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Comparative evaluation of fodder qualities in different parts of locally available moringa (*Moringa oleifera*) strains

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ABSTRACT

An experiment was conducted at ICAR-National Dairy Research Institute, Karnal (Haryana) to generate precise information on nutritional qualities of leaves, twigs and leaves with twigs parts of *Moringa oleifera* strains. The samples were collected from 5 years old established moringa trees from research farm of NDRI, Karnal. Total six treatments were formed by using the two locally available moriga strains, i.e. Rajasthan local and Haryana local strain, and three types of samples obtained from each strain, i.e. leaves, tender green twigs and leaves with twigs. The treatments were replicated four times and statistically analyzed by using randomized block design (RBD). The results showed that highest value of crude protein, ether extract, total ash, digestible dry matter, relative feed value and net energy for lactation was found in leaves of Haryana local strain of moringa, however, leaves of Rajasthan local strain of moringa also recorded at par value of ether extract, total ash, digestible dry matter and net energy for lactation with leaves of Haryana local. Twigs of both Rajasthan and Haryana local strain of moringa recorded at par value of dry matter content, NDF and ADF.Further, highest value of P, S, Zn, Cu and Mn was found in leaves of Rajasthan local strain of moringa, whereas, highest value of N, Ca, Mg and Fe was found in leaves of Haryana local strain of moringa. However, leaves of both Rajasthan and Haryana local strain of moringa recorded at par values of P, S, Ca, Mg, Zn, Cu and Mn.

Key words: Fodder quality, Moringa strains, NE_l, Nutrient content, Proximate content

Moringa oleifera is a remarkable species with its high nutritional value and good biomass production, which can be used as a nutritional supplement (Sanchez *et al.* 2006). Moringa leaves are rich source of nutrients, viz. calcium, potassium, magnesium, iron, zinc, copper etc. and also contains good amount of crude protein, crude fat, carbohydrate, vitamin A, B and C; and amino acids like arginine, methionine, leucine, valine, tryptophan etc. which are essential for improving livestock production and productivity. Moreover, low-quality livestock fodders or rations can be improved by adding moringa leaves as a supplement, which increases the dry matter intake and the digestibility of the fodder by livestock (Richter *et al.* 2003). It also contributes toward better livestock performance and high yield of good quality products. Leaves of moringa are also graded as best ruminant feed (Girdhar *et al.* 2018). Further, in dry months, when no other fodder is available and the fodder quality is diminished due to harsh and severe climatic conditions, moringa leaves can be used as a substitute for commercial rations (Nouman *et al.* 2013). Different ecotypes or strains of moringa can show variations in leaf biomass and metabolites (Lin *et al.* 2019). Thus, their proper nutritive evaluation is the need of the hour for their optimum utilization in low producing animals of our country (Das *et al.* 2015). The information on perennial crops like moringa that provide good quality green fodder throughout the year for livestock production is meager. Hence, a need to generate precise information on nutritional qualities of leaves, twigs and leaves with twigs, parts of locally available *Moringa oleifera* strains was felt.

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MATERIALS AND METHODS

The samples were collected from 5 years old moringa trees from ICAR-National Dairy Research Institute (NDRI), Karnal (Haryana), Research farm. Among the samples there were two moringa strains, i.e. Rajasthan Local and Haryana Local. Seeds of Rajasthan local strain of moringa brought from Rajasthan and planted at NDRI research farm by raising nursery whereas, Haryana local strain is the moringa strain which is locally available in Haryana. Three types of samples were obtained from each strain, i.e. leaves; tender green twigs and leaves with twigs.

Comparative analysis of the samples was carried out by using six treatment (Rajasthan Local leaves, Haryana local leaves, Rajasthan Local twigs, Haryana Local twigs, Rajasthan Local leaves with twigs and Haryana Local leaves with twigs) with four replication in Randomized block design (RBD) (Gomez 1984).

Collected samples were air dried for 5–6 days, and oven dried at 60°C for 3 days, thereafter thoroughly grounded (Wiley mill) to pass through 1 mm screen for analysis of quality parameters. The grinded samples were stored in polycarbonate bottles until further analysis. The analysis of the samples was carried out by using standard procedures. Dry matter content, ether extract, total ash and acid detergent fibre (ADF) was determined by using standard procedures of AOAC (2005). The crude protein of sample was calculated by multiplying the N content with the factor 6.25. Neutral detergent fibre (NDF) was analyzed as described by Van soest *et al.* (1991). Analysis of minerals/nutrients was carried out by using digested sample by following methods. Nitrogen by using micro Kjeldahl method, phosphorus by yellow colour method, sulphur by Chesnin and Yien (1950) method, potassium and sodium by flame photometer method, calcium and magnesium by ICPE method and micronutrients (Zn, Mn, Cu and Fe) by Lindsay and Norvell (1978) method.

Total digestible nutrients (TDN), digestible dry matter (DDM), dry matter intake (DMI), relative feed value (RFV) and net energy for lactation (NE_l) were estimated according to the following equations adapted from Horrocks and Vallentine (1999) whereas, relative feed quality (RFQ) was adapted from Undersander *et al.* (2010):

TDN = “1.291 × ADF + 101.35

DMI = 120/%NDF on dry matter basis

DMD = 88.9 “ (0.779 × ADF)

RFV = DMD × DMI × 0.775

$$RFQ = \frac{(DMI,\% \text{ of } BW) \times (TDN,\% \text{ OF } DM)}{1.23}$$

NE_l (Mcal/kg) = [1.044 “ (0.0119 × ADF)] × 2.205

RESULTS AND DISCUSSION

Proximate chemical constituents: Proximate analysis of different parts of moringa strains revealed that highest dry matter content was found in twigs of Haryana local strain. However, twigs of Rajasthan local strain also recorded at par value of dry matter content with twigs of Haryana local strain. Further, the dry matter content in different parts of both the varieties was found in the order of twigs > leaves + twigs > leaves. It has been observed that the twigs contain highest dry matter content followed by leaves with twigs and leaves in both the strains of moringa. The higher dry matter content in the twigs of moringa might be due to the facts that twigs contain less water content as compared to leaves, i.e. less moisture percentage in twigs as compared to leaves (dry matter content is inversely proportional to moisture content). It is explicit from the data (Table 1) that highest crude protein content and ether extract was found in leaves of Haryana local followed by leaves of Rajasthan local strain of moringa. Leaves with twigs part of both Haryana and Rajasthan local strain contain statistically at par of crude protein and ether extract. Similarly, twigs of both Haryana local and Rajasthan local strain also contain at par values of both the parameters. Among the different parts of moringa, leaves contain higher value whereas stem contain lower values of crude protein and ether extract (Verma and Nigam 2014). Olugbemi *et al.* (2010) reported that higher value of crude protein content was observed in moringa leaves. Nouman *et al.* (2013) also reported that highest and lowest value of ether extract was obtained in moringa leaves and stem respectively.

Table 1. Comparative analysis of proximate chemical constitutes (%) in different parts of locally available moringa strains

Strains with parts	DM	CP	EE	TA	AIA	NDF	ADF
RL leaves	21.88	23.07	5.65	10.79	0.97	14.15	8.25
HL leaves	22.50	26.13	6.00	11.03	1.22	12.62	6.99
RL twigs	27.93	10.18	3.91	8.64	4.10	39.02	23.44
HL twigs	29.00	11.35	4.29	9.11	4.48	37.84	22.32
RL leaves with twigs	24.97	18.08	5.04	9.68	2.41	25.00	13.43
HL leaves with twigs	25.55	20.00	5.20	10.12	2.65	24.87	11.92
SEm.±	0.87	0.64	0.15	0.14	0.08	0.51	0.42
CD (P= 0.05)	2.61	1.92	0.45	0.41	0.23	1.54	1.28

RL, Rajasthan local strain of moringa; HL, Haryana local strain of moringa; DM, Dry matter content; CP, Crude protein; EE,Ether extract; TA, Total ash; AIA,Acid insoluble ash; NDF,Neutral detergent fiber; ADF,Acid detergent fiber.

Analysis of data (Table 1) further indicates that different parts of moringa strains recorded significant variation in total ash and acid insoluble ash contents. Leaves of Haryana local recorded significantly higher total ash content over leaves with twigs of Haryana local, leaves with twigs of Rajasthan local, twigs of Haryana local and twigs of Rajasthan local. However, leaves of Rajasthan local strain recorded at par value of total ash content with leaves of Haryana local strain. Whereas, maximum value of acid insoluble ash was recorded in twigs of Haryana local strain of moringa followed by twigs of Rajasthan local, leaves with twigs of Haryana local, leaves with twigs of Rajasthan local, leaves of Haryana local and leaves of Rajasthan local. Among the different parts of moringa, leaves contain higher value whereas stem contain lower value of total ash content (Nouman *et al.* 2013; Verma and Nigam 2014). The value of acid insoluble ash was 0.97 to 1.22 in the leaves which was higher than the investigation of moringa leaves (0.35 to 0.65%) by Samia *et al.* (2018). The lowest values of NDF and ADF were found in leaves of Haryana local strain. However, leaves of Rajasthan local strain also recorded at par value of both the parameters with leaves of Haryana local strain. Leaves with twigs part of Haryana local strain contain 24.87% and 11.92% of NDF and ADF, respectively. However, leaves with twigs parts of Rajasthan local strain of moringa also contain at par value of NDF with leaves with twigs part of Haryana local strain. Nouman *et al.* (2013) reported that comparative analysis of different parts of moringa revealed that NDF and ADF were found in the order of stem > leaves with stem > leaves. Lower NDF and ADF content in moringa leaves show its better fodder quality. Aregheore (2002) also reported that mixtures with different proportions of moringa leaves, twigs, or branches have different NDF contents.

Fodder qualities and net energy for lactation: Comparative analysis of fodder qualities in different parts of locally available moringa strains (Table 2) revealed that highest value of TDN was found in leaves of Haryana local strain of moringa followed by leaves of Rajasthan local. Leaves with twigs parts of Haryana and Rajasthan local strains of moringa contain 85.96% and 84.02% of TDN, respectively. Further, twigs of both Haryana and Rajasthan local strain of moringa recorded at par value of TDN. According to Lithourgidis *et al.* (2006) TDN refers to nutrients that are available to livestock and related to ADF concentration in feed/fodder. TDN content in forage is inversely related with ADF concentration in feed therefore, as concentration of ADF increases, there is a decline in TDN content which limits an animal's ability to utilize the nutrients that are present in the forage (Carmi *et al.* 2006). Further, different parts of moringa strains recorded significant variation in digestible dry matter (DDM) and dry matter intake (DMI). The highest value of DDM and DMI was recorded in leaves of Haryana local strain of moringa. However, Rajasthan local strain of moringa contain at par value of DDM with Haryana local strain of moringa. Leaves with twigs parts of Haryana local strain recorded 79.61% and 4.85% of DDM and DMI, respectively. Leaves with twigs parts of Rajasthan local strain also recorded at par value of DMI with leaves with twigs parts of Haryana local strain. Twigs part of both the moringa strains contain at par value of DDM and DMI. ADF and NDF are used to predict the DDM and DMI, respectively. DDM is negatively correlated with ADF whereas DMI is negatively correlated with NDF. Horrocks and Vallentine (1999) also reported that where NDF is NDF is high forage quality and DMI are low.

Highest relative feed value (RFV), relative feed quality (RFQ) and net energy for lactation (NE_l) recorded in leaves of Haryana local followed by leaves of Rajasthan local. However, leaves of both Haryana and Rajasthan local strain of moringa found at par value of NE_l. Leaves with twigs part of both Haryana and Rajasthan local strain of moringa recorded at par value of RFV and RFQ. Further, twigs of both the strains contain lowest value of RFV, RFQ and NE_l. Relative feed value (RFV) is an index which is used to predict intake and energy value of forage which is derived from DMD and DMI (Lithourgidis *et al.* 2006). According to Horrocks and Vallentine (1999), forage with RFV value >151 is considered prime. In the present investigation, in all the parts of both the moringa strain RFV is >151. Hence, it is assumed that all the plant parts of moringa can be used as a valuable fodder. Differences in the digestibility of the fiber fraction can result in a difference in animal performance when forages with a similar RFV are fed. Therefore, the RFQ index has been developed to overcome this difference. This index takes into consideration the differences in digestibility of the fiber fraction and can be used to more accurately predict animal performance and match animal needs (Jeranyama and Garcia 2004). NE_l includes energy used for maintenance and milk production because energy is used with the same efficiency whether for milk production or for maintenance. Using databases containing the ADF content of feeds and the NE_l content of those feeds, regression equations have been developed to predict $NE_l$from the ADF content of a feed. As ADF increases, NE_l decreases (Ondarza 2000).

Macro nutrients: The comparative analysis of macro nutrients (Table 3) revealed that the concentration of macro nutrients differ significantly in different parts of the moringa strains. The highest value of nitrogen content was found in leaves of Haryana local strain which was significantly

Table 2. Comparative analysis of fodder qualities(%) and net energy for lactation (Mcal/kg)in different parts of locally available moringa strains

Strains with parts	TDN	DDM	DMI	RFV	RFQ	NE_l
RL leaves	90.70	82.47	8.48	542.09	625.40	2.09
HL leaves	92.33	83.46	9.57	619.19	718.62	2.12
RL twigs	71.10	70.64	3.08	168.41	177.80	1.69
HL twigs	72.54	71.51	3.17	175.83	187.10	1.72
RL leaves with twigs	84.02	78.44	4.80	291.86	327.94	1.95
HL leaves with twigs	85.96	79.61	4.85	299.13	338.85	1.99
SEm.±	0.55	0.33	0.20	12.66	14.71	0.01
CD (P= 0.05)	1.65	1.00	0.59	38.17	44.34	0.03

RL, Rajasthan local strain of moringa; HL, Haryana local strain of moringa; TDN, Total digestible nutrients; DDM,Digestible dry matter; DMI, Dry matter intake; RFV, Relative feed value; RFQ, Relative feed quality;NE_l, Net energy for lactation.

Table 3. Comparative analysis of macro nutrients (ppm) in different parts of locally available moringa strains

Strains with parts	N	P	S	K	Na	Ca	Mg
RL leaves	36912	2467	8216	5409	299	26504	8022
HL leaves	41808	2352	7950	4625	311	26893	8345
RL twigs	16292	1766	5281	9198	718	18111	3080
HL twigs	18164	1654	5196	8625	734	19426	3276
RL leaves with twigs	28932	2188	6978	7116	425	23538	5944
HL leaves with twigs	32000	2052	6709	6022	462	23721	6230
SEm.±	1019	72	95	113	13	617	112
CD (P= 0.05)	3072	216	285	342	41	1859	337

RL, Rajasthan local strain of moringa; HL, Haryana local strain of moringa; N, Nitrogen; P, Phosphorus; S,Sulphur; K, Potassium, Na, Sodium, Ca, Calcium; Mg,Magnesium.

superior over leaves of Rajasthan local strainas well as twigs and leaves with twigs parts of both the strains. Leaves with twigs part of Haryana local strain contain 32,000 ppm of nitrogen content which was statistically at par with leaves with twigs part of Rajasthan local strain. Similarly, twigs of both Haryana local and Rajasthan local strain also contain at par values of nitrogen content. These findingsare in close confirmation with Verma and Nigam (2014) who reported that moringa leaves contain higher values of crude protein as compared to stem and as per the standard procedure crude protein of sample was calculated by multiplying the N content with the factor 6.25. Further, highest concentration of phosphorus and sulphur was recorded in the leaves of Rajasthan local strain of moringa. However, leaves of Haryana local also recorded at par values of phosphorus and sulphur with leaves of Rajasthan local. Leaves with twigs part of Rajasthan local strain contain 2188 and 6978 ppm of phosphorus and sulphur, respectively which was statistically at par with leaves with twigs part of Haryana local strain. Further, twigs of both Rajasthan and Haryana local strain also contains at par values of phosphorus and sulphur. These results corroborate the findings of Moyo *et al.* (2011) who reported that dried leaves of moringa contain 3,000 ppm and 6,300 ppm of phosphorus and sulphur respectively.

Further, it is evident that there was a remarkable difference in potassium concentration in different parts of moringa strains (Table 3). Highest potassium concentration was found in the twigs of Rajasthan local strain of moringa followed by twigs of Haryana local, leaves with twigs of Rajasthan local, leaves with twigs of Haryana local, leaves of Rajasthan local and leaves of Haryana local. Whereas, maximum sodium content was found in twigs of Haryana local strain of moringa. However, twigs of Rajasthan local strain also recorded at par value of sodium content with twigs of Haryana local strain. Leaves with twigs part of Haryana local strain contain 462 ppm of sodium content which was statistically at par with leaves with twigs part of Rajasthan local strain. Further, leaves of both Haryana local and Rajasthan local also recorded at par values of sodium content. Further, maximum concentration of calcium and magnesium was observed in the leaves of Haryana local strain of moringa. However, leaves of Rajasthan local also recorded at par value of calcium and magnesium with leaves of Haryana local. Leaves with twigs part of both Haryana and Rajasthan local strain also recorded at par value of calcium and magnesium. Similarly, twigs of both Haryana and Rajasthan local also recorded at par values of calcium and magnesium content. It has been observed from the above discussion that the highest potassium and sodium content was found in twigs followed by leaves with twigs and leaves whereas, highest calcium and magnesium was found in leaves followed by leaves with twigs and twigs in both the strains of moringa. Verma and Nigam (2014) also reported that moringa leaves contain lower values of potassium and sodium but higher values of calcium and magnesium as compared to stem. However, in the present study higher concentration of potassium, sodium, calcium and magnesium were observed in different parts of moringa as compared to their concentrations observed by the Verma and Nigam (2014).

Micro nutrients: The comparative analysis of the data (Table 4) clearly indicates that there was a remarkable difference of the micro nutrient concentration in different parts of the moringa strains. The highest value of zinc, copper and manganese was found in leaves of Rajasthan local strain which was significantly superior over leaves of Haryana local strain as well as twigs and leaves with twigs parts of both the strains. Leaves with twigs part of both Rajasthan and Haryana local strain contain at par value of zinc, copper and manganese. Similarly, lowest concentration of zinc, copper and manganese was found in twigs of Haryana local strain which was statistically at par with twigs of Rajasthan local strain. These results of the present investigation are in close agreement with Moyo *et al.* (2011) who reported that dried leaves of moringa contain 31.03, 8.25 and 86.93 ppm of zinc, copper and manganese, respectively. Verma and Nigam (2014) also reported that moringa leaves contain higher zinc content as compared to stem.Further, highest value of iron content was found in leaves of Haryana local strain which was significantly superior over leaves of Rajasthan local strain as well as twigs and leaves with twigs parts of both the strains. Leaves with twigs part of Haryana and Rajasthan local strain at par value of iron content. Similarly, twigs of both Haryana and Rajasthan local also contain at par values of iron content. The similar finding had also been reported by Moyo *et al.* (2011) who reported that dried leaves of moringa contain 490 ppm of iron. Verma and Nigam (2014) also reported that moringa leaves contain higher iron content as compared to stem.

Table 4. Comparative analysis of micro nutrients (ppm) in different parts of locally available moringa strains

Strains with parts	Zn	Cu	Mn	Fe
RL leaves	50.93	13.63	103.75	488.75
HL leaves	47.50	12.30	99.25	521.00
RL twigs	26.20	9.13	74.88	195.00
HL twigs	23.25	7.70	70.13	210.75
RL leaves with twigs	40.53	11.65	89.00	394.50
HL leaves with twigs	38.20	10.75	83.75	415.25
SEm.±	1.17	0.50	1.77	8.09
CD (P= 0.05)	3.53	1.51	5.34	24.40

RL,Rajasthan local strain of moringa; HL, Haryana local strain of moringa; Zn,Zinc; Cu, Copper; Mn, Manganese; Fe,Iron.

Based on the findings of the above study it is observed that leaves of both moringa strains contain higher crude protein, ether extract, total ash, total digestible nutrients, digestible dry matter, relative feed value and quality, net energy for lactation and several essential minerals Twigs of both the strains contain higher dry matter content, K and Na. Leaves with twigs part of moringa contain appreciable amount of crude protein, ether extract, total ash, total digestible nutrients, digestible dry matter, relative feed value and quality, net energy for lactation and all the essential macro and micro mineral. Hence, it is concluded that when leaves with twigs part of moringa used as animal feed/fodder it will fulfill the dietary and nutritional requirement of livestock animals. Further, in dry months, when no other fodder is available and the fodder quality is diminished due to harsh and severe climatic conditions, moringa can be used as a substitute for commercial rations.

REFERENCES

AOAC. 2005. *Official Methods of Analysis, Eighteenth revised*. Association of Official Analytical Chemists, Arlington, Virginia, USA.

Aregheore E M. 2002. Intake and digestibility of *Moringaoleifera*-batiki grass mixtures by growing goats. *Small Ruminants Research* **46**: 23–8.

Carmi A, Aharoni Y, Edelstein M, Umiel N, Hagiladi A, Yosef E, Nikbachat M, Zenou A and Miron J. 2006. Effects of irrigation and plant density on yield, com-position and *in vitro* digestibility of a new forage sorghum variety, Tal, at two maturity stages. *Animal Feed Science and Technology* **131**: 120–32.

Chesnin L and Yien C H. 1950. Turbidimetric determination of available sulphate. *Proceeding Soil Science Society of America* **14**: 149–51.

Das L K, Kundu S S, Kumar D and DattC. 2015. Fractionation of carbohydrate and protein content of some forage feeds of ruminants for nutritive evaluation. *Veterinary World* **8**(2): 197–02.

Giridhar K S, Prabhu T M, Singh C, Nagabhushan V, Thirumalesh T, Rajeshwari Y B and Umashankar B C. 2018. Nutritional potentialities of some tree leaves based on polyphenols and rumen *in vitro* gas production. *Veterinary World* **11**(October): 1479–85.

Gomez K A. 1984. *Statistical Procedure for Agricultural Research.* John Wiley and Sons Inc., Croda.

Horrocks R D and Vallentine J F. 1999. *Harvested Forages*. Academic Press, London, UK.

Jeranyama P and Garcia A D. 2004. Understanding relative feed value (RFV) and relative forage quality (RFQ). Extension Extra, Cooperative Extension Service. SDSU.http://agbiopubs.sdstate.edu/articles/ExEx8149.pdf

Lin H, Zhu H, Tan J, Wang H, Wang Z, Li P, Zhao C and Liu J. 2019. Comparative analysis of chemical constituents of *Moringaoleifera* leaves from china and India by ultra-performance liquid chromatography coupled with quadrupole-time-of-flight mass spectrometry. *Molecule* **24**: 1–25.

Lindsway W L and Norvell W A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of American Journal* **42**: 421–48.

Lithourgidis A S, Vasilakoglou I B, Dhima K V, Dordas C A and Yiakoulaki M D. 2006. Forage yield and quality of common vetch mixtures with oat and triticale in two seeding ratios. *Field Crops Research* **99**: 106–13.

Moyo B, Patrick J, Masika P J, Hugo A and Muchenje V. 2011. Nutritional characterization of moringa (*Moringa oleifera* Lam.) leaves. *African Journal of Biotechnology* **10**(60): 12925–33.

Nouman W, Basra S M A, Siddiqui M T, Yasmeen A, Guli T and Alacyde M A C. 2014. Potential of *Moringa oleifera*L. as livestock fodder crop: A review. *Turkish Journal of Agriculture and Forestry* **38**: 1–14.

Olugbemi T S, Mutayoba S K and Lekule F P. 2010. Effect of moringa (*Moringa oleifera*) inclusion in cassava based diets fed to broiler chickens. *International Journal of poulty Sciences* **9**: 363–67.

Ondarza M B D. 2000. Energy. Paradox Nutrition. Nutrition consulting for the dairy industry. http://www.milkproduction.com/Library/Scientific articles/Nutrition /Energy/

Richter N, Perumal S and Klaus B. 2003. Evaluation of nutritional quality of moringa (*Moringao leifera* Lam.) leaves as an alternative protein source for Nile tilapia (*Oreochromis niloticus* L.). *Aquaculture* **217**: 599–11.

Samia M Y, Elbadri O E, Eltahir A S, Mohammed E E and Ahmed K S. 2018. Proximate Composition of *Moringa oleifera* Lam. from different Regions in Sudan. *CPQ Microbiology* **1**(4): 1–13.

Sanchez N R, Stig L and Inger L. 2006. Biomass production and chemical composition of *Moringa oleifera* under different management regimes in Nicaragua. *Agroforestry System* **66**: 231–42.

Undersander D, Moore J E and Schneider N. 2010. Relative forage quality.*Focus on Forage* **12** (6): 1–3.

Van Soest P J, Robertson J B and Lewis B A. 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Sciences* **74**(10): 3583–97.

Verma K S and Nigam R. 2014. Nutritional assessment of different parts of *Moringa oleifera* Lamm collected from Central India. *Journal of Natural Product and Plant Resources* **4**(1): 81–6.