International Journal of
Dairy Science

ISSN 1811-9743

Academic
Journals Inc.

www.academicjournals.com

OPEN ACCESS International Journal of Dairy Science

ISSN 1811-9743
DOI: 10.3923/ijds.2020.80.87

Research Article
Effect of Feeding Moringa Seed Cake as an Alternative Protein Source in Lactating Ewe's Rations

[1]Ahmed A. Aboamer, [1]Hossam M. Ebeid, [2]Mahmoud M. Shaaban, [1]Ramadan M.A. Gawad, [2]Mohamed M. Mostafa and [3]Aboelfetoh M. Abdalla

[1]Department of Dairy Sciences, National Research Centre, 33 El-Bohouth Street, P.O. Box 12622, Dokki, Giza, Egypt
[2]Department of Biological Applications, Nuclear Research Center, Atomic Energy Authority, Inshas, Cairo, Egypt
[3]Department of Horticultural Crops Technology, National Research Centre, 12622 Dokki, Giza, Egypt

Abstract

Background and Objectives: The use of non-traditional oilseeds such as *Moringa oleifera* Lam seeds has being an attractive as feed resource for livestock production. The objective of this study was to evaluate moringa seed cake (MSC) as an alternative source of protein in lactating ewe's ration. **Materials and Methods:** The control diet consists of concentrate mix and Egyptian clover hay (50:50). Cotton seed meal was substituted by MSC at two levels (2.5 and 5%). Three trials were conducted. An *in vitro* true dry matter (IVTDM) and fiber fractions digestibility were determined using the batch culture system. *In vitro* gas production (GP) technique was used to determine the amount of gas produced over a 3, 6, 12 and 24 h incubation. For the lactation trial, twenty-one of lactating Ossimi ewes were assigned into three groups using complete random design to study the effect of MSC on animal performance. **Results:** Total GP after 24 h and potential extent of GP were significantly ($p<0.05$) increased, while the rate of release was significantly ($p<0.05$) decreased for ewes fed MSC levels. The highest digestibility values were observed for the group fed MSC at a level of 2.5%. Daily fat-corrected milk and composition were significantly ($p<0.05$) improved in ewes fed MSC at level 2.5%. However, increasing levels to 5% significantly ($p<0.05$) decrease milk production and composition. **Conclusion:** Moringa seed cake could be included in lactating ewes' diets as a source of protein at a low level (2.5%) to improve milk production performance without any adverse effect.

Key words: Moringa seed cake, nutrient digestibility, blood metabolites, milk and composition, lactating Ossimi ewes, rumen fermentation, livestock production

Citation: Ahmed A. Aboamer, Hossam M. Ebeid, Mahmoud M. Shaaban, Ramadan M.A. Gawad, Mohamed M. Mostafa and Aboelfetoh M. Abdalla, 2020. Effect of feeding moringa seed cake as an alternative protein source in lactating ewe's rations. Int. J. Dairy Sci., 15: 80-87.

Corresponding Author: Hossam M. Ebeid, Department of Dairy Sciences, National Research Centre, 33 El-Bohouth Street, P.O. Box 12622, Dokki, Giza, Egypt
Tel: 20201115726274 Fax: 2023337093

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Moringa tree, (*Moringa oleifera* Lam.) has many potential valuables and properties which make it of great scientific interest. It is a fast-growing, multipurpose tree and characterized by its ability for drought-tolerant. It has a wide range of uses such as food, medicine and animal feed[1,2]. Moringa seed cake, the by-product of oil extraction contains a high level of crude protein (25-60%) that differs according to the extraction method[2-4]. It is commonly used as a natural coagulant for water purification due to its active ingredients that coagulate various undesirable moieties[5]. It is almost free of tannins, saponins, glucosides, alkaloids and inhibitors of trypsin and amylase but contains glucosinolates[6]. Moringa seed protein has a great potential to modify rumen fermentation[7]. It has a high positive charge with an antibacterial activity against both Gram-negative and Gram-positive bacteria[5]. Different *in vitro* studies reported that a significant decrease in protein degradability[8,9]. Salem and Makkar[7] reported that feeding lambs with increasing level of MSC up to 4 g/head/day had positive effects on rumen fermentation, digestion and average of daily gain, however, feeding level above 4 g/day decreased the daily gain of lambs due to the presence of glucosinolates and the high concentration of the active moiety.

However, using of MSC in the diets of dairy animals did not well documented. The aim of this study was to evaluate the impact of inclusion Moringa seeds cake in the diets of lactating Ossimi ewes on nutrients digestibility and blood metabolites and milk production performance.

MATERIALS AND METHODS

This study was carried out from April, 2018 to June, 2018 at the experiments station, Atomic Energy Authority, Inshas, Cairo, Egypt for lactation experiment, while the *in vitro* trials were conducted two months before the *in vivo* study at Dairy Sciences Department, National Research Centre, Egypt.

Moringa seed cake preparation: Moringa seed cake by-product has been got from Moringa Production Unit, National Research Centre, Egypt, after oil extraction using the non-solvent mechanical cold-press method according to the method of Fils[10]. The collected cakes were transported to the Animal Milk Production Lab., at Dairy Sciences Department, National Research Centre, Egypt. Then, the cake was air-dried for one week and ground through a Wiley mill 1 mm screen before use.

Experimental rations: Two MSC levels (2.5 and 5%) were tested as a substitution for cotton seed meal in the concentrate mix. The control diet was consisting of concentrate mix and Egyptian clover hay (50:50). Concentrate mix was consisting of yellow corn grain, dried olive pulp, cotton seed meal, soybean meal, wheat bran, salt, di-calcium phosphate, mineral mixture, vitamin AD3 and bicarbonate sodium. Ration ingredients and each experimental diet were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE) and ash contents according to AOAC[11]. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed according to Van Soest and Robertson[12]. Cotton seed meal was replaced by MSC at levels 0, 2.5 and 5% for control, MSC2.5 and MSC5 experimental groups, respectively. Experimental rations were formulated to be iso-energetic and iso-nitrogenous.

***In vitro* batch culture:** Batch culture system was used to evaluate the effect of MSC levels on *in vitro* true dry matter and fiber fractions digestibility. Rumen fluid was collected from 3 ruminally cannulated sheep (mean weight 51±0.5 kg). Before the morning feeding, rumen liquor was collected, squeezed through 4-layers of cheesecloth into a Schott Duran® bottle (L) with an O_2-free headspace and immediately transported to the laboratory at 39°C where it was used as a source of inoculum. A mixture of tested ration in the ratio of 50:50 was used as a substrate. Each treatment was tested in 6 replicates accompanied by blank vessels (no substrate). A 400 mg of the milled substrate was added to the incubation vessels of 100 mL capacity. Each vessel was filled with 40 mL of the incubation medium consists of rumen inoculum: buffer in the 1:2 (v/v). Buffer was prepared according to Goering and Van Soest[13] procedure. After 24 h of incubation at 39°C, residuals were transferred into ANKOM bags for future NDF analysis[12]. Rumen pH was measured using pH-meter electrode. Residuals were dried at 70°C and analyzed. IVTDMD was calculated by ANKOM[14] as follows:

$$\text{IVTDMD} = \left[100 - \frac{(W_3 - (W_1 \times C_1))}{(W_2 \times DM)} \times 100\right]$$

where, W_1 is the bag tare weight, W_2 is the sample weight, W_3 is the final bag weight after *in vitro* and sequential NFD treatment, C_1 is the blank bag correction (final oven-dried weight/original blank bag weight).

***In vitro* gas production technique:** The Menke and Steingass[15] *in vitro* gas production technique was used to determine the amount and kinetics of gas production. About 200 mg of each ration was inserted into three glass syringes (100 mL). Each syringe was filled with 30 mL of the incubation medium consists of rumen inoculum: buffer in the 1:2 (v/v). Buffer was prepared according to Goering and Van Soest[13] procedure. The volume of gas recorded during incubation at 3, 6, 12 and 24 h of incubation. Data from gas production was fitted according to Orskov and McDonald[16] by the following model:

$$Y = a+b\ (1-e^{-ct})$$

where, Y is the volume of gas produced with time (t), c is the gas production rate, b is the potential extent of gas production.

Lactation study: The *in vivo* study was carried out at the experiments station, Atomic Energy Authority, Inshas, Cairo, Egypt. Analysis for feed, feces and milk samples was undertaken at Animal Milk Production Lab., Dairy Sciences Department, National Research Centre, Egypt. Twenty one of lactating Ossimi ewes (about 3 years old and weighing on average (51±0.5 kg) after 15 days of parturition were randomly assigned into three groups (seven each) using complete random design. Ewes fed the experimental diets 15 days before parturition and 60 days during lactation. Ewes were fed dry matter according to 4% of their body weight twice daily at 8.00 and 15.00, water was offered freely. Total tract apparent digestibility of OM, CP, EE, NDF and ADF were determined by total fecal collection. The total of feces excreted from 3 ewes of each group was manually collected, during three continuous collection periods of eight hours, on days 43-45 of the period. Fecal composite samples were oven-dried at 55°C for 48 h and the 100°C , ground in Wiley mill to pass a 1 mm sieve and thereafter subjected to chemical analysis for CP, EE, NDF and ADF and ash contents were determined as previously described. The acid-insoluble ash (AIA) technique[17] was used as an internal marker for nutrient digestibility calculation as suggested by Sales and Janssens[18].

Blood samples were withdrawn from the coccygeal vein of 3 ewes of each group on the final day of the experiment period to determine some biochemical analyses (plasma urea nitrogen, total protein, albumin, glucose, cholesterol, triglyceride, alanine aminotransferase (ALT) and aspartate aminotransferase (AST) concentrations). Samples were obtained immediately after 3 h of the morning feeding meal. Blood samples were collected in tubes containing EDITA as anti-coagulant agent then were centrifuged at 4000×g for 15 min and the obtained plasma was frozen at -20°C until analysis. The blood plasma parameters were determined by T80 UV/VIS Spectrometer, PG Instruments Ltd, UK) according to the standard protocols of the suppliers (brochures) and using a commercial kit (Biodiagnostic Co. for Diagnostic and Research Reagents; Dokki, Giza, Egypt).

The lactating ewes were milked twice a day at 09.00 am and 17.00 pm every 2 weeks of experimental period. Milk samples were immediately collected from each animal after morning and evening milking and milk yield was recorded. Milk samples were analyzed for total solids, fat, total protein and lactose by Bentley150 infrared milk analyzer (Bentley Instruments, Chaska, MN, USA). Solids-not-fat (SNF) was calculated by subtracting fat from total solids percentage. Fat corrected milk (4% fat) was calculated by using the following[19] Eq. 1:

$$FCM = 0.4\ M+15\ F \quad (1)$$

where, M is the milk yield (g) and F is the fat yield (g).

Statistical analysis: Data from the *in vitro* and *in vivo* experiments were subjected to analysis of variance using the GLM procedure of SAS[20] (version 9.4) according to the model:

$$Y_{ij} = \mu+T_i+e_{ij}$$

where, Y_{ij} is the parameter under analysis of the ij ewes of lactation trails, μ is the overall mean, T_i is the effect due to treatment on the parameter under the analysis, e_{ij} is the experimental error for ij on the observation. Duncan's multiple range test was used to test the significance among means[21] which considered to be significant when $p<0.05$.

RESULTS AND DISCUSSION

Feed ingredients and ration composition: As shown in Table 1, MSC contains a little bit less crude protein content as compared to the cotton seed meal. However, the content of lipids is remarkably high (141.2 vs. 87.3). Moreover, cotton seed meal had higher NDF content than MSC. Nutrients contents remain after oil extraction differs according to the extraction method[2,3]. Also, differences between results are probably due to difference in varieties, plant phenology and/or plant production system. Lignin content increases with increasing seed age and therefore the greater lignin content and reduced protein content of the moringa seeds in the

Table 1: Chemical composition of ration ingredients (g kg^{-} DM)

Feed stuff	DM	Ash	CP	NDF	ADF	OM	EE
Clover hay	926.0	90.6	147.8	445.3	311.8	835.4	27.9
Corn	901.9	12.8	72.8	376.5	37.4	889.1	47.4
Olive pulp dry	895.5	49.4	69.0	683.5	690.7	846.1	116.1
Cottonseed meal	927.0	49.8	244.7	527.1	337.3	877.2	87.3
Moringa seed cake	942.2	71.8	236.0	460.3	349.5	870.4	141.2
Soybean	928.7	64.4	436.6	216.7	86.2	864.3	10.9
Wheat bran	918.4	45.6	150.6	407.8	121.7	872.8	36.7

DM: Dry matter, CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, OM: Organic matter, EE: Ether extract

Table 2: Ration ingredients and chemical composition

	Treatments		
Items	Control	MSC 2.5%	MSC 5%
Ingredients (g kg^{-1}) DM			
Egyptian clover	500.0	500.0	500.0
Yellow corn	177.5	177.5	177.5
Olive pulp dry	75.0	75.0	75.0
Cottonseed meal	115.0	102.5	90.0
Moringa cake	-	12.5	25.0
Soybean meal	20.0	20.0	20.0
Wheat bran	100.0	100.0	100.0
Salt	5.0	5.0	5.0
Di-calcium phosphate	5.0	5.0	5.0
Mineral mixture	1.5	1.5	1.5
Vitamin AD3	0.5	0.5	0.5
Bicarbonate sodium	0.5	0.5	0.5
Chemical composition (g kg^{-1}) DM			
Organic matter	844.4	844.3	844.2
Crude protein	143.9	143.8	143.7
Ether extract	45.0	45.7	46.3
NDF	446.5	445.6	444.8
ADF	267.0	267.2	267.3
Ash	74.1	74.4	74.7

NDF: Neutral detergent fiber, ADF: Acid detergent fiber, MSC: Moringa seed cake

Table 3: Degradability of DM and CP and rumen parameters of moringa seed cake *in vitro*

	Treatments				
Items	Control	MSC 2.5%	MSC 5%	SEM	p-value
TGP, mL/200 mg DM	35.90^{a}	40.45^{b}	45.67^{c}	1.71	<0.01
b (%)	37.95^{a}	50.30^{b}	54.70^{b}	3.07	0.02
c (% h^{-1})	0.1115^{b}	0.0650^{a}	0.0763^{a}	0.01	0.05
IVTDMD (%)	64.77	66.10	65.38	0.78	0.22
NDFD (%)	22.01	25.04	23.09	1.73	0.23
ADFD (%)	24.36	24.92	22.81	1.69	0.52
pH	7.17^{b}	7.14^{b}	7.01^{a}	0.05	0.01

MSC: Moringa seed cake, TGP: Total gas production, b: The potential extent of gas production, c: Gas production rate, IVTDMD: *In vitro* true dry matter digestibility, NDFD: Neutral detergent fiber digestibility, ADFD: Acid detergent fiber digestibility, $^{a-c}$within a row, means without a common lowercase superscript differ (p<0.05)

present experiment suggested that the seeds used were more mature than those used in other research[22]. The MSC used in the present study had a lower OM and CP, but had a greater NDF and ADF content than those reported by Olivares-Palma *et al.*[23], who used pressed Moringa oil seed cake compared to the present work. As shown in Table 2, the chemical compositions of the rations did not significantly affect MSC substitution.

Rumen fermentation: Table 3 represents the rumen degradability of DM and fiber fractions (NDF, ADF). Data show that, MSC had no significant effect on *in vitro* rumen digestibility. However, MSC 2.5 had numerically higher values for DM, NDF and ADF digestibility. Total accumulated gas production has been increased (p<0.05) as increasing MSC levels (Table 3), while the rate of gas accumulation was significantly (p<0.05) decreased in diets contains MSC as compared to control diet. Rumen pH was slightly decreased in the higher level of MSC substitution (MSC5) (p<0.05). However, there is no significant difference between MSC 2.5 and the control diet. The antimicrobial activity of high positive charge protein in MSC that has antimicrobial activity has a potential impact in modifying the ruminal fermentation, leading to decrease ruminal protein degradability that could enhance the post ruminal protein supply[5,7-9]. Feeding of MSC at high level led to increase the concentration of the active moiety (cationic proteins) in the feed that might have negative impact on rumen fermentation than if it is in optimal concentration[7]. Negative linear relationship between IVDMD and MSC levels had been reported by Olivares-Palma *et al.*[23]. Considering the kinetic of gas production, inclusion of MSC lead to a significant increase in the total gas production (GP_{24}) and potential extend of gas production. However, the rate of gas release was significantly lower compared with the control diet (p<0.05). The amount of gas produced is as a result of fermentation and the indirect gas produced from the buffering of short chain fatty acids (SCFA) produced during fermentation. Only substrate fermented to acetate and butyrate produced gas. Propionate yields gas only from buffering of the acid[2,24] reported that rumen parameters (pH, ammonia and total volatile fatty acids) were not affected by MSC. Therefore, the observed differences in the kinetics of gas production might be due to a change in the molar proportion of different SCFA produced.

Table 4: Nutrient digestibility of lactating ewes in the experimental groups

	Treatments				
Items	Control	MSC 2.5%	MSC 5%	SEM	p-value
OMD	59.95	64.46	61.08	1.144	0.286
CPD	66.01	69.55	67.31	0.837	0.234
EED	77.29	80.73	75.34	1.540	0.477
NDFD	50.29	57.83	54.43	1.502	0.106
ADFD	55.34	55.17	51.71	1.736	0.051

MSC: Moringa seed cake, OMD: Organic matter digestibility, CPD: Crude protein digestibility, EED: Ether extract digestibility, NDFD: Neutral detergent fiber digestibility, ADFD: Acid detergent fiber digestibility

Table 5: Blood metabolites of lactating ewes in the experimental groups

	Treatments				
Items	Control	MSC 2.5%	MSC 5%	SEM	p-value
Protein (g dL^{-1})	5.94	6.37	6.05	0.44	0.2986
Albumin (g dL^{-1})	4.57	4.00	4.38	0.09	0.0741
Urea (mg dL^{-1})	55.16^{b}	49.77^{ab}	47.81^{a}	16.87	0.0530
Glucose (mg dL^{-1})	50.07^{b}	53.48^{a}	53.45^{a}	21.14	0.0727
Cholesterol (mg dL^{-1})	87.43	77.07	77.15	29.92	0.4792
Triglyceride (mg dL^{-1})	41.29	40.51	38.09	50.71	0.8201
ALT (U mL^{-1})	24.12	24.69	23.44	0.55	0.790
AST (U mL^{-1})	24.1	26.67	22.23	0.90	0.788

ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, MSC: Moringa seed cake, ^{a,b}Within a row, means without a common lowercase superscript differ ($p<0.05$)

Table 6: Milk yield, fat corrected milk and milk composition in lactating ewes fed experimental rations

	Treatments				
Items	Control	MSC 2.5%	MSC 5%	SEM	p-value
Average milk yield (g/day)	412.10	502.50	465.40	0.028	0.180
Average FCM (g)	321.10^{b}	455.30^{a}	370.20^{ab}	0.023	0.010
Chemical composition (%)					
Fat	6.63^{b}	7.39^{a}	6.81^{b}	0.34	0.0001
Protein	4.49^{b}	4.92^{a}	4.54^{b}	0.16	0.0019
Lactose	4.06^{b}	5.31^{a}	4.51^{ab}	0.91	<0.0001
SNF	12.14^{b}	13.50^{a}	12.48^{b}	1.16	0.0002
Ash	0.95^{b}	1.05^{a}	0.97^{b}	0.01	0.0004
Milk yield composition (g/day)					
Fat	27.42^{b}	37.83^{a}	31.51^{b}	0.94	0.002
Protein	18.93^{b}	25.18^{a}	21.05^{ab}	0.65	0.0331
Lactose	16.83^{b}	26.90^{a}	20.50^{ab}	0.15	0.0173
SNF	51.00^{b}	69.24^{a}	57.84^{ab}	0.52	0.0188

FCM: Fat corrected milk, SNF: Solid-non-fat, MSC: Moringa seed cake, $^{a-c}$Within a row, means without a common lowercase superscript differ ($p<0.05$)

Digestibility coefficients: Nutrient digestibility were calculated to estimate the nutritive value of MSC based on chemical composition for feeding and feces. Table 4 summarizes data for digestibility coefficients of the components for OM, CP, EE, NDF and ADF. Organic matter, CP and EE digestibility are numerical high with both of MSC levels vs. control. However, MSC2.5 had the numerical highest values. The NDFD was insignificantly higher with 2.5 and 5% MC levels by 7.54 and 4.14%, respectively vs. control. While, MSC at level of 5% decreased ADF digestibility ($p = 0.051$).

The results are in agreement with those reported by El-Naggar *et al.*[2], they found a significant improvement in all nutrient digestibility (DM, OM, CP, EE and CF) and average daily gain of lambs fed ration with a partial substitution of soybean meal protein by (0, 25 and 50% MSC). The improvement of nutrients digestibility are a reflection for positive nitrogen balance and the reduction in urinary nitrogen output[7] which lead to increase the nitrogen retention and reflected on sheep gain. The positive effect of MSC on nutrients digestibility could be due to the antimicrobial effect of MSC protein on fuses the inner and outer membranes bacteria and decreasing the degradability of feed proteins in rumen and increase the post ruminal protein supply[5,8,9,25]. The ruminal degradability of MSC protein was about 61% as mentioned by Krishnamoorthy *et al.*[26].

Blood metabolites: Blood metabolites are frequently used to scan for metabolic health status in dairy herds[27]. In the current study, values of total protein, albumin, cholesterol, triglyceride, enzyme activities of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were insignificantly altered by MSC replacement (Table 5). A significant reduction ($p = 0.05$) was found for urea blood concentration in ewes fed MSC 2.5, compared to the control group. However, glucose blood was ($p = 0.07$) increased with MSC levels. Lipids derivatives such as cholesterol and triglyceride were not affected by MSC replacement in rations. Results show that, MSC substitution had no adverse effect on blood metabolites and they were in the normal range. No data are available on the effect of MSC in blood metabolites. Bruno *et al.*[28] suggested that reduced urea nitrogen in the plasma indicates an improvement in protein utilization. Decreasing *in vitro* ruminal degradable protein could result in a reduction in ammonia release in the rumen and blood urea level.

Bijina *et al.*[29] and Kumari[30] reported that *Moringa oleifera* supplementation decreased fat metabolism derivatives (total cholesterol and triglycerides) compared to the control group. These studies report consistent with the present results.

Milk yield and composition: As shown in Table 6, ewes fed MSC 2.5 had ($p<0.05$) higher FCM, milk fat, protein, lactose, SNF and ash percentages compared to control group. However, the average milk yield was no significantly differed among groups. There is no previous studies available for the effect of MSC substitution on milk production. Previous researches are focused on the effects of using Moringa leaves as fresh forage, dried foliage and/or concentrate form or ensilage as supplement or substitute[31-34] or evaluated it by in Sacco method with Holstein cows[35]. Studies with dairy cows

reported an improvement in daily milk yield as a response to feeding dried or fresh leaves and soft twigs of Moringa leaves supplement[31,32]. Previous study using lactating goats showed an increase in milk yield in response to feeding Moringa leaves as a sesame or concentrate replacer[33].

The improvement in milk production might be due to the improvement in nutrients digestibility and feed efficiency[36]. Brisibe *et al.*[37] reported that inclusion of Moringa in dairy rations resulted in a high rate of digestibility in the rumen increasing the availability of energy results and milk production. Moreover, the observed improvement in milk fat could be due to the potential effect of MSC on the molar proportion of SCFA produced in the rumen. On the production side, the Moringa seed has been reported that amino acids content[6,38] that are combine to form proteins. Rumen microbes synthesize the essential amino acids from other amino acids or from nitrogen containing substances. The efficiency of rumen microbial growth and activity in the rumen is enhanced by the presence of adequate amino acids, peptides and most macro and micro minerals[39]. Another explanation, Moringa tree (leaves, pods and seeds) has rich essential phytochemicals and phytosterols such as stigmasterol, sitosterol and kampesterol which is a precursor for hormones required for reproductive growth as well as synthesis lactogogue. These compounds increase the estrogen hormone production, then in turn stimulates the proliferation of the mammary gland ducts to produce milk[40]. Moreover, Moringa is rich provide vitamin C, vitamin A and calcium which is very important for dairy animals and help to feed metabolism as well as produced milk rich in their contents. Conclusively, the overall effect of moringa seed cake as an alternative protein source in lactating ewes diets on degradability and mediated rumen fermentation kinetics in a desirable fashion leading to enhance feed degradability, while increasing milk production that is beneficial for both breeder and environment. Moreover, careful selection of levels of MSC depending on the diet of animals may help to improve the efficiency of rumen microbial fermentation, feed degradability and utilization. However, further *in vivo* studies are wanted to establish the efficacy of Moringa seed cake in ruminants.

CONCLUSION

Moringa seed cake could be used as protein source in lactating Ossimi ewe's rations up to 2.5% to improve milk production without any adverse effect on blood metabolites. More studies were needed to evaluate the effect of Moringa seed cake at different level of substitution on the molar proportion of short chain fatty acids produced during fermentation.

ACKNOWLEDGMENT

This research was supported by a National Research Center, Egypt, in accordance with the Research Project ID Number: 11090125.

SIGNIFICANCE STATEMENT

This study discovers the potential of using Moringa seed cake as an alternative protein source in the diets of lactating ewes, which can be beneficial for improving milk production performance. This study will help the researcher to uncover the critical area of the level of feeding moringa seed cake to lactating ewes that many researchers were not able to explore. Thus, a new theory on the impact of feeding Moringa seed cake on nutrient digestibility and milk production performance may be arrived at.

REFERENCES

1. Yisehak, K., M. Solomon and M. Tadelle, 2011. Contribution of moringa (*Moringa stenopetala*, Bac.), a highly nutritious vegetable tree, for food security in South Ethiopia: A review. Asian J. Applied Sci., 4: 477-488.
2. El-Naggar, S.I., G.A.E. Abou-Ward, M.A.E. Tawila, S.M. Gad and A.M. Ali, 2017. Impact of incorporating *Moringa oleifera* seed cake as protein source in growing lambs ration. Agric. Eng. Int.: CIGR J., 19: 289-292.
3. Fuglie, L.J., 2001. The Miracle Tree: The Multiple Attributes of Moringa. CTA Publications, Wageningen, The Netherlands, Pages: 172.
4. Folkard, G. and J. Sutherland, 1996. *Moringa oleifera*: A tree and a litany of potential. Agrofor. Today, 8: 5-8.
5. Folkard, G., J. Sutherland and R.S. Al-Khalili, 2001. Water Clarification Using *Moringa oleifera* Seed Coagulant. In: The Miracle Tree: The Multiple Attributes of Moringa, Fuglie, L.J. (Ed.). CTA Publication, Wageningen, The Netherlands, pp: 77-81.
6. Makkar, H.P.S. and K. Becker, 1997. Nutrients and antiquality factors in different morphological parts of the *Moringa oleifera* tree. J. Agric. Sci., 128: 311-322.
7. Salem, H.B. and H.P.S. Makkar, 2009. Defatted *Moringa oleifera* seed meal as a feed additive for sheep. Anim. Feed Sci. Technol., 150: 27-33.
8. Hoffmann, E.M., S. Muetzel and K. Becker, 2003. Effects of *Moringa oleifera* seed extract on rumen fermentation *in vitro*. Arch. Anim. Nutr., 57: 65-81.
9. Makkar, H.P.S., G. Francis and K. Becker, 2007. Bioactivity of phytochemicals in some lesser-known plants and their effects and potential applications in livestock and aquaculture production systems. Animal, 1: 1371-1391.

10. Fils, J.M., 2000. The Production of Oils. In: Edible Oil Processing, Hamm, W. and R.J. Hamilton (Eds.). Sheffield Academic Press, England, UK.
11. AOAC., 1995. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists, Washington, DC., USA., Pages: 1094.
12. Van Soest, P.J. and J.B. Robertson, 1980. Systems of Analysis for Evaluating Fibrous Feeds. In: Standardization of Analytical Methodology for Feeds, Pigden, W.G., C.C. Balch and M. Graham (Eds.). International Development Research Centre, Ottawa, ON., Canada, ISBN-13: 9780889362178, pp: 49-60.
13. Goering, H.K. and P.J. Van Soet, 1970. Forage fiber analyses (apparatus, reagents, procedures and some applications). Agriculture Handbook No. 379, ARS-USDA, Washington, DC., USA., pp: 1-20. http://naldc.nal.usda.gov/download/CAT87209099/PDF
14. ANKOM Technology, 2010. Instrument and procedure manuals. ANKOM Technology, Macedon, NY., USA.
15. Menke, K.H. and H. Steingass, 1988. Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. Anim. Res. Dev., 28: 7-55.
16. Orskov, E.R. and I. McDonald, 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. J. Agric. Sci., 92: 499-503.
17. Van Keulen, J. and B.A. Young, 1977. Evaluation of acid-insoluble ash as a natural marker in ruminant digestibility studies. J. Anim. Sci., 44: 282-287.
18. Sales, J. and G.P.J. Janssens, 2003. Acid-insoluble ash as a marker in digestibility studies: A review. J. Anim. Feed Sci., 12: 383-400.
19. Gaines, W.L., 1928. The energy basis of measuring energy milk in dairy cows. Bulletin No. 308, University of Illinois Agricultural Experiment Station, Urbana, IL., USA.
20. SAS., 2015. SAS User's Guide: Statistics. Version 9.4, SAS Institute Inc., Cary, NC., USA.
21. Duncan, D.B., 1955. Multiple range and multiple F tests. Biometrics, 11: 1-42.
22. Jung, H.G. and M.S. Allen, 1995. Characteristics of plant cell walls affecting intake and digestibility of forages by ruminants. J. Anim. Sci., 73: 2774-2790.
23. Olivares-Palma, S.M., S.J. Meale, L.G.R. Pereira, F.S. Machado and H. Carneiro *et al*., 2013. *in vitro* fermentation, digestion kinetics and methane production of oilseed press cakes from biodiesel production. Asian-Australas. J. Anim. Sci., 26: 1102-1110.
24. Makkar, H.P.S., 2004. Recent Advances in the *in vitro* Gas Method for Evaluation of Nutritional Quality of Feed Resources. In: Assessing Quality and Safety of Animal Feeds, Jutzi, S. (Ed.). FAO Animal Production and Health Paper No. 160, Food and Agriculture Organization, Rome, Italy, ISBN-13: 9789251050460, pp: 55-88.
25. Shebek, K., A.B. Schantz, I. Sines, K. Lauser, S. Velegol and M. Kumar, 2015. The flocculating cationic polypetide from *Moringa oleifera* seeds damages bacterial cell membranes by causing membrane fusion. Langmuir, 31: 4496-4502.
26. Krishnamoorthy, U., H. Soller, H. Steingass and K.H. Menke, 1995. Energy and protein evaluation of tropical feedstuffs for whole tract and ruminal digestion by chemical analyses and rumen inoculum studies *in vitro*. Anim. Feed Sci. Technol., 52: 177-188.
27. Hansen, H.H., N.E, El-Bordeny and H.M. Ebeid, 2017. Response of primiparous and multiparous buffaloes to yeast culture supplementation during early and mid-lactation. Anim. Nutr., 3: 411-418.
28. Bruno R.G.S., H.M. Rutigliano, R.L. Cerri, P.H. Robinson and J.E.P. Santos, 2009. Effect of feeding *Saccharomyces cerevisiae* on performance of dairy cows during summer heat stress. Anim. Feed Sci. Technol., 150: 175-186.
29. Bijina, B., S. Chellappan, J.G. Krishna, S.M. Basheer, K.K. Elyas, A.H. Bahkali and M. Chandrasekaran, 2011. Protease inhibitor from *Moringa oleifera* with potential for use as therapeutic drug and as seafood preservative. Saudi J. Biol. Sci., 18: 273-281.
30. Kumari, D.J., 2010. Hypoglycaemic effect of *Moringa oleifera* and *Azadirachta indica* in type 2 diabetes mellitus. Bioscan, 5: 211-214.
31. Sanchez, N.R., E. Sporndly and I. Ledin, 2006. Effect of feeding different levels of foliage of *Moringa oleifera* to creole dairy cows on intake, digestibility, milk production and composition. Livest. Sci., 101: 24-31.
32. Mendieta-Araica, B., R. Sporndly, N. Reyes-Sanchez and E. Sporndly, 2011. Moringa (*Moringa oleifera*) leaf meal as a source of protein in locally produced concentrates for dairy cows fed low protein diets in tropical areas. Livest. Sci., 137: 10-17.
33. Sultana, N., A.R. Alimon, K.S. Huque, A.Q. Sazili, H. Yaakub, J. Hossain and M. Baba, 2015. The feeding value of Moringa (*Moringa oleifera*) foliage as replacement to conventional concentrate diet in Bengal goats. Adv. Anim. Vet. Sci., 3: 164-173.
34. Cohen-Zinder, M., H. Leibovich, Y. Vaknin, G. Sagi and A. Shabtay *et al*., 2016. Effect of feeding lactating cows with ensiled mixture of *Moringa oleifera*, wheat hay and molasses, on digestibility and efficiency of milk production. Anim. Feed Sci. Technol., 211: 75-83.
35. Ebeid, H.M., A.E. Kholif, M. Chrenkova and U.Y. Anele, 2019. Ruminal fermentation kinetics of *Moringa oleifera* leaf and seed as protein feeds in dairy cow diets: *In sacco* degradability and protein and fiber fractions assessed by the CNCPS method. Agrofor. Syst., (In Press). 10.1007/s10457-019-00456-7.
36. Aboamer, A.A., M.S.A. Khattab, S.A.H. Abo El-Nor, H.M. Saleh and A.M. Kholif *et al*., 2017. A study of nutrient digestibility, milk production and performance of lactating Barki ewes fed synchronous least cost ration. Int. J. Dairy Sci., 12: 114-121.

37. Brisibe, E.A., U.E. Umoren, F. Brisibe, P.M. Magalhaes and J.F.S. Ferreira *et al*., 2009. Nutritional characterisation and antioxidant capacity of different tissues of *Artemisia annua* L. Food Chem., 115: 1240-1246.
38. Mune, M.A.M., E.C. Nyobe, C.B. Bassogog and S.R. Minka, 2016. A comparison on the nutritional quality of proteins from *Moringa oleifera* leaves and seeds. Cogent Food Agric., Vol. 2, No. 1. 10.1080/23311932.2016.1213618.
39. Swanepoel, N., P.H. Robinson and L.J. Erasmus, 2010. Amino acid needs of lactating dairy cows: Impact of feeding lysine in a ruminally protected form on productivity of lactating dairy cows. Anim. Feed Sci. Technol., 157: 79-94.
40. Mutiara, K.T., Harijono, T. Estiasih and W.E. Sri, 2013. Effect lactagogue moringa leaves (*Moringa oleifera* Lam) powder in rats white female wistar. J. Basic Applied Scient. Res., 3: 430-434.