Indian J. Anim. Nutr. 2019. 36 (3): 228-234
doi: 10.5958/2231-6744.2019.00038.0

Indian Journal of Animal Nutrition

Effect of Feeding Moringa *(Moringa oleifera)* as Green Fodder on Feed Intake, Milk Yield, Microbial Protein Synthesis and Blood Profile in Crossbred Cows

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ABSTRACT

To evaluate the effect of feeding Moringa *(Moringa oleifera)* as green fodder on feed intake, milk yield, microbial protein synthesis, and blood profile, a study was conducted on twenty lactating crossbred cows in Anand district of Gujarat. Cows were divided into two groups of ten each, based on milk yield (9-10 kg/d), fat content (3.5-3.8%) and stage of lactation (av. 60 days in milk). Cows in control group were fed 3.0 kg each chaffed wheat and pulse straw, 15.0 kg green hybrid Napier grass and 5.0 kg cattle feed (23.0% CP; 4.0% EE), Whereas, cows in experimental group were fed 15.0 kg Moringa green fodder (by replacing 15.0 kg hybrid Napier) for 90 days. Nutrient requirement was adjusted by reducing quantity of cattle feed (3.5 kg). Study revealed that milk yield and fat content increased ($P<0.01$) by 9.17% and 7.41%, respectively in experimental group as compared to control group. Level of β-carotene improved by 37.76%, while level of cholesterol decreased by 17.60% in cows fed Moringa as green fodder. Feeding of Moringa fodder improved intestinal flow of microbial nitrogen from 112.67 to 159.53 g/d ($P<0.01$). Serum concentration of non-esterified fatty acid (NEFA) reduced from 0.28 to 0.22 meq/L ($P<0.05$) whereas, the Ferric Reducing Antioxidant Power (FRAP) increased from 442.73 to 849.44 ($P<0.01$) in experimental group. Level of serum immunoglobulin, IgM was higher by 22.19% ($P<0.05$) in experimental cows. Organoleptic properties of milk were not affected by feeding Moringa green fodder. The average net daily income was higher by ₹ 46.21 ($P<0.01$) by replacing hybrid Napier with Moringa fodder. It is concluded that *Moringa oleifera* is highly nutritious fodder, and palatable; thus can be used as green fodder for lactating cows under field conditions.

Keywords: Crossbred cows, Hybrid napier, Milk yield, Moringa, Organoleptic

INTRODUCTION

One of the major constraints for dairy production in India is the non-availability or fluctuating quantity and quality of the year-round green fodder supply. Farmers feed their animals mostly on crop residues and poor quality straw/hay that are low in nitrogen, high in lignocellulose and poor in minerals and vitamins that leads to low digestibility and reduced voluntary feed intake (Sultana *et al.,* 2014). Utilization of fodder trees and shrubs could be a potential strategy for increasing the quality and availability of feeds for resource-limited dairy farmers. Moringa *(Moringa oleifera)*; originated in the northwest region of India, Pakistan and south of Himalayan mountains is recently being investigated for its fast growth, higher nutritional attributes, and utilization as a livestock fodder crop (Nouman *et al.,* 2014). Moringa tree is a drought-tolerant, fast-growing, multi-purpose and one of the most useful trees due to its medicinal and nutritional properties, and therefore described as a *'miracle tree'* (Yisehak *et al.,* 2011, Ashfaq *et al.,* 2012 and Meel *et al.,* 2018). Moringa grows in all types of soil, naturally drought resistant crop and grows even during the scarcity period of the fodder. The tree has a capacity to produce high quantities of fresh biomass per unit area and produces dry matter yield from 4.2 to 8.3 tonnes per hectare with a cutting frequency of 40 days interval (Wasif *et al.,* 2014, Mariswamy *et al.,* 2017). Moringa leaves contains high levels of crude protein, essential vitamins, minerals and amino acids (Makkar and Becker, 1997; Gidamis *et al.,* 2003). Nevertheless, the potential benefits and actual worth of the tree as inclusion in

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ruminant feeding have not been yet fully exploited (Akinbamijo *et al.,* 2004). Keeping the aforesaid facts in mind, the present investigation was planned to find out the possibilities of utilization of *Moringa oleifera* as green fodder on feed intake, milk production performance, and economics in lactating crossbred cows.

MATERIALS AND METHODS

Present study was undertaken at an organized dairy farm of Sihol village in Anand district of Gujarat. Twenty lactating crossbred cows (450 kg ± 20) in early to mid-stage of lactation were selected. Cows were divided into two groups of ten each, based on milk yield (9-10 kg/d), fat (3.5-3.8%) and stage of lactation (av. 60 days in milk). Cows in control group were fed 3.0 kg each chaffed wheat and pulse straw, 15.0 kg green hybrid Napier and 5.0 kg cattle feed (crude protein: 23%; crude fat: 4%). However, cows in the experimental group were fed 15.0 kg Moringa green fodder, 3.0 kg each of chaffed wheat and pulse straw, and 3.5 kg cattle feed for 90 days. Nutrient requirements of cows were met as per NRC (2001).

The chemical composition of feeds and fodder offered to lactating crossbred cows during the trial period was carried out as per AOAC (2005). The milk samples were collected at weekly intervals from individual cows during both milking time (06:00 and 18:00 hrs). Pooled milk samples (100-150 ml) from each cows were analysed for fat, SNF, protein and lactose contents by an automatic milk analyser (based on ultrasonic principle with accuracy of ± 0.1-0.2%). Blood samples were collected from the jugular veins and analyzed for protein, glucose, triglycerides, creatinine, NEFA, Ferric Reduction Anti-oxidant Power (FRAP) activity (Benzie and Strain, 1996) and immunoglobulin (IgG, IgM, IgA and IgE) by using kit supplied by DiaSys Diagnostic Systems GmbH (Germany).

Spot urine (100 ml) samples were collected from individual cows in the morning and preserved with sufficient quantity of 10% H_2SO_4 to maintain pH below 3.0. The urine samples were assayed for allantoin, uric acid and creatinine (Young and Conway, 1942; Hawk *et al.,* 1976). Purines absorbed and microbial nitrogen (N) supply was calculated from the daily urinary purine derivatives excreted (IAEA, 1997):

- PDC (Purine derivative: creatinine) index = Purine derivative/ Creatinine x $LW^{0.75}$

Whereas LW is live weight in kg

- Intestinal flow of microbial nitrogen (g/d) =Absorbed purine (mmol/d) x 0.727

For calculation, following factors were considered

- microbial digestibility of microbial purines is assumed to be 0.83;
- the N content of purines is 70 mg N/mmol and
- Ratio of purine N to total N in mixed rumen microbes is taken as 11.6:100.

Organoleptic test of milk samples was conducted by a panel of 10 members from different departments. For organoleptic test, milk sample was evaluated two times during the trial, so two observations were recorded. Members were selected to represent the two genders and dairy technology/ non-dairy technology background. Total four samples were evaluated; i) cow milk (control), ii) milk produced from Moringa-fed cow (study sample), iii) cow milk containing 1.0% Moringa extract, and iv) cow milk containing 2.0% Moringa extract. Moringa extract was prepared by mixing chaffed Moringa fodder in water in proportion of 23:100 by weight. The content was heated to 70 ºC, kept closed at room temperature for 15 min, and then filtered through the nylon filter. The filtrate added to milk @ 1.0% and 2.0% for sensory evaluation.

Data were analysed using one-way ANOVA with SPSS package programme (SPSS 9.00 software for Windows, SPSS Inc., Chicago, IL) as per Snedecor and Cochran (1994). When F-test was significant ($P<0.05$), Turkey's test was utilized to compare significant difference ($P<0.05$) among the groups.

RESULTS AND DISCUSSION

Chemical composition of Moringa and Hybrid Napier fodders indicates that the crude protein (18.25 *vs* 9.43%), ether extract (3.42 *vs* 2.01%) and calcium (2.41 *vs* 0.31%) contents were higher in Moringa fodder as compared to Hybrid Napier fodder (Table 1). Moringa green fodder also contained higher amount of trace minerals such as copper (13.15 *vs* 6.83 ppm), zinc

(24.61 *vs* 20.00 ppm), manganese (61.25 *vs* 55.53 ppm) and iron (591.09 *vs* 308.22 ppm).

In our study, non-significant impact on dry matter intake (DMI) was observed between the groups (Table 2). Similar results were also observed by Mendieta-Araica *et al.* (2011), who reported that there were no significant differences among treatments with regard to feed intake when Moringa leaf meal was fed to cows. However, Reyes *et al.* (2006) observed an increase in DMI (8.5 vs 10.2 vs 11.0 kg DM/day) with the supplementation of 2.0 kg and 3.0 kg DM of Moringa, respectively, as compared to control.

Milk yield improved (P<0.01) by 9.17% in experimental group, as compared to control group. The average milk fat in control and experimental groups was 3.82% and 4.11%, respectively, which indicates that the Moringa fodder supplementation in lactating crossbred cows increased (P<0.01) milk fat content. Sarwatt *et al.* (2004) reported that when Moringa leaf meal at 10, 20, or 30% of dry matter was used as substitution for cotton seed cake, resulted in significant improvement of milk yield by 1.4, 0.9 and 0.8 kg/cow/day, respectively. Reyes *et al.* (2006) also observed improvement in milk yield by feeding Moringa in crossbred cows. Significant improvement in total solids content (12.36 *vs* 12.79%; P<0.01) of milk was observed. However, other milk constitutes such as milk protein, lactose and SNF were not affected (P>0.05) by feeding Moringa to crossbred cows.

The daily feeding cost (₹ /head) of ration was lower (156.86 *vs* 149.01; P<0.01) in experimental group. This is mainly due to the lower cattle feed intake in experimental group as compared to control group. However, daily realizable receipt (₹ /head) from the sale of milk was higher by 13.40% (P<0.01) in experimental group as compared to control group. Thus, net daily income of farmers increased by ₹ 46.21 per animal by feeding Moringa as green fodder in lactating crossbred cows.

Microbial N flow to the duodenum is considered as an important and sensitive indicator to optimize the rumen metabolism in dairy animals. Urinary excretion of allantoin has been successfully used to estimate the microbial protein synthesized in the rumen and subsequently digested in the lower gut of ruminants (Dipu *et al.,* 2006). In our study, daily average intestinal flow of microbial N increased from 112.67 to 159.53 g which indicate higher (P<0.01) yield of microbial protein after feeding Moringa fodder (Table 3). Feeding of Moringa fodder in the ration of crossbred cows had resulted in improvement of purine derivative (PD) concentration (P<0.05), PDC index, total PD excreted and absorbed

Table 1. Chemical composition of Moringa and Hybrid Napier fodder (DM basis)

Parameters	Moringa green fodder	Hybrid Napier
CP (%)	18.25	9.43
EE (%)	3.42	2.01
CF (%)	29.03	31.15
Total Ash (%)	9.18	8.84
AIA (%)	0.83	2.33
Ca (%)	2.41	0.31
P (%)	0.28	0.30
Mg (%)	0.67	0.80
K (%)	0.69	2.10
Na (%)	0.117	0.05
Cu (ppm)	13.15	6.83
Zn (ppm)	24.61	20.00
Mn (ppm)	61.25	55.53
Fe (ppm)	591.09	308.22

Table 2. Effect of feeding *Moringa oleifera* on milk yield, milk composition and economics in crossbred cows

Parameter	Control	Experimental	SEM
Feed Intake			
DMI (kg/d)	12.06±0.27	11.81±0.30	0.100
Milk Yield and Milk Composition			
Milk yield (kg/d)	9.89^{a}±0.47	10.80^{b}±0.39	0.127
Total solids (%)	12.36^{a}±0.08	12.79^{b}±0.04	0.044
Fat (%)	3.82^{a}±0.04	4.11^{b}±0.04	0.027
SNF (%)	8.54±0.07	8.68±0.04	0.043
Protein (%)	3.22±0.03	3.30±0.03	0.019
Lactose (%)	4.41±0.03	4.60±0.04	0.023
β-carotene (µg %)	1.63^{a}±0.05	2.24^{b}±0.08	0.051
Cholesterol (mg %)	12.73^{b}±0.37	10.49^{a}±0.18	0.198
Economics			
Feeding cost (₹/day)	156.86^{a}±3.50	149.01^{b}±3.74	1.308
Realizable receipt from sale of milk (₹/head/d)	286.32^{a}±14.21	324.68^{b}±10.95	3.992
Average gross income (₹/head/d)	129.46^{a}±10.81	175.67^{b}±8.33	3.938
Net daily increase in income (₹/head)		+ 46.21	

^{ab}Mean bearing different superscripts in a row differ significantly (P<0.01)

purine (P<0.01), thus, (P<0.01) improved microbial N supply to cows. Microbial protein synthesis in rumen depends upon supply of ammonia, energy and carbon skeleton for amino acid synthesis (Tomar *et al.,* 2010). Most of the carbon skeletons are produced as a result of degradation of carbohydrates into volatile fatty acids. Due to feeding of Moringa fodder, greater availability of energy or protein might have resulted in increased microbial protein synthesis, thereby, improving the performance of lactating crossbred cows. Soliva *et al.,* (2005) reported that Moringa leaves are a good protein source and a convenient substitute of soybean and rapeseed meals for ruminants, and they are able to improve the microbial protein synthesis in the rumen.

Changes in serum lipid profile in cows subjected to the both feeding regimes are presented in Table 4. Levels of serum immunoglobulins; IgG, IgM and IgA (mg/ml) increased from 19.28 to 24.03 (P=0.084), 3.02 to 3.69 (P=0.011) and 0.45 to 0.53 (P=0.487), respectively on feeding Moringa as green fodder. However, the levels of glucose, triglycerides, cholesterol, HDL, LDL and creatinine were not affected (P>0.05) on feeding Moringa. Presence of NEFA in

Table 3. Effect of feeding *Moringa oleifera* fodder on microbial protein synthesis

Parameter	Control	Experimental	SEM
Allantoin (mmol/l)	10.32^{c}±0.44	11.92^{d}±0.51	0.386
Uric acid (mmol/l)	1.16±0.10	1.15±0.10	0.068
Creatinine (mmol/l)	6.82±0.56	6.40±0.36	0.323
Purine derivatives (mmol/l)	11.48^{c}±0.41	13.08^{d}±0.50	0.373
PDC index	175.87±12.97	205.14±10.46	8.891
Intestinal flow of microbial nitrogen (g/d)	112.67^{a}±9.19	159.53^{b}±8.73	8.608
Microbial protein yield (g CP/d)	704.21^{a}±57.46	997.06^{b}±54.57	53.803

$^{a, b}$Means with different superscript in a row differ significantly (P<0.01); ^{c,d}Means with different superscript in a row differ significantly (P<0.05).

blood is a direct indicator of energy balance and massive fat mobilization, suggesting more energy requirement than supplied in the diet. NEFA can be managed by optimizing the capacity of the liver to dispose of excess NEFA by exporting it back to the blood stream in the form of very low density lipoproteins (VLDL). In this process, the body uses VLDL for availing more usable energy for various body functions and health of the liver is maintained. In our study, mean serum NEFA level reduced to 0.22 mmol/l in experimental group, as compared to control group (0.28 mmol/l).

Level of serum Ferric Reducing Antioxidant Power (FRAP) was also observed significantly higher (442.73 *vs* 849.44; P<0.01) in Moringa fed group. Present results indicates that feeding of Moringa as green fodder in the ration of dairy cows had potential effect on increasing internal antioxidant defense. It is reported that Moringa leaves contains flavonoids such as kaempferol, rhamnetin, isoquercitrin and kaempferitrin, which could significantly contribute in scavenging free radicals or act as free radical terminator (Iqbal and Bhanger, 2006; Pourmorad *et al.,* 2006; Khalafalla *et al.,* 2010 and Satish *et al.,* 2013). Anti-oxidant properties of methanolic extract of Moringa leaves has been observed by Siddhuraju and Becker (2003) and Odukoya *et al.,* (2005). Studies conducted by Asokkumar *et al.* (2008) and Oyedemi *et al.* (2010) also indicated that Moringa can reduce reactive free radicals that might lessen oxidative damage in the tissues through hydrogen peroxide decomposition.

Following are the sensory evaluations of Moringa-fed cow milk based on its organoleptic characteristics:

Observations I:

Sample	Flavour defect		Odour defect		Over all acceptability	
	Yes	No	Yes	No	Yes	No
A	5	5	1	9	8	2
B	10	0	9	1	5	5
C	9	1	5	5	3	7
D	1	9	0	10	10	0

Note: The digits indicate the number of panellists. A- Study sample (Moringa-fed cow milk) B- Sample prepared using 1% Moringa extract, C- Sample prepared using 2% Moringa extract, D- Control (Cow milk). Overall acceptability: D>A>B>C.

Table 4. Effect of feeding *Moringa oleifera* on serum profile in crossbred cows

Parameter	Control	Experimental	SEM
Total protein (g/dl)	6.82±0.15	7.09±0.09	0.094
Albumin (g/dl)	3.51±0.09	3.60±0.05	0.050
Globulin (g/dl)	3.31±0.09	3.49±0.10	0.068
Glucose (mg/dl)	58.98±2.74	61.88±3.08	2.003
Triglyceride (mg/dl)	43.49±0.57	40.89±2.17	1.142
NEFA (meq./L)	0.28^{d}±0.02	0.22^{c}±0.02	0.016
Total Cholesterol (mg/dl)	236.96±11.99	209.25±7.79	8.172
HDL (mg/dl)	144.42±8.45	167.07±8.56	6.183
LDL (mg/dl)	49.65±4.10	32.53±2.87	3.702
IgG (mg/ml)	19.28±1.33	24.03±2.01	1.384
IgA (mg/ml)	0.45±0.10	0.53±0.03	0.052
IgM (mg/ml)	3.02^{c}±0.08	3.69^{d}±0.19	0.147
IgE (mg/ml)	0.07±0.00	0.05±0.00	0.003
Creatinine (mg/dl)	0.98±0.03	1.01±0.08	0.041
Serum FRAP	442.73^{a}±77.54	849.44^{b}±62.81	82.509

^{a,b} Means with different superscript in a row differ significantly (P<0.01); ^{c,d} Means with different superscript in a row differ significantly (P<0.05).

Observations II:

Sample	Flavour defect		Odour defect		Over all acceptability	
	Yes	No	Yes	No	Yes	No
A	2	8	0	10	10	0
B	5	5	1	9	9	1
C	10	0	5	5	3	7
D	5	5	1	9	7	3

Note: The digits indicate the number of panellists. A- Control (Cow milk), B- Study sample (Moringa-fed cow milk), C- Sample prepared using 2% Moringa extract and D- Sample prepared using 1% Moringa extract. Overall acceptability: A>B>D>C.

Based on the above observations, the overall acceptability of milk samples on organoleptic characteristics are considered as: cow milk (control) > Moringa-fed cow milk > cow milk containing 1.0% Moringa extract > cow milk containing 2.0% Moringa extract. Similar results were also observed by Reyes *et al.* (2006a) who reported that organoleptic characteristics, colour, smell and taste were not significantly affected by feeding Moringa in lactating cows.

CONCLUSIONS

Present study concludes that Moringa is palatable and is a highly nutritious fodder with antioxidant properties, which has reflected on the improvement in milk yield, and milk fat; thus improving net daily income of dairy farmers. Therefore, *Moringa oleifera* can be recommended as green fodder in the ration of crossbred cows.

ACKNOWLEDGEMENTS

The financial assistance and facilities provided by the management of National Dairy Development Board, Anand for undertaking this study are gratefully acknowledged. Authors are also thankful to the owner of dairy farm at Sihol village of Anand district, where the study was undertaken.

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Received on 09-06-2019 and accepted on 03-10-2019