effects of MOM on feed intake, weight gain and daily milk yield and composition among Sudanese Desert goats, and to evaluate the impact of the MOM on milk production, composition

body, weight of the Desert goats and their kids compared to conventionally used dairy ration and natural grazing in the study area.

MATERIALS AND METHODS

Study Area: This study was carried out in North Kordofan State, (Latitudes 11.15⁰ and 16.45⁰N and longitudes 27.05⁰ to 32⁰E). The State represents two thirds of Kordofan region (Wikipedia, 2015) and has a population of about 3,3 million according to 2011 census (70 % of the population of Kordofan region (Khatir and Jadalla, 2014). It is divided into four ecological zones according to isohyets and soil types: arid, semi-arid and low rainfall savanna on sand and low rain fall savanna on clay (Harrison and Jackson, 1958).

The soil in North Kordofan is predominantly sandy interspaced by silt depressions in the northern parts, with stabilized and disturbed sand dunes known as "goz" or silt depression and clay pockets known as "gardud". Most crops are grown on *gardud* while sands are used as rangelands with some cropping (FAO, 2008). Rain water is harvested into natural and excavated reservoirs (*hafirs*), earth dams, seasonal pools and water yards to be used for irrigation, and human and livestock consumption. In addition to harvested water, Boreholes, hand pumps and open wells are drilled to use up underground water.

Bara locality, the study site, is situated within semi-arid zone (latitudes 14⁰.00 and 16⁰.40 N) with annual rainfall ranging from 150 to 300 mm. The inhabitants usually raise camels, goats and sheep and practice farming. Millet, watermelon and horticultural crops are the main crops produced.

The experimental animals were penned at Shag Alnom village, 5 kilometers

from Bara. The soil is extremely sandy characterized by sand dunes. Villagers depend on animal husbandry keeping sheep and Desert goats and camels. Rain fed agriculture is practiced on Goz slopes and depressions. *Acacia senegal* is conserved for Gum Arabic production. The climate change mitigation innovations project, a state and UN sponsored activity, provides many services including agricultural extension, animal husbandry, water harvesting, health and education.

The experimental Animals: Sixteen lactating Desert goats at second parity, with single kids, were used in this study. The does were 2-2.5 years of age and their initial weight was 25.00+ 0.750kg. The animals were randomly divided into four groups of four animals each. The does were individually penned, equipped with feeding and drinking troughs. Prior to commencement of treatments the goats were ear-tagged, and drenched with broad spectrum anthelmintic (Ivomec®). Ten days adaptation period was used. Goats and kids were weighed at the beginning of the trial, after 30 days and at the end of the trial. The does were milked twice a day; at 8:00 am and 6:00 pm from one teat Leaving the second teat for the kids.

Milk quantity of each goat was daily recorded using a graduated cylinder. Milk samples were taken at mid trial time for chemical analysis.

The Experimental Feed: The lactating goats were fed four rations. Natural grazing (NG) comprising of Adan elfar (*Requina obcordata*) and Huskaneet (*Cenchrus biflorus*) alone, NG and 250g/d dairy ration, NG and 300 g and 400g of *Moringa olifeira* meal (MOM). Moringa meal was prepared as mixture of leaves, twigs and capsules. Twigs and capsules were crushed and mixed to the dry leaves at 60% leaves, 25% twigs and 15% capsules.

The natural grazing was collected from the experimental site and consisted mainly of *Adan elfar* and *Huskaneet*. Dairy ration supplement was prepared using sorghum grains (35%), groundnut cake (30%), wheat bran (30%), limestone (4%) calcium salt (0.5%) and sodium chloride (0.5%). The concentrated supplement and *M. olifeira* meal were offered at 7:00 in the morning and consumed completely before offering the basal feed (the natural grazing hay) *ad libitum*. The quantity of feed consumed was determined at 6:30 am every morning before offering supplements. The experimental feed is presented in Table (1).

Table 1: Feed amounts and daily feed intake (Kg/day)

Feed type	Daily consumption(kg)	Duration	Total intake (kg)
Moriga olifeira	4.6	50	230
Requina obcordata	20	50	1000
Cenchrus biflorus	5	50	250
Dairy ration	1	50	50

Chemical Analysis: The ingredients used in dairy ration formulation, the *Moringa olifeira* meal and the natural grazing were analyzed using the proximate analysis methods according to

the Association of the Official Analytical Chemists, AOAC, (2000). *In vitro* dry matter and organic matter digestibility coefficients were

determined according to Telly and Terrie (1980) procedures.

Milk Protein and total solids of milk samples taken from different groups of does were analysis according to the methods described by Willit, (1951) while milk ash was determined according to Baily, (1937) and lactose

was assessed according to procedures described by AOAC (2000).

The digestible energy (DE) was calculated as follows according to McDonald *et al.*, (2000):

$$DE = 1.05TDN \text{ and } ME \text{ (Mj/ Kg DM)} = \text{DOM} \times 4.4 \times 0.82 \times 4.184$$

Table 2: Chemical composition of feed ingredients used in the experiment

Feed	DM	OM	CP	CF	EE	NFE	ASH
Requina obcordata (Adan Far)	97.7	77.35	17.1	37.4	4.0	71.9	19.6
Moringa olifeira (Rawag)	96.5	86.9	27.5	24.7	6.0	29.9	9.6
Cenchrus biflorus Haskaneet	96.8	83.5	9.2	37.9	5.0	37.3	13.38
Dairy ration	95.4	89.8	22.2	26.1	3.0	29.9	15.6

Statistical Analysis: Data collected during the study from a complete randomized experimental design (CRD) with four replications, was analyzed via analysis of variance according to Steele and Torrie (1998). Where significant variance obtained, Duncan multiple range test was used to separate means. The analysis was carried out using

MSTAT-C statistical package (Fischer, 1990).

RESULTS

Effects of supplementation Moringa olifeira Meal on feed intake of does:

The natural grazing (NG) intake as basal feed and intake of *Moringa olifeira* meal, dairy and ration and total dry matter intake of the lactating Desert goats is presented in Table (3).

Table 3: Feed and energy intake and in vitro digestibility of lactating goats as affected by the level of *Moringa oliferia* meal consumed treatments

Parameters studied	I	II	III	IV	SE
Offered Moringa olifeira meal (g/d)	---	300	400	--	--
Requina obcordata (g/d)	1000	1000	1000	1000	---
Cenchrus biflorus (g/d)	250	250	250	250	----
Dairy ration (g/d)	----	--	--	250	----
Natural grazing	1100	950	860	750	± 25
Total dry matter intake(kg)	55.00	62.50	63.00	53.5	±11.23
Feed intake(g/ day/head)	1100	1250	1260	1250	±100
IV DMD %	51.55	61.23	65.62	66.45	±13.25
IVOMD %	52.45	63.23	67.45	67.78	±15.16
Energy intake ME/Kg DM	765	823	845	805	±25

Goats on NG and 400g *Moringa olifeira* meal (MOM) consumed significantly (P<0.01) higher amount of feed than those on NG plus 300g MOM, NG and the ration plus natural grazing. Daily feed intakes of the groups were 1100,

1250, 1260 and 1000 g/d/ For the group on the natural grazing alone, natural grazing supplemented with 300g MOM and NG supplemented with 250g the ration respectively.

Effects of Ingestion of *Moringa olifeira* Meal on nutrients' digestibility and energy Intake of the lactating goats:

Effects of supplementation of lactating goats with *Moringa olifeira* meal on *in vitro* nutrients' digestibility and energy intake is presented in Table (4). *In vitro* dry matter digestibility coefficients were 51.55, 61.23, 65.62 and 66.45% for group I to IV respectively. The organic matter digestibility coefficients were 52.45, 63.23, 67.45 and 67.78 % for I, II, III and IV, respectively. Energy intake (M cal /d) was 765, 823, 845, and 805 for natural NG alone, NG+300 MOM, NG and 400 g MOM and NG supplemented with 250 CS, respectively. The *in vitro* coefficients and energy intake values variations among the groups were significant (P<0.01).

Effect of feeding *Moringa olifeira* Meal on live bodyweight of lactating goats:

Effects of MOM supplementation on live body weight changes in lactating goat is presented in table (4). The daily weight

gains for the lactating goat groups were 10, 145, 152.6 and 130 g for groups I-IV respectively. There were significant differences (P<0.01) in weight gain between the groups that were supplemented with MOM and those on the natural grazing. The differences between the two supplemented groups with MOM were insignificant (P>0.05). Kids' weight gain also was similar to those of their dams. Kids with dams on the natural grazing supplemented with MOM or concentrate supplement gained greater daily weight than those on the natural grazing alone. The kids of dam groups that were supplemented with MOM or natural grazing and concentrate supplement showed also significant (P<0.01) weight gains. Their daily weight gains were 67.9, 55 and 95.5 g/d for kids of dam on NG+ 300, NG and 400g MOM and 250g concentrate, respectively. While those belonged to dams on the natural grazing alone gained only 23.24 g/d.

Table 4: Live body weight change and kids' weight as affected by level of *Moringa olifeira* meal consumed by does

Parameter studied	Treatments				
	I	II	III	IV	SE
Number of animals	4	4	4	4	0
Days on trial	50	50	50	50	0
Initial weight of goats (kg)	23.750	23.750	23.750	23.750	0
Final weight of goats	24.250	31.00	31.380	30.250	0
Daily feed intake (g)	1100	1250	1260	1000	11.13
total weight gain of goats (kg)	0.500	7.250	7.630	6.500	2.343
Daily weight gain of goats (g)	10	145	152.6	130	±15.3
Initial weight of kids(kg)	3.838	3.050	3.250	3.275	±.
Final weight of kids (kg)	5.000	6.445	6.000	6.250	±11.13
Total weight gain of kids (g)	1.162	3.395	2.750	2.975	25.33
daily weight gain of kids (g)	23.24	67.9	55	95.5	15.13

Effects of supplementation of lactating goats with MOM on milk yield: Effects of supplementing lactating Desert goats with *Moringa olifeira* meal (MOM) on milk yield is presented in table (5). Dams on the natural grazing produced

smaller amounts of milk compared with those on the natural grazing supplemented with 300 or 400g *Moringa olifeira* meal. Animals on natural grazing supplemented with concentrate were superior in milk production for the

groups that were on natural grazing alone or supplemented with MOM. Goat groups produced 25, 88.750. 100.600 and 72.500 liters milk per the total experimental period and on daily bases

they produced 0.500 , 1.775, 2.012 and 1.450 liters for those on the natural grazing alone , on NG and supplemented with MOM at 300 and 400 g and those on NG and 250 concentrate supplement

Table 5: Weekly average milk production of goats as affected by Level of Moringa Meal in the ration (liter/day) Rations

Weeks	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	SE
1	0.548	0.850	0.887	0.677	
2	0.480	1.105	0.972	0.805	
3	0.832	1.402	1.100	1.582	
4	.500	1.365	1.605	0.947	
5	0.952	1.675	1.227	1.195	
6	0.500	1.383	1.947	1.222	
7	0.513	1.783	2.095	1.282	

Chemical composition of Goats' Milk as affected by the level of Moringa olifeira meal in the ration: Chemical composition of the milk produced by goats on NG supplemented with MOM at different levels is presented in table (8). Total solids % was 12.86, 13.53, 12.70 and 13.01 for goats on NG alone, NG supplemented with 300 g MOM, NG supplemented with 400g MOM and NG with CS, respectively. Milk fat percentage was 3.70 for those group of

goats on NG alone, and 3.65 on the two levels of MOM, and 3.65 % for the group on CS. Milk protein was 3.80, 3.60, 3.64 and 3.68 % for those on NG alone, NG supplemented with 300g MOM, 400 g MOM and 250g CS, respectively. Lactose was 4.57, 5.04, 4.81 and 3.96% for the group on NG alone, NG plus 300 g MOM, NG plus 400 g MOM and NG supplemented with 250g CS, respectively.

Table 6: Mean percentages of milk chemical composition of lactating goats

Treatment	Milk components (%)				
	TSS	Ash	Fat	CP	Lactose
Control	12.86	0.77	3.70	3.80	4.57
NG + 300 MOM	13.53	0.90	3.65	3.60	5.04
NG + 400 MOM	12.70	0.68	3.65	3.64	4.81
NG+ concentrate	12.86	0.97	4.65	3.68	3.69
SE					

DISCUSSION

Moringa olifeira Meal and Feed Intake of Does: The lactating goats consumed *Moringa olifeira* meal without being subjected to adaptation though moringa leaves were reported containing saponins, which may impair palatability (Amaglo *et al.*, 2010). This could be attributed to its high protein content and good palatability. Similar observations were reported by Heuzé *et al.*, (2014)

who found that all *Moringa olifeira* was eaten by goats immediately. It was also observed that total dry matter intake of goats was significantly ($P < 0.01$) increased upon supplementation with MOM meal. The group on NG and MOM consumed greater amount of total dry matter and that was attributed to effects of supplementation with good quality roughage that improved rumen ecosystem and increased micro flora population leading to higher

digestibility, faster movement of the digesta from the gut and eventually increasing total feed intake (McDonald *et al.*, 2010). Similar results were also reported by Asaolu *et al.*, (2012) who fed goats on *Moringa* Multi Nutrient Block (MMNB) supplementation and found significant ($P < 0.01$) increase in feed intake.

Baba *et al.*, (2000) studied the effects of inclusion of tree leaves on performance of lactating goats and found that goats on low quality roughage supplemented with *Leuceana leucocephala*, *Artocarpus heterophyllus* and *Melastroma marabathricum* (NCB) increased average dry matter and water intakes.

Effects of Feeding *Moringa olifera* Meal on nutrient digestibility: Nutrients digestibility of the rations increased with supplementation of does with MOM compared with NG alone. This might be attributed to increased nutrients needed by the cellulytic bacteria that digested more dry matter. Organic matter digestibility was also similar to that of the dry matter for the same reasons and due to high protein content of MOM. The results of this study are similar to **Effects of feeding goats with *Moringa olifera* Meal on milk production:** Milk production increased significantly ($P < 0.01$) upon supplementation of Desert goats with MOM. That might be attributed to the nutrients supplied by the high quality roughage that was shown to contain 27.1% compared with 11.2 % for the natural grazing and minerals. The concentrated ration though had high protein and energy had cereal grains that usually produce lower volatile fatty acids that are necessary for inducing lactating animals to produce more milk (McDonald *et al.*, 2010). Nevertheless, giving concentrated diets induced goats to produce more milk than offering natural

those reported by McDonald *et al.*, (2010) who found that feeding legume supplements could improve dry matter and organic matter digestibility in goats. Butterworth and Mosi (1985) reported that legume good quality hay might increase dry matter and organic matter digestibility. Protein and organic matter of *Moringa olifera* were reported being readily digestible in the rumen and/or in the intestine (Makkar *et al.*, 1997; Makkar *et al.*, 1997 and Kakengi *et al.*, 2005). The available data on digestibility of *Moringa olifera* parts are highly variable, and *in vitro* and *in vivo* OM digestibility reported in the literature range from 40 to 80%, possibly due to the large variability in fiber content (Heuzé *et al.*, 2014).

Kandylis *et al.*, (2008) studied the effects of supplementation of the low quality roughage with tree leaves and demonstrated that feeding of mulberry leaves with 12 % crude protein and low fiber content, resulted in a high apparent digestibility of the feed when fed to sheep on a mixed forage and concentrate diet.

grazing alone. The results reported here are similar to those reported by Sultana *et al.*, (2012) who found that milk yield was significantly ($P < 0.01$) increased with the supplementation of goats with concentrate. Sánchez *et al.*, (2006) conducted an experiment on effects of feeding *Moringa olifera* to dairy cows and found that it increased ($P < 0.05$) DM intake from 8.5 to 10.2 and 11.0 kg DM day⁻¹ and milk production from 3.1 to 4.9 and 5.1 kg.

Effects of goat with *Moringa olifera* Meal on milk composition: Crude protein and total solids % was similar for all goat groups that were on different levels of *Moringa olifera* meal but fat

was higher in milk produced from goats on natural grazing and concentrate than those on MOM. Lactose was higher in milk produced from dose fed MOM at different levels. This is consistent with the fact that high milk yield is associated with lower fat %. The results reported here are similar to those reported by McDonald *et al.*, (2010) who demonstrated that low fat and total solids were obtained from goats that produced higher levels of milk. Contrary, Bhatta *et al.*, (2002) studied the effects of feeding tree foliage on milk yield and composition of natural grazing lactating goats and found that the milk composition (milk protein and solid-not fat) also significantly ($P < 0.05$) improved in goats on tree foliage. The authors concluded that feeding of tree foliage in lactating goats maintained on range improved milk yield and composition.

Effects of feeding Moringa olifera Meal on body weight of does and kids: Live body weight gain of lactating increased in goats supplemented with MOM compared with those fed the natural grazing alone. It was greater for the group of goats on NG supplemented with 400g MOM followed by those on NG and 300g MOM and NG supplemented with 250 g CS and finally those on the NG alone. Greater weight gain was reported for goats on NG supplemented with MOM and that might be attributed to increased feed intake, better nutrients digestibility and higher level of energy, protein, minerals and vitamins of *Moringa olifera* leaves. Consuming *M olifera* might have also increased microbial protein that contains all essential amino acids needed for optimal metabolism. The group that was fed NG with concentrate ration gained smaller weight less than that recorded for MOM fed groups. That difference could be explained on better

utilization of nutrients when the supplement was tree forage rather than concentrate diet in ruminants. Similar results were reported by McDonald *et al.*, (2010) who concluded that feeding tree leaves have resulted in increased body weight gains of ruminants. Butterworth and Mosi (1985) also reported that feeding goats and sheep with legume hay resulted in increased intake, nutrients digestibility and eventually higher live body weight gains. However, Jadalla *et al.*, (2012a) reported small weights of sheep fed natural grazing supplemented with a limited amount of groundnut haulms because the study was intended to envisage sustaining lambs at maintenance level by such pattern of feeding since taking NG alone resulted in weight loss during the dry season. The differences in weight gain between the two groups that were supplemented with MOM were insignificant ($P > 0.05$).

Kids that belonged to dams on natural grazing supplemented with MOM or concentrate gained greater daily weight than those on the natural grazing alone. The groups that were supplemented with MOM or natural grazing and concentrate showed significant differences ($P < 0.01$) in weight gain. The improved weight gain might be attributed to increased milk production of the lactating goats on supplementation. Similar results were reported by Sitana (2010) who showed that feeding molasses blocks to Desert does on natural grazing improved their milk production and weight gain of their kids. Jadalla *et al.*, (2012b) studied supplementation of Desert does on sorghum straws supplemented with concentrates and observed increased milk production and greater body weight gains of the does and kids compared with those on the straws alone.

CONCLUSION:

It was concluded that feeding 300 and 400 g / head per a day was capable for increasing feeding intake, nutrients digestibility, milk production as well as improving milk quality. Consequently live body weight gain of the lactating Desert goats and their kids increased. *Moringa olifeira* meal could replace expensive dairy rations that were necessary to sustain milk production in goats on natural grazing. Due to its high nutritive value, low cost and adaptability to be planted in the area that suits its growth, the species is expected to be integrated into agro-forestry pattern in North Kordofan.

RECOMMENDATIONS:

It is recommended that *Moringa olifeira* meal be used at levels of supplementation of this study for goats milk production as low cost feed source that can reduce production cost and increase production. It will also assist in better performance for both does and their kids. It is also recommended that North Kordofan community be encouraged to grow *Moringa olifeira* on rangelands of the State. More studies are recommended for using MOM in different purposes for feeding goats and other classes of animals in the area.

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