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Comparative study on feeding value of *Moringa* leaves as a partial replacement for alfalfa hay in ewes and goats☆

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ABSTRACT

A Comparative study on feeding value of *Moringa* leaves diet (MOD) as a partial replacement for alfalfa hay diet (AHD) in ewes and goats was carried out. Twenty animals from each group were used in a 6-week experiment. Each group of the animals was divided into two groups with 10 animals in each group and arranged in a replicated 2×2 crossover design. Differences in MOD value vs. AHD were analysed by using Student's *t*-tests. MOD had significantly ($p \le 0.05$) higher ash, fat, nitrogen-free extracts, metabolizable energy, total phenolic content and antioxidant activity than AHD. However, crude protein, fibre, neutral detergent fibre and acid detergent fibre were significantly higher in AHD than MOD. Milk yield was significantly greater when goats and ewes were fed MOD than AHD. Feeding MOD to ewes and goats significantly affected milk composition with higher fat, lactose, and solid non-fat contents than AHD. Milk energy contents and outputs were significantly ($p \le 0.01$) higher in ewes and goats fed MOD than AHD. Goats and ewes fed MOD had significantly lower malondialdehyde (MDA) in their milk and serum than that fed AHD. Catalase content in milk and serum of goats and ewes fed MOD was significantly ($p \le 0.05$) higher than that of animals fed AHD. The total antioxidant capacity (TAC) and vitamin C were higher in milk and serum of goats and ewes fed MOD than that fed AHD. Lower cholesterol and glucose contents were noted in the serum of goats and ewes fed MOD. Average daily gain by kids and lambs was significantly ($p \le 0.01$) higher in kids and lambs fed MOD than that fed AHD. Replacement of alfalfa with *M. oleifera* had a positive effect on milk yield, composition and quality of ewes and goats and growth performance of kids and lambs.

1. Introduction

In most developing countries livestock sector plays a significant economic role, and it is essential for the food security of the population. In Saudi Arabia and other Middle East countries, there is a problem of lack of adequate supply of feed for livestock year round. Consequently, farm production in these countries is generally low, mainly due to poor feed quality and insufficiency of available feeds.

The use of concentrates as supplements to low-quality hay is known to improve intake and digestibility of roughages (Nurfeta, 2010). However, the supplementation with concentrates is restricted under smallholder livestock production systems as a result of inadequacy and the high price of concentrates. Thus, there is a search for alternative unconventional and cheap feed sources that may contain valuable components of animal diets and can easily be produced and be readily available to farmers. Use of fodder trees and shrubs could be a potential approach for increasing the quality and availability of feeds for resource-limited livestock farmers during the dry season. According to Moyo et al. (2012), *Moringa oleifera* serves as good and cheap source of protein and micronutrients. Improvement in the intake, digestibility and body weight gain was reported when tree leaves were used as a supplement for low-quality grass (Manaye et al., 2009). One of such trees is *Moringa* tree which is a multipurpose tree that is cost-effective with numerous industrial and feeding uses.

Moringa (*Moringa oleifera*) is a slender, deciduous, perennial evergreen tree that originated in India but has spread to other parts of the world (Foidl et al., 2001). Among all trees in the world, it is one of the fastest growing trees with high biomass yield, high crude protein of +25% and a balance of other nutrients in the leaves (Makkar and Becker, 1996; Foidl et al., 2001).

Recently, several types of research have been investigating the use of *M. oleifera* leaf as a protein source and feed components in animal production especially in goats (Asaolu et al., 2012; Babeker and Abdalbagi, 2015; Sultana et al., 2015), sheep (Adegun et al., 2011)

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and also in other ruminant (Mendieta-Araica et al., 2011 and Sarwatt et al., 2004) and was found to be effective.

The use of *Moringa* foliage as a protein source has several advantages which include: the ability to be harvested several times per growing season; small difference in the intake of both fresh or dried *Moringa* leaves and ability to store its dried leaf for longer periods without deterioration in nutritive value (Mendieta-Araica et al., 2011). *M. oleifera* also contain natural antioxidants like vitamin C, tocopherols, flavonoids and other phenolic compounds (Laandrault et al., 2001; Iqbal and Bhanger, 2006). *Moringa oleifera* leaves are rich in nutrients such as protein, fatty acid, mineral and vitamins and have potentials to be used as a feed additive with multiple purposes (Moyo et al., 2013).

Various factors such as the type of feed and environmental conditions may influence the performances of growth and milk quality of livestock. Therefore, a comparative study on the effect of partial replacement of alfalfa hay diet (AHD) with *Moringa oleifera* leaves diet (MOD) on milk yield, composition and oxidative status of milk and serum of dairy ewes and goats and growth performance of lambs and kids was carried out.

2. Materials and methods

2.1. Experimental site

This study was carried out in Al-Khaldiah Agricultural Farm situated in Riyadh, Kingdom of Saudi Arabia (24°23′22″ N and 45° 53′55″ E). The climate is marked with a dry season between April-September with a mean annual ambient temperature of 31.6 °C and monthly rainfall of 8.4 mm.

2.2. Moringa oleifera (MOD) and alfalfa hay diets (AHD) preparation

Fresh mature *M. oleifera* leaves were manually harvested from mature trees (3–4 months old) at Durt-elizdihar Agricultural Farm, Gazan, Saudi Arabia. Alfalfa hay was obtained from Al-Khaldiah Agricultural Farm situated in Riyadh, Kingdom of Saudi Arabia. Both fodders were air-dried under partial shade by spreading on clean plastic sheets for 72 h and turned three times a day. The dried leaves were ground to fine powder and mixed with other ingredients in the form of pellets using pellet making machine at Al-Khaldiah Agricultural Farm, Riyadh, Saudi Arabia. The diets were formulated as follows:

AHD: Alfalfa hay (40%), corn (25%), barley (21.8%), soya bean meal (10.2%), NaCl (1.0%), limestone (1.0%), $NaHCO_3$ (0.8%) and vitamin mix (0.2%).

MOD: Alfalfa hay (15%), *M. oleifera* (25%), corn (25%), barley (27.6%), soya bean meal (4.4%), NaCl (1.0%), limestone (1.0%), $NaHCO_3$ (0.8%) and vitamin mix (0.2%).

2.3. Animal feeding and experimental design

Twenty dairy Najdi ewes, with an average weight of 55 kg and 2 years old and 20 dairy Aardi goats, with an average weight of 37 kg and 2 years old, were each divided into two groups with 10 animals in each group. Twenty lambs, with an average weight of 19.2 kg and 3 months old and 20 Aardi kids, with an average weight of 16.2 kg and 3 months old were each divided into two groups with 10 animals in each group. The groups of each were assigned to a replicated 2×2 crossover design. One group of the animals of each type received AHD, whereas the other group received MOD. Two weeks later, the treatment order was reversed. To minimize the crossover effect each experimental period consisted of 2 weeks adaptation period to treatments and 6 weeks data collection. All goats and ewes were at their second lactation and were approximately at the same stage of lactation. The animals were kept in semi-open sheds at AlKhalidiya Farm, Riyadh, KSA. The animals were fed (2 kg/day/animal) with the diets. For measurement of growth performance, the kids and lambs were weighed daily and then pooled into one sample per week throughout the collection period (6 weeks) then the average weight of the whole period was taken.

2.4. Chemical analysis of experimental diets

The dry matter, crude protein, fat, crude fibre, neutral detergent fibre, acid detergent fibre and ash contents of the experimental diets were determined according to the standard methods of Association of Official Agricultural Chemists (AOAC, 1990). The metabolizable energy of the experimental diets was estimated using the energy equation in TMR proposed by Boguhn et al. (2003). The total phenolic content (TPC) of the experimental diets was determined using the Folin-Ciocalteu method (Singleton and Rossi, 1965). The free radical scavenging activity of the diets was analysed using 2, 2,-diphenyl-2-picryl-hydrazyl (DPPH) according to Turkmen et al. (2005). All measurements were carried out in triplicate.

2.5. Milk sampling and milk composition analysis

Goats and ewes were hand-milked daily, and the milk yield was weighed and recorded. Samples were immediately refrigerated at 4 °C and pooled into one sample throughout the collection periods (6 weeks). Samples were stored in plastic vials and immediately cooled to 4 °C, transported to the laboratory and kept frozen at −80 °C for further analyses.

Milk composition was analysed using a Milko Scan (Minor Type 78100, FOSS Electric, Denmark). The energy content of milk was calculated according to Tyrell and Reid (1965).

2.6. Milk and blood serum analysis

Blood samples were collected weekly before feeding by jugular venipuncture into plain vacationer tubes. The blood samples were centrifuged at 3000 rpm for 10 min to separate the sera. The separated serum samples were kept frozen at −80 °C for further analyses.

Total antioxidant capacity (TAC) of milk and serum samples was estimated using Antioxidant Assay Kit (Cayman, USA). Catalase activity was determined in milk and serum using Catalase Assay Kit (Cayman, USA). The concentration of malondialdehyde (MDA) in milk and serum for each group of animals as an average value of six weeks treatments was measured using thiobarbituric acid reactive substances (TBARS) Assay Kit (Cayman, USA). Vitamin C content was measured using Ascorbic Acid Colorimetric Assay Kit (BioVision, USA). The concentrations of glucose and cholesterol of serum were measured using Randox Assay Kits (Randox, Laboratories Ltd., UK). For each group of animals, the average value of six weeks treatments was calculated.

2.7. Statistical analysis

According to the design (crossover 2×2) applied, differences in carryover effects (treatment x period) were evaluated according to Jones and Kenward (1989), and they were considered not significant. Therefore, the results of the two treatment sequences were combined. For all parameters, statistical comparison between means as a result of feeding AHD or MOD was performed using Student's *t*-test at $p \le 0.01$ and 0.05.

3. Results

3.1. Chemical composition of the experimental diets

The chemical composition of the formulated diets used in this experiment is shown in Table 1. The dry matter content and metabolizable energy of MOD were higher ($p \le 0.05$) than that of AHD. However,

Table 1
Chemical composition of the experimental diets (dry-weight basis).

Parameter	Diet		Difference in ADH vs MOD
	ADH	MOD	
Dry matter (%)	91.20 ± 0.19	91.74 ± 0.25	*
Ash (%)	8.07 ± 0.23	8.98 ± 0.11	**
Crude protein (%)	18.66 ± 0.41	17.24 ± 0.13	*
Fat (%)	2.96 ± 0.22	4.30 ± 0.25	**
Crude fibre (%)	11.83 ± 0.24	10.13 ± 0.08	**
NDF (%)	27.00 ± 0.23	20.90 ± 0.20	**
ADF (%)	16.00 ± 0.11	11.20 ± 0.10	**
Nitrogen free extract (%)	58.48 ± 0.36	60.35 ± 0.45	**
ME (MJ/kg DM)	7.10 ± 0.07	7.30 ± 0.08	*
Total phenolics (mg GAE/g sample)	3.23 ± 0.12	5.11 ± 0.23	**
Antioxidant activity (%)	56.89 ± 0.53	67.96 ± 0.69	**

Values are means (± SD) of triplicate samples.
AHD= Alfalfa hay diet; MOD= M. oleifera diet. NDF=Neutral Detergent Fibre, ADF=Acid Detergent Fibre; ME=Metabolizable energy.
** p≤0.01.
* p≤0.05.

AHD had significantly (p≤0.01) higher protein content (18.66%) than MOD (17.24%). A similar result was observed in the crude fibre which was significantly (p≤0.01) higher in AHD. The ash, fat contents and NFE of MOD were significantly (p≤0.01) higher than that of AHD while neutral detergent fibre and acid detergent fibre were significantly (p≤0.01) higher in AHD. Furthermore, MOD exhibited significantly (p≤0.01) higher TPC (5.11%) and antioxidant activity (67.96%) than that of AHD.

3.2. Milk yield and composition

Table 2 shows the milk yield and composition of dairy ewes and goats fed with AHD and MOD. Milk yield of the ewes fed with MOD was significantly (p≤0.05) higher than those fed with AHD. Also goats fed with MOD had significantly (p≤0.01) higher milk yield than those fed with AHD. Significantly (p≤0.05) higher fat, lactose, and solid non-fat contents were observed in the milk of ewes and goats fed on MOD than AHD. AHD and MOD feeding had no significant effect on the protein, total solids and freezing point depression of the ewes and goats' milk but the values were varied slightly. The milk energy content was significantly (p≤0.05) higher in the milk of ewes fed MOD than AHD while milk energy output was significantly (p≤0.01) higher in the milk of both ewes and goats fed MOD than AHD.

3.3. Milk oxidative status, vitamin C, and cholesterol concentration

Table 3 shows milk oxidative status, vitamin C, cholesterol concentrations of ewes and goats fed with alfalfa hay (AHD) and *M. oleifera* leaves diet (MOD). Ewes fed MOD significantly (p≤0.05) had lower malondialdehyde (MDA) in the milk (7.74 nM MDA) than those fed AHD (11.42 nM MDA). Also feeding goats with MOD significantly (p≤0.05) lowered MDA to 6.42 nM MDA compared to those fed AHD (8.73 nM MDA). Feeding the ewes and goats with MOD significantly increased the TAC (p≤0.05) and vitamin C (p≤0.01) contents of milk compared to those fed with AHD. The catalase content of the ewes and goats' milk was significantly (p≤0.05) higher in MOD than AHD.

3.4. Serum oxidative status, vitamin C, cholesterol and glucose concentrations

The MDA of the ewes (p≤0.05) and goats' (p≤0.01) serum was significantly reduced when fed with MOD compared to those fed with AHD (Table 4). No significant dietary effect was observed on the TAC and vitamin C of the ewes' serum. However, goats fed with MOD had significantly higher TAC (p≤0.01) and vitamin C (p≤0.05) content in their serum than those fed with AHD. Also, feeding ewes and goats with MOD significantly lowered the cholesterol (p≤0.01) and glucose (p≤0.05) contents of the serum compared to those fed with AHD.

3.5. Growth performance of animals

Table 5 shows the total body weight gain (BWG) and average daily gain (ADG) of ewes' lambs and goat kids fed with alfalfa hay (AHD) and *M. oleifera* leave diet (MOD). Partial replacement of the diet of lambs with MOD increased significantly (p≤0.01) total BWG (13.44 kg) of the animals compared to AHD (9.66 kg), but no significant variation in total BWG was observed in goat kids fed with the diets. The ADG of the lambs and kids fed with MOD was significantly (p≤0.01) higher than those fed with AHD.

4. Discussion

4.1. Chemical composition of the experimental diets

To balance the protein of the formulated diets, the concentration of both barley and soybean meal are varied between the diets. The protein content of MOD used in this study was comparable with the values reported by Sànchez et al. (2006) and Soliva et al. (2005) for *M. oleifera* meals, but lower than the value reported by Fadiyimu et al. (2010). Although the protein of AHD was higher than that of MOD but both values are higher than the minimum microbial activity requirement to support acceptable ruminal microbial activity and the main-

Table 2
Milk yield and composition of ewes and goats fed with alfalfa hay (AHD) and *M. oleifera* leaves diet (MOD).

Parameter	Ewes		Difference in ADH vs MOD	Goat		Difference in ADH vs MOD
	ADH	MOD		ADH	MOD	
Milk yield (kg/day)	1.84 ± 0.29	2.63 ± 0.46	*	3.46 ± 0.44	5.34 ± 0.59	**
Fat (%)	3.51 ± 0.21	4.12 ± 0.23	*	3.91 ± 0.21	4.29 ± 0.10	*
Protein (%)	4.82 ± 0.10	4.83 ± 0.14	NS	3.51 ± 0.06	3.56 ± 0.06	NS
Lactose (%)	3.63 ± 0.27	4.21 ± 0.17	*	4.51 ± 0.07	4.73 ± 0.03	*
Total solids (%)	12.20 ± 0.32	12.83 ± 0.51	NS	12.60 ± 0.21	13.11 ± 0.22	*
Solid non-fat (%)	9.44 ± 0.13	9.84 ± 0.14	*	8.80 ± 0.07	8.93 ± 0.07	*
Freezing point depression (%)	0.52 ± 0.03	0.61 ± 0.05	NS	0.57 ± 0.003	0.61 ± 0.003	NS
Milk energy content (MJ/kg)	3.03 ± 0.14	3.38 ± 0.16	*	3.07 ± 0.87	3.23 ± 0.93	NS
Milk energy output (MJ/day)	6.06 ± 0.18	8.21 ± 0.09	**	10.62 ± 0.66	17.25 ± 0.53	**

Values are means (± SD) of pooled samples. AHD, Alfalfa hay diet; MOD, *M. oleifera* diet,
** p≤0.01.
* p≤0.05 and NS, not significant.

Table 3
Milk oxidative status, vitamin C, cholesterol concentrations of ewes and goats fed with alfalfa hay (AHD) and *M. oleifera* leaves diet (MOD).

Parameter	Ewes		Difference in ADH vs MOD	Goat		Difference in ADH vs MOD
	AHD	MOD		AHD	MOD	
TBARS (nM MDA)	11.42 ± 1.91	07.74 ± 1.01	*	8.73 ± 1.24	6.42 ± 1.19	*
TAC (mM/1)	3.43 ± 0.34	05.05 ± 0.21	*	10.61 ± 0.79	13.82 ± 0.84	**
Catalase (nM/min/ml)	57.06 ± 1.92	60.81 ± 1.35	*	49.50 ± 2.41	54.25 ± 1.10	*
Vitamin C (mg/100 ml)	3.79 ± 0.38	6.04 ± 0.69	**	1. 50 ± 0.22	3.09 ± 0.24	**

Values are means (± SD) of pooled samples. AHD, Alfalfa hay diet; MOD, M. oleifera diet,
** p≤0.01.
* p≤0.05 and NS, not significant.

Table 4
Serum oxidative status, vitamin C, cholesterol and glucose concentrations of ewes and goats fed with alfalfa hay (AHD) and *M.* oleifera leaves diet (MOD).

Parameter	Ewes		Difference in ADH vs MOD	Goat		Difference in ADH vs MOD
	AHD	MOD			MOD	
TBARS (nM MDA)	2.92 ± 0.52	1.91 ± 0.21	*	3.47 ± 0.21	2.04 ± 0.31	**
TAC (mM/L)	16.82 ± 1.01	17.22 ± 0.23	NS	26.47 ± 0.55	29.57 ± 0.49	**
Catalase (nM/min/ml)	23.93 ± 2.12	28.23 ± 2.41	*	10.17 ± 0.23	12.72 ± 0.86	*
Vitamin C (mg/100 ml)	1.22 ± 0.15	1.39 ± 0.58	NS	0.88 ± 0.12	2.73 ± 0.65	*
Cholesterol (mg/100 ml)	61.12 ± 3.20	52.50 ± 3.12	**	65.51 ± 3.81	54.87 ± 3.42	*
Glucose (mg/100 ml)	62.20 ± 3.22	60.09 ± 3.41	*	85.58 ± 3.72	68.37 ± 4.23	**

Values are means (± SD) of pooled samples. AHD, Alfalfa hay diet; MOD, M. oleifera diet.
** p≤0.01.
* p≤0.05 and NS, not significant.

tenance requirement for a protein of the host ruminant (McDonald et al., 2002). The high dry matter and ash contents of MOD may lead to increase in activity of cellulolytic rumen microflora, and this can result in rapid degradation of the diet and passage of digesta in the rumen. The nutritional quality of animals fed with MOD may increase due to the high-fat content of the diet that can supply essential fatty acids and calorie needed. Moreover, the low nitrogen-free extracts and fibre may also lead to a reduction in the amount of fibre and time needed by rumen microflora to digest. The high phenolic content and antioxidant activity of MOD may prevent the body of the animals from oxidative damage; thereby improve the health and production performance of the animals. *M. oleifera* have potent antioxidant activity against free radicals, prevent oxidative damage to major biomolecules and provide significant protection against oxidative damage (Sreelatha and Padma, 2009).

4.2. Milk yield and composition

For both ewes and goats, feeding of MOD increased milk yield significantly (p≤0.05 and p≤0.01) during the feeding period. *Moringa oleifera* diet improved the milk yield due to its lower NDF and ADF and higher metabolizable energy contents. In addition, despite the slightly lower protein value of *Moringa* diet as compared to alfalfa, *Moringa* protein has excellent rumen bypass characteristics (Sarwatt et al., 2004). Although no significant effect was observed in ewes fed with MOD and AHD except at week 1 and 6 but the milk yield of ewes fed on MOD was higher than that reported by Tufarelli et al. (2011) in subjects fed diets supplemented with vitamin and trace element. Partial replacement of alfalfa hay with *Moringa* leaves in goats and ewes feed delayed the decline in lactation period, and this could be due to high protein degradation of *Moringa* leaves, which is comparable with soybean meal diet, and lead to better feed utilization by the lactating animal. According to Zarkadas et al. (1995), feeding on *Moringa* leaves prolongs lactation period because due to high concentration of amino acids. The significant increase in milk fat, lactose and solid non-fat in ewes and goats fed with MOD confirms the findings of previous works where diets supplemented with vitamins and minerals rich diets for dairy goats (Kholif et al., 2015) and ewes (Abbeddou et al., 2015), led to an improvement in milk production. *M. oleifera* leaves have high mineral contents most especially P, Ca, and Mg than those of native pasture (Gizachew et al., 2002). The finding of the present study regarding the dietary effect on milk protein is similar to the finding observed in goats (Kholif et al., 2015) and ewes (Abbeddou et al., 2015). However, the parameters (milk protein, lactose and freezing point depression) were increased after substituting with MOD, and these could be ascribed to better utilization of nutrients by the animals. Therefore, the milk produced by ewes and goats fed with MOD probably has a benefit for cheese production. The milk energy content of the present study for both animals was comparable to that reported by Kholif et al. (2015) for Anglo-Nubian goats but higher than its milk energy output.

Table 5
Total body weight gain (BWG) and average daily gain (ADG) of ewes' lambs and goat kids fed with alfalfa hay (AHD) and M. oleifera leaves diet (MOD).

Parameter	Lambs		Difference in ADH vs MOD	Goat kids		Difference in ADH vs MOD
	AHD	MOD		AHD	MOD	
Total BWG (kg)	9.66 ± 0.24	13.44 ± 0.29	**	6.90 ± 0.62	7.70 ± 0.43	NS
ADG (g)	230.0 ± 5.79	320.0 ± 7.14	**	164.0 ± 3.50	183.0 ± 4.90	**

Values are means (± SD) of pooled samples. AHD, Alfalfa hay diet; MOD, M. oleifera diet, *, p≤0.05 and NS, not significant.
** p≤0.01

4.3. Milk oxidative status

Reduction in MDA value in the milk of ewes and goats fed with MOD could be due to the high phenolic content of MOD that prevents autoxidation of milk fat thus preventing the formation of MDA. *M. oleifera* leaves have a high antioxidant activity that can provide a health benefit to animals (Mbikay, 2012). The diet (MOD) had a significant effect on catalase content of the ewes and goats' milk, and the activity of the enzyme can prevent MDA formation by catalysing the decomposition of hydrogen peroxides to water and oxygen. This could also be responsible for the low MDA value observed on the ewes and goats' milk. Ewes and goats' milk are deficient in vitamin C but substituting their diet with *M. oleifera* increased their vitamin C content compared to AHD. This could be due to the presence of adequate macro- and micro-minerals and vitamins contained in *M. oleifera* leaves which enhance the efficiency of rumen microbial growth and activity, and hence improved milk quality (Gebregiorgis et al., 2012).

4.4. Serum oxidative status

The MDA value of the serum followed the same trend as that of milk for both animals, and the reduction in the serum MDA of ewes fed with MOD could be attributed to the high catalase activity of the ewes' serum that prevents the degradation of hydroperoxides to MDA. However, the high catalase content and TAC in the serum of goats fed with MOD compared to those fed with AHD may have contributed to the reduction in MDA value of the goats' serum. This positive effect may be due to the high antioxidant activity present in MOD. Replacement of AHD with MOD led to a significant increase in vitamin C in goats' serum but non-significant increase in ewes' serum. This could be due to better utilization and absorption of *Moringa* nutrients such as minerals, vitamins and protein by the goats, which are essential for milk production and quality. The reduced cholesterol content in ewes and goats fed with MOD could be ascribed to the functional effect of phenolic acids and antioxidant activity in *M. oleifera*. The synthesis and absorption of cholesterol can be lowered in the presence of phytochemicals and antioxidants (Saxena et al., 2013). In addition, the high glucose content observed in the ewes and goats serum fed with AHD could be responsible for the increase in their cholesterol content. According to Iqbal et al. (2012), glucose is one of the main precursors for cholesterol synthesis in the small intestine or liver. The glucose levels obtained in the serum of both animals fed with MOD were comparable to that reported by Abdulaziz (2012) and Dhanotiya (2004) for ewe and goats, respectively.

4.5. Growth performance

The increase in total BWG by lambs fed with MOD could be due to better utilization of *M. oleifera* protein with better rumen bypass characteristics. The ADG values of lambs and kids fed with MOD were higher than those obtained in previous studies in ewes and goats fed on *M. oleifera* (Adegun et al., 2011; Moyo et al., 2012). The higher ADG of lambs and kids fed MOD compared to those fed AHD could be partly due to the higher fat content and mineral content in the MOD, which could have increased live weight gain by improving nutrient utilization efficiency. According to Safari et al. (2009), a coating of proteins by fats can boost protein nutrition, thus preventing degradation, thereby increasing post-ruminal protein supplies. The lower ADG observed in the animals fed with AHD could be due to lower nutrient intake (Safari et al., 2009).

5. Conclusion

The results of this study suggest that partial replacement of alfalfa hay with *M. oleifera* in the diet of ewes and goats positively affected their milk yield and composition. MOD had a greater effect on the milk yield of goats and growth performance of lambs. Oxidative status of milk and serum of both animals were improved after replacing their diets with *M. oleifera*. Thus, *M. oleifera* as a supplement in ruminant diets may be a promising way of improving the growth performance, milk yield and composition as well as minimizing the oxidative damage of milk and serum of ewes and goats.

Conflict of interest

1. The current study is compliance with ethical standards.
2. The authors declare that they have no conflict of interest.

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