RESEARCH ARTICLE

Effect of Incorporation of *Moringa oleifera* Meal in Feed on Growth Performance of Crossbred Heifers

Asif N. Sherasiya[1], Pravin M. Lunagariya[2*], Rakesh J. Modi[3], Jigar H. Patel[2], Mahesh M. Chaudhary[2], Kishan N. Wadhwani[2]

Abstract

The experiment was planned to ascertain the effect of incorporation of *Moringa oleifera* meal (MOM) replacing compounded concentrate mixture @ 5% level on the growth, digestibility, and feed conversion in crossbred dairy heifers. A total of fourteen crossbred female calves (75% Holstein Friesian x 25 % Kankrej) of similar body weight and age were selected and randomly blocked in two treatments having seven animals in each. The control TMR (T1) was prepared using compounded concentrate mixture, groundnut straw, hybrid Napier, salt, and mineral mixture @ 50, 23, 25, 1, and 1% on a dry matter basis, respectively. Compounded concentrate mixture was replaced with MOM @ 5% to formulate TMR T2. Body weight (kg), weight gain (kg/day), and height at withers (cm) of calves were non-significantly different between the treatments. The heart circumference (cm) and body length (cm) of crossbred calves were significantly ($p < 0.01$) higher in the T1 group compared to the T2 group. The daily intake on an as-fed and digestible basis of DM, OM, CP, EE, CF, and NFE differed non-significantly between treatments. An intake of digestible DM, OM, CP, and TDN on a metabolic body weight basis (g/kg $W^{0.75}$) was significantly reduced ($p < 0.01$) by MOM incorporation. The requirements of DM, CP, DCP, and TDN to gain each kilogram of live weight were non-significantly ($p > 0.05$) higher in the T2 group (5% MOM) than the T1 control group. *M. oleifera* meal @5% can be used to replace compounded concentrate mixture without significantly affecting growth, intake of nutrients, digestibility of nutrients, and feed conversion ratio of crossbred heifers.

Keyword: Crossbred heifers, Digestibility, Feed conversion efficiency, Feed intake, Growth, *Moringa oleifera* meal.

Ind J Vet Sci and Biotech (2022): 10.21887/ijvsbt.18.2.4

Introduction

The major constraint for dairy production in India is a shortage of quantity and quality of the feeds and fodders round the year, which results in underfeeding of growing livestock and economic losses. This necessitates introducing cheap and easily available unconventional feedstuffs to support livestock development (Oduro *et al*., 2008). *Moringa oleifera* leaves are abundant in protein, amino acids, fatty acids, minerals, vitamins, calcium, potassium, various phenolic and oxy carotenoid (Deshmukh, 2014), and deciduous (Mishra *et al*., 2012). *Moringa* leaves seem to improve rumen microbial protein synthesis due to the considerable contents of quickly fermentable nitrogen and energy (Soliva *et al*., 2005; Worku, 2016). It is considered a substitute for soybean meal and rapeseed meal as a protein source for ruminants (Soliva *et al*., 2005). *Moringa* leaves as a supplement in ruminant diets were found to enhance milk yield and composition as well as minimize oxidative damage of milk and serum of ewes and goats (Babiker *et al*., 2017). Despite considerable interest in *Moringa* as a source of protein for ruminants, elaborate information on the effects on the growth of crossbred growing dairy animals is scanty. Therefore, this experiment was planned to evaluate the effect of incorporation of *M. oleifera* meal in compounded concentrate mixture on growth, digestibility, and feed conversion in crossbred dairy heifers.

[1]Animal Nutrition Research Station, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand-388001, Gujarat, India.

[2]Livestock Research Station, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand-388001, Gujarat, India.

[3]Dept. of Livestock Production Management, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand-388001, Gujarat, India

Corresponding Author: Pravin M. Lunagariya, Livestock Research Station, College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand-388001, Gujarat, India, e-mail: drpravinml@gmail.com

How to cite this article: Sherasiya, A.N., Lunagariya, P.M., Modi, R.J., Patel, J.H., Chaudhary, M.M., & Wadhwani, K.N. (2022). Effect of Incorporation of *Moringa oleifera* Meal in Feed on Growth Performance of Crossbred Heifers. Ind J Vet Sci and Biotech. 18(2), 21-25.

Source of support: Nil

Conflict of interest: None.

Submitted: 20/11/2021 **Accepted:** 23/02/2022 **Published:** 10/04/2022

Materials and Methods

The present study was conducted at Livestock Research Station, Anand Agricultural University, Anand, Gujarat, after obtaining permission from Institutional Animal Ethics Committee (322/LRS/2020). A total of fourteen crossbred

female calves (75% Holstein Friesian x 25% Kankrej) of similar body weight and age were selected and randomly blocked in two treatment groups with seven animals each. The mean body weight (110.14 ± 5.13 and 111.86 ± 7.62 kg) and age (184.43 ± 22.96 and 178.71 ± 24.01 days) of crossbred female calves of treatments T1 and T2 were similar.

PKM 1 variety of *M. oleifera* fodder cultivated in University farm was used in this experiment. It was first harvested at 75 days, and subsequent cuts were made at 60 days intervals. *Moringa* fodder was sun-dried for 3 days on the cemented yard. Whole leaves and ground soft twigs (2 mm sieve) were mixed @ 84 and 16%, respectively, and named as *M. oleifera* meal (MOM). The control TMR (T1) was prepared using Compounded concentrate mixture (CCM), groundnut straw (GNS), Hybrid Napier (HN), Salt and Mineral mixture (MM) @ 50, 23, 25, 1, and 1% on dry matter basis, respectively. Compounded concentrate mixture was replaced with MOM @ 5% to formulate TMR T2. Groundnut straw was ground, and Hybrid Napier was chaffed at 5 mm size to prepare TMR. All ingredients, including salt and mineral mixture, were weighed and thoroughly mixed to prepare TMR on a clean floor daily. TMR was fed to crossbred calves to meet the nutrient requirement as per NRC (2001) standard.

All the experimental calves were housed in a well-ventilated barn and individually fed TMR in the morning (10:00 hrs) and afternoon (15:00 hrs). Feed leftover was collected the next day morning (7:00 hrs) and recorded to arrive at daily feed intake. The calves were let loose for exercise for two hours in the morning under controlled conditions. The clean, fresh drinking water was provided during the loose condition in the morning and also offered at tying place at 14:00 and 18:00 hours. Body weight and measurements, *viz.,* heart girth, height at withers, and body lengths were taken bi-weekly before feeding and watering in the morning. All calves were de-wormed with broad-spectrum anthelmintic before initiation and after 3 months of the experiment. The digestion trial of seven days was conducted after 90 days on all the fourteen crossbred calves. A proper record of feed offered, leftover, and feces voided by each heifer were maintained during the entire digestion trial period on 24 hrs basis at 8:00 hours in the morning. Ingredients used, TMR, leftover, and feces were analyzed for proximate principles and fiber fractions as per AOAC (1995) and Van Soest *et al*. (1991), respectively. TMRs samples and MOM were analyzed six times during the experiment.

The cost of feeding was worked out based on daily intake and purchase price of all ingredients, except for Hybrid Napier and MOM, which were taken at University sale price and cultivation cost, respectively. The costs of CCM, MOM, GNS, HN, MM, salt, T1, and T2 calculated were 27.00, 13.92, 8.50, 2.00, 120.00, 3.00, 17.19, and 16.53 Rs/kg, respectively. Experimental data generated using a completely randomized design was analyzed as per Snedecor and Cochran (1994).

Results and Discussion

Composition of Feed, Fodders, and Total Mixed Ration-TMR

Mean proximate composition and fiber fractions of feeds, fodders, and TMR are presented in Table 1. Both the TMRs were similar in proximate and fiber fraction composition. Similarly, 3, 6, and 9% incorporation of *Moringa oleifera* in TMR of lactating Holstein dairy cows was similar in CP, EE, Ash, NDF, and ADF content to control TMR (Dong *et al.,* 2019). *Moringa oleifera* Meal-MOM contained 24.97% crude protein, 28.78% NDF, and 21.52% ADF on a dry matter basis. Dey *et al*. (2014) reported comparable crude protein (26.34 ± 0.67%) in Moringa leaves. However, Nouala *et al*. (2006) reported slightly lower CP (23.27%), NDF (18.74%), and ADF (16.07%) in *Moringa oleifera* leaves. Seradja *et al*. (2019) also reported lower crude protein as 20.1, 21.0, and 20.4% of DM in Moringa forage consisted of leaves, twigs and new buds harvested at 30, 40 and 50 days after pruning. This variation may be due to different agro-climatic zone and the variety of Moringa.

Dry Matter and Nutrients Intake of Crossbred Heifers

The feed and nutrient intake of calves raised on TMR without and with 5% MOM are presented in Table 2. The daily intake of DM, OM, and CP on percent and metabolic body weight basis, except CP (g/kg $W^{0.75}$), was statistically not influenced ($p > 0.05$) by 5% incorporation of *Moringa oleifera* meal replacing compounded concentrate mixture

Table 1: Proximate and fiber fractions of feeds, fodders, and TMR (%DM basis)

Ingredient	*CCM*	*HN*	*GNS*	*MOM*	*T1*	*T2*
OM	92.66	89.52	86.03	86.66 ± 0.55	86.27 ± 0.69	86.59 ± 0.58
CP	25.48	7.60	10.29	24.97 ± 0.08	18.80 ± 0.18	18.49 ± 0.22
EE	4.27	2.44	2.12	4.04 ± 0.03	3.66 ± 0.05	3.75 ± 0.07
CF	16.57	34.43	33.04	12.29 ± 0.23	19.57 ± 0.08	19.22 ± 0.14
NDF	39.80	68.08	60.68	28.78 ± 0.25	53.22 ± 0.36	53.18 ± 0.12
ADF	28.32	52.87	52.88	21.52 ± 0.23	36.41 ± 0.86	36.89 ± 0.98
NFE	46.34	45.05	40.58	45.36 ± 0.66	44.24 ± 0.48	45.13 ± 0.28
Ash	7.34	10.48	13.97	13.34 ± 0.21	13.73 ± 0.12	13.41 ± 0.14

CCM = Compound Concentrate Mixture, HN = Hybrid Napier, GNS= Ground Nut Straw, and MOM = *Moringa oleifera* Meal.

in a ration of crossbred heifers. Similar to our findings, a non-significant ($p > 0.05$) effect on dry matter and nutrients intake was reported on supplementation of *Moringa oleifera* @ 3% and 6% in a ration of Holstein dairy cows (Dong *et al*., 2019), micro-supplementation @30, and 60 g/day to lactating Jersey cows (Kekana *et al*., 2019), and 5, 10 and 15% *Moringa* supplementation via Urea Molasses Multi-nutrient *Moringa* Block (UM3B) in Bali cattle (Malik *et al*., 2019). Shankhpal *et al*. (2019) also reported a non-significant ($p > 0.05$) effect on dry matter intake on feeding 15.0 kg *Moringa* green fodder replacing 15.0 kg green hybrid Napier grass in a ration of crossbred cows. In contrast, to present findings, Aharwal *et al.* (2018) and Elaidy *et al*. (2017) reported an increase in dry matter and nutrient intake by replacement up to 15% with *Moringa oleifera* leaf meal in the calf starter fed to buffalo calves.

Growth Performance of Crossbred Heifers

The growth performance of crossbred calves on TMR without and with 5% MOM is presented in Table 2. Bodyweight (kg), weight gain (kg/day), and height at withers (cm) of calves differed non-significantly between treatments. The heart girth (cm) and body length (cm) of calves were significantly ($p < 0.01$) higher with the T1 ration compared to the T2 ration. Numerically higher bodyweight (kg) and weight gain (kg/day) was observed in the T1 (174.29 ± 4.81; 0.951 ± 0.029) group compared to T2 (172.86 ± 5.49; 0.890±0.031) group of calves. Similar to our findings, Kekana *et al*. (2019) reported a non-significant influence on the body weight of lactating Jersey cows by micro-supplementation (30 and 60 g/cow/day) of *Moringa oleifera* leaf meal. In contrast, to the present finding, Aharwal *et al*. (2018) and Aharwal *et al*. (2019) reported improved body weight gain of Murrah buffalo calves fed concentrate mixture replaced with *Moringa oleifera* leaf meal @ 5, 10, and 15% level. Elaidy *et al*. (2017) also noticed significantly ($p < 0.05$) higher mean daily weight gain (kg/day) of buffalo calves fed calf starter with 5, 10, and 15% dry *Moringa oleifera* leaves-DMOL than control ration without or high (20%) DMOL.

Table 2: Nutrients intake and growth performance of crossbred heifers fed TMR without and with 5% MOM

Intake	*T1*	*T2*
Nutrient intake		
DMI (kg)	4.72 ± 0.11	4.68 ± 0.13
OMI (kg)	4.07 ± 0.10	4.05 ± 0.12
CPI (kg)	0.887 ± 0.022	0.866 ± 0.025
EEI (kg)	0.173 ± 0.004	0.176 ± 0.005
CFI (kg)	0.923 ± 0.023	0.900 ± 0.026
NFEI (kg)	2.09 ± 0.05	2.11 ± 0.06
DMI (% BW)	2.72 ± 0.01	2.73 ± 0.02
OMI (% BW)	2.35 ± 0.01	2.36 ± 0.02
CPI (% BW)	0.512 ± 0.002	0.504 ± 0.003
DMI (g/kg $W^{0.75}$)	98.28 ± 0.53	98.11 ± 0.72
OMI (g/kg $W^{0.75}$)	84.79 ± 0.46	84.95 ± 0.63
CPI(g/kg $W^{0.75}$)	18.48 ± 0.10	18.14 ± 0.13
Growth Performance		
Initial body weight (kg)	110.14	111.86
Final body weight (kg)	230.00	224.01
Total gain in body weight (kg)	119.86	112.15
Mean body weight (kg)	174.29 ± 4.81	172.86 ± 5.49
Weight gain (kg/day)	0.951 ± 0.029	0.890 ± 0.031
Heart girth (cm)	123.49^{A} ± 0.76	120.49^{B} ± 0.98
Body length (cm)	119.49^{A} ± 0.98	116.54^{B} ± 1.02
Height at withers (cm)	109.63 ± 0.73	108.75 ± 0.76

Mean with different superscripts (A, B) in row differ significantly ($p < 0.01$)

Digestibility of Nutrients and Intake of Digestible Nutrients

The digestibility coefficients of DM and other nutrients of TMR T1 and T2 are presented in Table 3. The digestibility coefficients of dry matter and nutrients like organic matter, crude protein, ether extract, nitrogen-free extract, crude fiber, neutral detergent fiber, and acid detergent fiber were statistically similar between the treatments with a numerical reduction in digestibility of T2 ration. Similar to our results, the crude fiber digestibility of ration in Bali cattle was non-

Table 3: Digestibility of nutrients and digestible nutrients intake of total mixed rations fed to crossbred heifer-calves

Parameter	*T1*	*T2*
Digestibility (%)		
DMD	54.63 ± 0.67	53.78 ± 0.84
OMD	61.58 ± 0.52	60.71 ± 1.40
CPD	70.44 ± 0.99	70.53 ± 0.78
EED	76.39 ± 0.47	75.03 ± 0.68
NFED	60.98 ± 0.89	60.31 ± 2.02
CFD	51.43 ± 0.58	49.43 ± 1.40
NDFD	55.44 ± 0.54	53.47 ± 1.22
ADFD	48.95 ± 0.67	47.09 ± 1.48
Intake of digestible nutrients		
DDMI (kg/day)	2.58 ± 0.07	2.52 ± 0.07
DOMI (kg/day)	2.51 ± 0.06	2.46 ± 0.07
DCPI (kg/day)	0.625 ± 0.016	0.611 ± 0.018
DEEI (kg/day)	0.132 ± 0.003	0.132 ± 0.004
TDNI (kg/day)	2.67±0.07	2.63±0.08
DDMI (g/kg $W^{0.75}$)	53.69^{A} ± 0.29	52.76^{B} ± 0.39
DOMI (g/kg $W^{0.75}$)	52.20^{A} ± 0.28	51.57^{B} ± 0.38
DCPI (g/kg $W^{0.75}$)	13.01^{A} ± 0.07	12.79^{B} ± 0.10
DEEI (g/kg $W^{0.75}$)	2.75 ± 0.01	2.76 ± 0.02
TDNI (g/kg $W^{0.75}$)	55.60^{A} ± 0.30	55.02^{B} ± 0.41

Mean with different superscripts (A, B) in row differ significantly ($p < 0.01$)

Table 4: Feed conversion ratio and feeding cost of crossbred heifers fed TMR without or with 5% MOM

Parameters	*T1*	*T2*
FCR		
kg DMI/kg gain	5.19 ± 0.18	5.62 ± 0.22
kg CPI/kg gain	0.976 ± 0.034	1.040 ± 0.042
kg DCPI/kg gain	0.687 ± 0.024	0.734 ± 0.030
kg TDNI/kg gain	2.96 ± 0.10	3.17 ± 0.13
Feeding cost		
Daily feed cost (Rs/day)	162.49^{a} ± 3.25	156.04^{b} ± 3.61
Feed cost/ kg gain (Rs/kg)	183.56 ± 3.58	187.92 ± 3.22
Total feed cost (Rs.)	20473.98 ± 458.33	19661.44 ± 921.80

Mean with different superscripts (a, b) in row differ significantly ($p < 0.05$)

significant ($p > 0.05$) on feeding Urea Mineral Molasses having 5, 10 and 15% *Moringa* meal (Malik *et al*., 2019). The CP and ADF digestibility of diet fed to Holstein dairy cows were non-significantly ($p > 0.05$) different in none, low or high replaced fodder silage with Moringa fodder silage, but the digestibility of DM and NDF was lower ($P < 0.05$) when high *Moringa oleifera* silage group (50% alfalfa hay and 100% maize silage were replaced by MO silage on DM basis) than without or low *Moringa oleifera* silage fodder (25% alfalfa hay and 50% maize silage replaced by MO silage on DM basis) group (Zeng *et al*., 2018). In these studies, Moringa was either incorporated in UMMB or fodder silage was replaced with Moringa. In contrast to our results, significantly higher digestibility of dry matter and nutrients like CP, EE and NFE as well as fibre portions like crude fiber, NDF and ADF was reported by Khalel *et al*. (2014) in Friesian cows, Imran *et al*. (2016) in lactating Nili Ravi buffaloes, Sanchez *et al*. (2005) in Creole dairy cows and Mendieta-Araica *et al*. (2011) in Brown Swiss dairy cows. Unlike other research works, in the present study, instead of fodder component, concentrate feed with high nutritive value was replaced with Moringa in the TMR of crossbred heifers, and hence a non-significant difference in the digestibility of nutrients, except crude protein, could be observed. Numerically improved CP digestibility, without significant reduction in digestibility of all other components of ration might be due to higher content of bio-available limiting amino acids like lysine and methionine (Henuk, 2018).

The intake of digestible DM, OM, CP, and TDN on metabolic body weight basis was significantly lower ($P < 0.01$) in heifers fed TMR with 5% MOM as compared to control. Similar to our findings, Aharwal *et al*. (2018) and Elaidy *et al*. (2017) reported an increase in dry matter and nutrient intake by replacement up to 15% with *Moringa oleifera* leaf meal in the calf starter fed to buffalo calves.

Feed Conversion Ratio and Feeding Cost

The data on feed conversion ratio (FCR) and feed cost of T1 and T2 TMR are presented in Table 4. The requirement of dry matter, crude protein, digestible crude protein, and total digestible nutrients to gain each kilogram of live weight was non-significant ($p > 0.05$) between the control and 5% MOM treatments. The daily feed cost was significantly ($p < 0.05$) lower by 6.45 Rs/day in crossbred heifers fed 5% MOM ration compared to control, but the feed cost to each kg gain in weight was non-significantly higher in the MOM group of heifers. Shankhpal *et al*. (2019) also reported significantly ($P < 0.05$) lower daily feeding cost of ration on feeding 15.0 kg *Moringa* green fodder replacing 15.0 kg green hybrid Napier grass in crossbred cows. Elaidy *et al*. (2017) with 5, 10, and 15% replacement of calf starter of suckling buffalo calves with *Moringa oleifera* leaves, and Khalel *et al*. (2014) with 50 and 100% replacement of berseem in a ration of Friesian cows with *Moringa oleifera* fodder found significant improvement in feed conversion ratio and better economic efficiency.

Conclusion

It can be concluded that *Moringa oleifera* meal @ 5% can be used to replace compounded concentrate mixture without significantly affecting growth, intake of nutrients, digestibility of nutrients, and feed conversion ratio of crossbred heifers.

Acknowledgement

The authors are grateful to the Dean of the Faculty and authorities of Anand Agricultural University, Anand, for providing the necessary facilities for this work.

References

Aharwal, B., Roy, B., Lakhani, G.P., Baghel, R.P.S., Saini, K.P.S., & Yadav, A. (2018). Effect of *Moringa oleifera* leaf meal on feed intake and growth performance of Murrah buffalo calves. *International Journal of Current Microbiology and Applied Sciences*, *7*(9), 1960-1973.

Aharwal, B., Roy, B., Yadav, A., & Saini, K. P. (2019).Economic analysis of *Moringa oleifera* leaf meal for Murrah buffalo calf rearing. *International Journal of Recent Scientific Research, 10*(7), 33337-33339.

AOAC (1995). *Official Methods of Analysis,* 16th end. Association of Official Analytical Chemists, Washington, DC.

Babiker, E.E., Juhaimia, F.A., Ghafoor, K., & Abdoun, K.A. (2017). Comparative study on feeding value of *Moringa* leaves as a partial replacement for *alfalfa* hay in ewes and goats. *Livestock Science, 195,* 21-26.

Deshmukh, P. (2014). Antibacterial and immune modulatory activity of *Moringa oleifera* in albino rats. *M.V.Sc. thesis,* Nanaji Deshmukh Veterinary Science University, Jabalpur, MP, India.

Dey, A., Paul, S.S., Pandey, P., & Rathod, R. (2014). Potential of *Moringa oleifera* leaves in modulating *in vitro* methanogenesis and fermentation of wheat straw in buffalo. *Indian Journal of Animal Sciences, 84*(5), 533-538.

Dong, L., Zhang, T., & Diao, Q. (2019). Effect of dietary supplementation of *Moringa oleifera* on the production performance and faecal methanogenic community of lactating dairy cows. *Animals,9*(5), 262.

Elaidy, A.A., Abou Selim, I.A., Abou-Elenin, E.I., Abbas, M.S., & Sobhy, H.M. (2017). Effect of feeding dry *Moringa oleifera* leaves on the performance of suckling buffalo calves. *Asian Journal of Animal Science, 11*(1), 32-39.

Henuk, Y.L. (2018). Many uses of moringa (*Moringa oleifera*) in human and animal nutrition. *Research & Reviews: Journal of Agriculture and Allied Sciences, 7*(1), 41-45.

Imran, M., Bilal, G., Mahrun Nisa, M.M., & Ali, M. (2016).Effect of feeding *Moringa oleifera* hay on performance, lactation and nitrogen balance in lactating Nili Ravi buffaloes in semi-arid areas of South Asia. *Journal of Animal and Poultry Sciences, 5*(1), 1-12.

Kekana, T.W., Marume, U., Muya, C.M., & Nherera-Chokuda, F.V. (2019). Lactation performance blood metabolites in lactating dairy cows micro-supplemented with *Moringa oleifera* leaf meal. *South African Journal of Animal Science, 49*(4), 709-716.

Khalel, M.S., Shwerab, A.M., Hassan, A.A., Yacout, M.H., El-Badawi, A.Y., & Zaki, M.S. (2014). Nutritional evaluation of *Moringa oleifera* fodder in comparison with *Trifolium alexandrinum* (berseem) and impact of feeding on lactation performance of cows. *Life Science Journal, 11*(10), 1040-1054.

Malik, A., Gunawan, A., Erlina, S., & Widaningsih, R.E. (2019).Effect of *Moringa oleifera (moringa)* supplementation via urea molasses multi-nutrient *moringa* block (UM3B) on nutrient intake and utilization in Bali cattle. *Journal of Animal Health and Production,7*(2), 70-74.

Mendieta-Araica, B., Spörndly, E., Reyes-Sánchez, N., &Spörndly, R. (2011). Feeding *Moringa oleifera* fresh or ensiled to dairy cows: Effects on milk yield and milk flavour. *Tropical Animal Health and Production*, *43*(5), 1039-1047.

Mishra, S.P., Singh, P., & Singh, S. (2012). Processing of *Moringa oleifera* leaves for human consumption. *Bulletin of Environment, Pharmacology and Life Sciences, 2*(1), 28-31.

Nouala, F.S., Akinbamijo, O.O., Adewumi, A., Hoffman, E., Muetzel, S., & Becker, K. (2006). The influence of *Moringa oleifera* leaves as substitute to conventional concentrate on the *in vitro* gas production and digestibility of groundnut hay. *Livestock Research for Rural Development*, *18*(9), 1-7.

NRC (2001). *Nutrient requirements of dairy cattle*: 2001. National Academies Press. Washington, DC, USA.

Oduro, I., Ellis, W.G., & Oswsu, D. (2008). Nutritional potential of two leafy vegetable: *Moringa oleifera* and *Ipomoe abatata* leaves. *Scientific Research and Essays, 3*(2), 57-60.

Sanchez, N.R., Sporndly, E., & Ledin, I. (2005). Effect of feeding different levels of foliage of *Moringa oleifera* to creole dairy cows on intake, digestibility, milk production and composition. *Livestock Science*, *101*(1-3), 24-31.

Seradja, A.R., Morazánb, H., Fondevilac, M., Liangd, J.B., de la Fuentea, G., & Balcells, J. (2019). *In vitro* and *in situ* degradation characteristics and rumen fermentation products of *Moringa oleifera* harvested at three different ages. *Tropical Animal Science Journal*, *42*(1), 39-45.

Shankhpal, S.S., Waghela, C.R., Sherasia, P.L., Sridher, V., Srivastava, A.K., & Singh, D. (2019). Effect of feeding *Moringa* as green fodder on feed intake, milk yield, microbial protein synthesis and blood profile in crossbred cows. *Indian Journal of Animal Nutrition,36*(3), 228-234.

Snedecor, G.W., & Cochran, W.G. (1994) *Statistical Methods*. 8th ed. Affiliated East-West Press Pvt. Ltd., New Delhi, India.

Soliva, C.R., Kreuzer, M., Foidl, N., Foidl, G., Machmuller, A., & Hess, H.D. (2005). Feeding value of whole and extracted *Moringa oleifera* leaves for ruminants and their effects on ruminal fermentation *in vitro*. *Animal Feed Science and Technology, 118*(1-2), 47-62.

Van Soest, P.J., Robertson, J.B., & Lewis, B.A. (1991).Methods of dietary fiber, neutral detergent fiber and non starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, *74,* 3583-3597.

Worku, A. (2016). *Moringa oleifera* as a potential feed for livestock and aquaculture industry. *African Journal of Agricultural Science and Technology*, *4*(4), 666-676.

Zeng, B., Sun, J.J., Chen, T., Sun, B.L., He, Q., Chen, X.Y., Zhang, Y.L., & Xi, Q.Y. (2018). Effects of *Moringa oleifera* silage on milk yield, nutrient digestibility and serum biochemical indexes of lactating dairy cows. *Journal of Animal Physiology and Animal Nutrition*, *102*(1), 75-81.