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Effect of feeding diets with processed *Moringa oleifera* meal as protein source in lactating Anglo-Nubian goats

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ABSTRACT

The aim of the current study was to assess the effect of including different forms of *Moringa oleifera* leaf meal in the diets of goats. Sixteen lactating Anglo-Nubian goats (36.2 ± 0.7 kg) were used in quadruplicated 4 × 4 Latin square design for 88 days. *M. oleifera* as fresh foliage, hay or silage replacing 750 g/kg dry matter (DM) of sesame meal were evaluated against a basal diet without *M. oleifera* (sesame meal as the sole protein source) as a control diet. *M. oleifera* leaf meal was ensiled for 60 days, whereas hay was made after air drying for 10 days. Goats fed *M. oleifera* silage or fresh biomass had higher ($P < 0.05$) DM intake (DMI) and digestibility of most nutrients compared with the control diet. In addition, DMI was greater ($P < 0.05$) in goats fed *M. oleifera* silage compared with hay. Feeding all three forms of *M. oleifera* decreased ($P < 0.05$) ruminal ammonia-N concentration and increased ($P < 0.05$) the proportion of ruminal propionate. Higher ($P < 0.05$) ruminal ammonia-N, propionate, and total short-chain fatty acids were noted in goats fed *M. oleifera* silage compared with hay. *M. oleifera* diets decreased ($P < 0.05$) blood serum triglycerides and cholesterol concentrations and increased ($P < 0.05$) serum glucose compared with the control. Moreover, feeding *M. oleifera* diets resulted in higher ($P < 0.05$) milk yield, energy-corrected milk and milk contents of protein and lactose than for the control diet, and higher ($P < 0.05$) milk fat contents were noted in goats fed *M. oleifera* fresh biomass and hay compared with the control diet. Feeding *M. oleifera* increased ($P < 0.05$) total unsaturated fatty acids and total conjugated linoleic acid of milk and decreased ($P < 0.05$) saturated fatty acids. It is concluded that feeding different forms of *M. oleifera* to replace 750 g/kg DM of sesame meal enhanced feed utilization, ruminal fermentation, milk yield and composition in lactating Anglo-Nubian goats. The best performance was observed in goats fed *M. oleifera* silage followed by fresh *M. oleifera* and then *M. oleifera* hay.

Abbreviations: ADFom, acid detergent fiber expressed exclusive of residual ash; AI, athrogenicity index; CLA, conjugated linoleic acid; CF, crude fiber; CP, crude protein; DE, digestible energy; DM, dry matter; DMI, dry matter intake; ECM, energy corrected milk; EE, ether extract; GOT, glutamate-oxaloacetate transaminase; GPT, glutamate-pyruvate transaminase; ME, metabolizable energy; MUFA, mono unsaturated fatty acids; NDFom, neutral detergent fiber expressed exclusive of residual ash; NE_L, net energy for lactation; NFE, nitrogen free extract; NSC, non-structural carbohydrates; OM, organic matter; PUFA, poly unsaturated fatty acids; SCFA, short-chain fatty acids; SFA, saturated fatty acids; TDN, total digestible nutrients; UFA, unsaturated fatty acids.

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1. Introduction

One of the most serious problems facing animal producers, especially smallholder resource-poor farmers, is the availability and price of protein sources. This situation has led to consideration of alternative and less-expensive ingredients with adequate protein content and a balanced amino acid profile. Plant leaf meal and tree foliage are considered as cost-effective protein sources that can be used in ruminant feeding (Alsersy et al., 2015; Kholif et al., 2015; Salem et al., 2015; Sultana et al., 2015). *Moringa oleifera* Lam (syns. *Moringa pterygosperm*, family *Moringaceae*) is one of these alternative protein sources. *M. oleifera* is an indigenous native tree from the Himalaya that is widely distributed almost worldwide (Soliva et al., 2005). Information is lacking on when *M. oleifera* was introduced into Egypt; however, it was used in ancient Egypt to purify drinking water and for medical purposes. Until now, *M. oleifera* was grown solely for human consumption, but interest is increasing in its use as animal feed (Khalel et al., 2014; Kholif et al., 2015). Because *M. oleifera* can be grown in different environmental conditions, with the ability to grow in all types of soils, it is now available in many cultivable areas in Egypt. In Egypt, the price per kg dry matter (DM) of *M. oleifera* depending on the purpose of use (quality): for human uses, ranging from 1 to 1.5 US$ (dried leaves) up to 20 to 24 US$ (seeds) vs. approximately 0.25–0.5 US$ per kg DM for animal feeding purposes. In contrast, the price of common protein concentrates in ruminant nutrition (e.g., sesame meal) ranges between 0.50 and 0.75 US$ per kg DM depending on the quality and availability. Because *M. oleifera* leaf meal contains about 280 g crude protein (CP)/kg DM, which is less than that of common protein concentrates in ruminant nutrition (e.g. soybean meal and cottonseed meal), but similar to sesame meal (260 g CP/kg DM), it can replace sesame meal in the diet of goats without affecting CP content of the diets.

M. oleifera leaf meal contains from 180 to 270 g CP/kg DM (Sultana et al., 2015), with approximately 470 g bypass protein/kg CP (Becker, 1995). Previous studies with fresh *M. oleifera* foliage (Kholif et al., 2015; Sultana et al., 2015) or silage (Mendieta-Araica et al., 2011a) for dairy cattle showed improved or at least unaffected milk production compared with traditional diets. *M. oleifera* yields between 43 to 115 tons of biomass/ha annually (Safwat et al., 2014). Feeding fresh *M. oleifera* provides adequate nutrition of ruminants, but because of the large variation in production over the year, there is a need to preserve it for use during the dry season when high-quality feed resources are scarce. Silage and hay can be good alternatives for preserving fresh forage, and they can be used to overcome feed shortages during the dry season. Previous research has demonstrated that *M. oleifera* can be ensiled alone or after mixing with other grass or sugarcane to increase the nutritive value of the silage (Mendieta-Araica et al., 2011a).

There is little information about *M. oleifera* silage or hay as a protein source in the diet of ruminants. Therefore, the aim of this study was to evaluate the effects of replacing sesame meal (a conventional protein source) at 750 g/kg DM with *M. oleifera* (as fresh foliage, hay or silage) on feed utilization, milk yield and composition of lactating Anglo-Nubian goats.

2. Materials and methods

Goats were cared and handled in accordance with the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 2010) at a private dairy farm near Behera governorate (Egypt) and at the Laboratory of Dairy Animal Production, National Research Centre (Egypt). The location is at latitude of 31°04′02.4″N and 30°31′42.19″E. The local climate of the area is temperate-tropic humid (14–28 °C), with winter rains and an annual average rainfall of 22 mm.

2.1. Planting and preparation of *M. oleifera*

As previously described by Kholif et al. (2015), viable, clean and disease-free *M. oleifera* seeds were obtained from The Egyptian Association of Moringa (National Research Centre, Egypt). Before sowing, seeds were soaked in clean water for 24 h and then kept in the dark for 24 h before planting in density of 100,000–150,000 seeds per ha. The field was irrigated biweekly with 900 m^3 water/ha, without using any fertilizer. Before starting the experiment, a uniformity cut (at 5–7 cm cutting height) was carried out 65 days after seeding, when plants reached a height of 65–70 cm; *M. oleifera* biomass composed of leaves and small twigs was harvested. *M. oleifera* used in the current experiment had 40 (±5) day cut intervals resulting in 9 harvests per year (yielding 70–80 tons of fresh biomass/ha/year; equal to ~23 tons DM). Part of the harvested *M. oleifera* was used for silage and another part for hay. Fresh *M. oleifera* biomass required to feed the goats was collected daily from the field every morning. The fresh material collected for feeding was always from 40 (±5) days aftermaths.

M. oleifera silage was prepared 60 days before the experiment using *M. oleifera* biomass of 45 days cut, with large twigs removed. The material was chopped, and molasses was added at 50 g/kg of fresh weight. The material was then packed into 40 × 70 cm polythene bags and compressed by hand to create anaerobic conditions. Bags were then sealed to serve as silos and stored indoors on a dry concrete floor until opening just before feeding. Before feeding, silage quality was evaluated by measuring pH, ammonia-N and lactic acid concentrations. A homogenized sample of silage (200 g fresh weight) mixed with 800 mL of distilled water and homogenized for 3 min with a laboratory blender and then filtrated through 4 layers of cheesecloth. The pH value was measured by using an HI 9321 microprocessor pH/mV/°C bench meter (Hanna® Instrument, Singapore). Ammonia-N concentration was determined by Kjeldahl distillation according to AOAC (1997. Before determination of lactic acid concentration, a sample (40 mL silage fluid) was centrifuged for 15 min at 6000*g* at 4 °C to prevent loss of volatiles. The concentration of lactic acid was determined using gas-liquid chromatography (model 5890, HP, Little Falls, DE, USA) where lactic acid (L-1750; Sigma-Aldrich, ON, Canada) was used as a standard.