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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 ($p \leq 0.05$) 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 ($p \leq 0.01$) 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 ($p \leq 0.05$) 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 ($p \leq 0.01$) 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)

☆ **Compliance with ethical standards**: All procedures described in this experiment were approved by the Faculty Research Ethics Committee at the King Saud University.

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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 $p \leq 0.01$ 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 ($p \leq 0.05$) than that of AHD. However,