Impact of Replacing Concentrate with Dried *Moringa Oleifera* leaves on Growth and Haemato-Biochemical Parameters of Goat Kids under Field Condition

RISHIKANT TRIPATHI[1], A. K. MISHRA[2]

[1,2]Department of Livestock Production Management, College of Veterinary Science and A.H, Rewa, Madhya Pradesh
Nanaji Deshmukh Veterinary Science University
South Civil Lines, Jabalpur, Madhya Pradesh- 482001
INDIA

Abstract: Decreasing community grazing land and increasing price of conventional feed and fodder is posing threat to sustainable goat farming and advocates investigation on alternate and cheap sources of nutritious feed and fodder. The present study was carried out on post-weaned kids of local goats to find out the effect of feeding dried *Moringa oleifera* leaves in replacement with concentrate mix on growth rate, feed conversion ratio and haemato-biochemical parameters of goat kids. The study was carried out at the existing shed of a farmer's home in the village, Baisa, Rewa (M.P). Total eighteen post-weaned kids of local goats of uniform age and weight were taken for the study. The three experimental treatments were control group=100% concentrate mixture; Treatment group 1= 75%, concentrate mixture + 25% dried *Moringa Oleifera* leaves and Treatment group 2 = 50% concentrate mixture + 50% dried *Moringa Oleifera* leaves. Dried *Moringa Oleifera* leaves mixed thoroughly with concentrate before offering to animals. Experimental kids were offered measured quantities of feeds and fodder and leftovers were measured on the next day. Body weight, feed efficiency, Dry matter intake of animals is recorded at fortnightly intervals and biochemical Parameters were recorded at 0-, 45- and 90-day's intervals. Design of the experiment was completely randomized design and recorded data was analyzed as per the standard statistical method. There was a linear but only numerical increase in growth rate and Dry matter intake but there were found significant ($P<0.01$) increase in feed efficiency and haemoglobin concentration ($P<0.05$) on increasing percentage of dried Moringa leaves in concentrate.

Keywords: Goats, Dried *Moringa Oleifera* leaves, Growth rate, Kids, Post-weaned

Received: July 7, 2022. Revised: September 5, 2022. Accepted: October 11, 2022. Published: November 8, 2022.

1 Introduction

Area under fodder production has been stagnant (only 4 to 5 % of total cultivated area) for decades [8]. The decreasing availability and growing cost of conventional feed and fodder is affecting productivity and disturbing the budget, respectively and putting a big question mark on sustainable livestock farming. The deficit in green and dry fodder was 63.50 and 23.56 %, respectively in 2015 as per 10th five-year plan which is projected to increase further by 2020 and 2025 [14]. In the current deficit situation fodder tree *Moringa oleifera* has potential to bridge the gap between demand and supply of feed and fodder. Its leaves serve as the source nutrient dense feed (balanced levels of essential amino acids, high concentration of protein, calcium, iron, Vitamin-A and Vitamin-C) and better biomass production, especially in dry periods, support its significance as livestock fodder [13]. *Moringa oleifera* species belongs to the genus Moringa, of the family Moringaceae. It is a multipurpose, drought resistant, fast growing tree of deciduous type and considered to have its origin in Agra and Oudh, in the northwest region of India and south of the Himalayan Mountains. The leaves contain 29.3% Crude Protein (CP), 6.23% Ether Extract (EE), 15.39% Crude Fiber (CF), 41.95% NFE and 8.43% ash (on DM basis) [12].

Large numbers of farm trials have been done on the effect of feeding dried *Moringa oleifera* leaves and recommends feeding Moringa leaves as it improves growth (body

weight, average daily body weight gain) [7]. Since only a few studies have done at farmers field on Moringa feeding, the present study was carried out on post-weaned kids of local goat to find out the effect of feeding dried *Moringa oleifera* leaves in replacement with conventional concentrate mix on growth, feed efficiency and biochemical parameters in goat kids at existing sheds of farmer's home in the village, Baisa, Rewa, Madhya Pradesh, India.

2 Materials and Method

2.1 Experimental animals and location

Total eighteen post-weaned goat kids of average three-month-old were selected from a flock of local goats at the farm of farmer of village Baisa, Rewa, Madhya Pradesh and distributed into three uniform groups on body weight basis. The experimental place is situated at 24ºN and 81 ºE longitudes at 450 MSL in the southern part of the third agro-climate zone, including Kymore plateau and Satpura hills. It has a tropical climate with average annual rainfall of 1128 mm. Summer temperature goes up to 45ºC and in winter it remains as low as 4ºC.

2.2 Experimental Treatments and Duration

The three experimental treatments were control group=100% concentrate mixture; Treatment group 1= 75% concentrate mixture + 25% dried *Moringa Oleifera* leaves (T1) and Treatment group 2 = 50% concentrate mixture + 50% dried *Moringa Oleifera* leaves (T2). Conventional concentrate mixture was mixed thoroughly at the rate 0%, 25%, and 50% with dried *Moringa Oleifera* leaves and was supplemented to animals at the rate of 1% of body weight. Kids were allowed daily 6 h of grazing and study was undertaken for 90 days (3 month).

2.3 Procurement of Moringa leaves

Dried *Moringa Oleifera* leaves were purchased from Rajasthan based farmers.

2.4 Procurement of concentrate

Concentrate was purchased from the local market. Proximate analysis of concentrate and dried *Moringa Oleifera* leaves individually and T1 and T2 concentrate mix was done as per standard method [5].

Table 1 Proximate compositions of Readymade concentrate *Moringa oleifera* leaves and concentrate mixtures on DM basis (%)

Parameters	Ready made Concentrate	Dried *Moringa Oleifera* leaves	T1 diet concentrate mix	T2 diet concentrate mix
Crude protein	17.23	28.20	23.62	26.00
Ether Extract	3.00	4.30	4.50	5.50
Nitrogen free extract	61.33	53.76	49.60	47.89
Crude Fiber	9.33	11.50	8.66	11.40
Acid insoluble ash	5.55	5.26	5.26	3.94
Moisture content	5.65	8.00	6.89	7.23

*Proximate analysis was performed at department of Animal Nutrition, COVSc. & AH, Rewa

2.5 General Management

Arrangements were done to house them separately from other animals in a well ventilated and protected shed and provided an individual feeder and watering bucket. The kids were managed under standard management practices. The goat kids were allowed 7 to 8 days of adjustment period during which they were gradually introduced to the experimental diets at 1% of their live body weight. All the experimental kids were de-wormed at the beginning of experiment by using Albendazole as an anthelmintic and were examined periodically for parasitic infestation

2.6 Observations Recorded

Body weight was recorded at start and then at fortnightly intervals using digital weighing balance. Daily measured quantities of feed were offered to the kids and leftovers were recorded on the next day. Economics of production was calculated based on price of procurement of different feeds and cost incurred in managemental activities.

2.7 Statistical Analysis

The recorded data obtained was analysed by analysis of variance using SPSS software version 20 statically package and methods [15].

3 Results and Discussion

3.1 Efficiency of feed utilization or feed conversion ratio

The influence of nutritional worth of feeds could be appreciated in terms of output such as body weight gain in comparison with dry matter consumption i.e., feed efficiency. The fortnightly feed efficiency calculated from the data of dry matter intake and body weight gain of each goat kid from all the groups and has been presented along with their mean in Table 2 and graphical representation is depicted in Fig 1. The mean values of feed efficiency were found to be 3.36±0.14, 3.04±0.12, 2.93±0.21 under control group, T1 and T2 group, respectively. The statistical analysis of data revealed a non-significant (P>0.05) effect among treatments in columns but there is significant (P<0.01) effect in rows among different treatment groups. This probably showed that the feed was better utilized at the higher level of inclusion of dried *Moringa oleifera* leaves and leaf-meal contains high level protein, essential vitamins, amino acids and low antinutritional factors like tannins, which could help the animals to better utilize the feed.

This probably showed that the feed was better utilized at the higher level of inclusion. *Moringa oleifera* leaf-meal contains high protein, essential vitamins, minerals, amino acids, and low anti-nutritional factors like tannins, which could help the animals to better utilize the feed [4]. The results obtained in the present study agree with those findings which show that feeding of Moringa leaves significantly increased feed efficiency in goats [9, 3] but disagreement with the findings shows a significant decrease in feed efficiency among the treatment groups [1].

Table 2 Feed conversion ratios at fortnightly interval

Interval	Control group	T1 group	T2 group	P- value
F.N 1	3.15±0.14^{Ab}	2.89±0.14^{Ab}	2.39±0.17^{Aa}	0.008
F.N 2	3.26±0.15	2.96±0.13^{Aab}	2.56±0.15^{ABa}	0.012
F.N 3	3.37±0.15	3.09±0.13^{Ab}	2.67±0.14^{ABa}	0.009
F.N 4	3.46±0.15	3.12±0.13^{Aab}	2.72±0.15^{ABa}	0.009
F.N 5	3.49±0.15	3.10±0.12^{Aab}	2.74±0.15^{ABa}	0.007
F.N 6	3.53±0.16	3.03±0.12^{Aa}	2.74±0.14^{ABa}	0.005
Overall	3.36±0.14^{A}	3.04±0.12^{A}	2.93±0.21^{B}	0.172
P-value	0.579	0.830	0.390	

Different superscripts in small letter (a, b, c, d) in a row and capital letter (A, B, C, D) in a column differ significantly

3.2 Body weight (Kg)

The body weight of each goat kid from all the groups were recorded at a fortnightly interval during the experimental period and is presented in Table 3. The final body weight of kids improved linearly with an increase in inclusion percentage of dried *Moringa Oleifera* leaves (Fig. 2). However, the difference was non-significant (P>0.05) in rows (11.18±0.42 *vs.* 11.52±0.38 *vs.* 11.94±0.54 Kg) but significant (P<0.01) effect in column among different treatment groups when compared from zero day to ninetieth day. The marked variation in weight gain by the animals fed the experimental diets may be attributed to dried *Moringa oleifera* leaves due to its high nutrient availability and palatability. The superior weight gains by T2 treatment over T1 followed by the control group may also be attributed to the high dry matter intake and feed utilization among T2 and T1 treatment groups. Increase in the body weight of goat kids in current study might be because *Moringa oleifera* is rich in amino acids, vitamins, and minerals particularly iron. The results obtained in the present study agreed with the reported non-significant change in final weight of goats offered concentrate with 50% *Moringa Oleifera* leaf meal [3]. Likewise, findings of goat kids were also parallel with present findings [6] however, they reported significant (P<0.05) change in body weight gain in lambs fed diet with partial replacement of Lucerne hay with *Moringa Oleifera* leaf

meal. The present findings were in partial agreement with the findings that reported non-significant differences in total body weight changes in goats fed with diet containing 0% and 5% *Moringa Oleifera* leaf meal [9] but the body weight change increased significantly (P<0.05) at 10% and 15% level of the diet. Contrary to present findings found significant (P<0.05) change in body weight on feeding *Moringa Oleifera* leaves to goat kids [7].

Table 3 Body weight (kg) of experimental Kids at fortnightly interval

Interval	Control group	T1 group	T2 group	P-value
0 DAY	8.60±0.42^{A}	8.61±0.38^{A}	8.57±0.55^{A}	0.998
F.N 1	9.01±0.42^{AB}	9.06±0.38^{AB}	9.10±0.55^{AB}	0.990
F.N 2	9.42±0.42^{ABC}	9.52±0.38^{ABC}	9.63±0.55^{ABC}	0.949
F.N 3	9.84±0.42^{ABC}	9.98±0.38^{BCD}	10.17±0.55^{ABC}	0.875
F.N 4	10.27±0.42^{BCD}	10.47±0.38^{CDE}	10.73±0.55^{BCD}	0.771
F.N 5	10.71±0.42^{CD}	10.98±0.38^{DE}	11.32±0.55^{CD}	0.642
F.N 6	11.18±0.42^{D}	11.52±0.38^{E}	11.94±0.54^{D}	0.509
P-value	<0.01	<0.01	<0.01	

*Different superscripts in small letter (a, b, c, d, e) in a row and capital letter (A, B, C, D) in a column differ significantly. F.N.: Fortnight

3.3 Supplemented Feed intake/ Dry Matter Intake (DMI) (g/d)

Feed intake has been described as a measure of diet appreciation, selection, and consumption by an animal. It is the key process which determines the quality of feed stuff which is ingested over the period usually per day.

The average daily supplemented feed intake on dry matter basis per goat kids in all the treatment groups calculated fortnightly is presented in Table 4. The overall mean values for daily supplemented feed intake at the end of the experiment were found to be 93.13+4.27, 95.42+5.65, 98.93±5.54 for control group, T1 and T2 group, respectively (Fig. 3). The feed intake (g/d) increased linearly at the end but the difference was non-significant (P>0.05) but there is significant (P<0.01) effect in the column among different treatment groups. Similar findings in goats fed concentrate with 50% *Moringa Oleifera* leaf meal [2]. Similar non-significant change in DMI was reported in goats fed with *Moringa Oleifera* leaves [7].

The results obtained in the present study are in partial concurrence with that feeding fresh and silage of *Moringa Oleifera* leaf improved DMI significantly however there was only numerical increase in feeding hay of *Moringa Oleifera* [11]. While, contrary to present findings, reported that *Moringa Oleifera* leaf-meal feeding significantly (P<0.05) reduced daily DMI in goats [4]. In present study dry matter intake was highest in T2 treatment group and is comparable in values in T1 group but least in case of control group. This may be due to dried *Moringa oleifera* leaves having higher protein quality, greater palatability and higher protein content, acceptability, consumption, and utilization of experimental diets by local goat kids.

Table 4 Fortnightly supplemented feed intake (g/day) in experimental kids

Interval	Control group	T1 group	T2 group	P-value
F.N 1	85.92± 4.17	85.99± 3.82	85.67± 5.47	0.999
F.N 2	90.05± 4.18	90.54± 3.78	104.86 ±12.38	0.344
F.N 3	94.19± 4.19^{ABC}	96.11± 3.84^{ABC}	96.27± 5.49^{AB}	0.938
F.N 4	98.39± 4.18^{ABC}	100.76 ±3.85^{BCD}	101.70 ±5.49^{AB}	0.870
F.N 5	102.68 ±4.18^{BC}	105.47 ±3.91^{CD}	107.30 ±5.48^{AB}	0.775
F.N 6	106.74 ±4.11^{C}	110.68 ±3.82^{D}	113.13 ±5.48^{B}	0.612
Overall	93.13± 4.27^{AB}	95.42± 5.65^{ABC}	98.93± 5.54^{AB}	0.733
P-value	<0.01	<0.01	<0.01	

*Different superscripts in small letter (a, b, c, d, e) in a row and capital letter (A, B, C, D) in a column differ significantly.
F.N.: Fortnight
**In addition to supplemented feed kids were allowed 6 hrs. daily grazing.

4 Haemato-Biochemical Parameters

Blood parameters were recorded at 0-day, 45 day and 90 days of the study by using an auto hematology analyzer.

4.1 Hemoglobin (Hb)

The findings of hemoglobin concentration with their standard error have been presented in Table 5 and graphical analysis depicted in Fig. 4. The overall mean of Hemoglobin at 0 day were 9.65±0.51, 9.55±0.39, 9.62±0.28 per cent in control, T1 and T2 group, respectively but after 90 days the values became 9.77±0.37, 10.42±0.34, 11.36±0.32 for control, T1 and T2 group, respectively which was statistically significant (P<0.05).

The changes in the hemoglobin were non-significant for the control group but it was significant (P<0.05) in case of T1 and T2 group. The Highest average Hb was found in goat kids fed with T2 diet while the lowest was found in goat kids fed with control diet. The statistical analysis of data as shown in Table 08 revealed significant (P<0.05) effect of treatments in 0 day and 90 days. In present study, the Hb values ranged 9.65 to 11.36 (g/dl) and fell within the normal physiological range of 8 to 12 (g/dl) for goats [10]. The Hb values tended to increase with the increasing levels of the test ingredient. This is an advantage as these diets seemed to be capable of supporting high oxygen carrying capacity of blood in these animals.

The results obtained in present findings disagree with the observations that non-significant difference in Hb values in goat fed Moringa leaves by replacing concentrate mixture [9, 3]. However, the present findings agree with the observations of a significant difference in Hb values in goats fed Moringa leaves in goat ration [6].

The increasing values of Hb concentration are observed with increasing levels of *Moringa oleifera*, suggesting that dried Moringa leaves are rich in iron and protein and their superiority in terms of their capability of supporting high oxygen carrying capacity of the blood. The normal hemoglobin indicates physiological stress free and absence of anemia related diseases which might be due to iron deficiency.

Table 5 Haemoglobin (g/dl)

Groups	DAY 0	DAY 45	DAY 90	P-value
Control group	9.65± 0.51^{Aa}	9.95± 0.28^{Aa}	9.76± 0.37^{Aa}	0.87
T1 group	9.55±0.39^{Aa}	10.39± 0.29^{ABa}	10.42± 0.34^{ABa}	0.15
T2 group	9.62±0.28^{Ac}	10.97± 0.24^{Bb}	11.36± 0.32^{Cc}	<0.01
P-value	0.98	<0.05	<0.01	

*Different superscripts in small letter (a, b, c) in a row and capital letter (A, B, C, D) in a column differ significantly

4.2 Serum Total Protein

The findings of mean serum total protein values with standard error in the groups have been presented in Table 6 and graphical analysis depicted in Fig. 5. The overall mean of serum total protein values at 0 day were 6.62±0.11, 6.56±0.10, 6.59±0.11 for control, T1 and T2 group, respectively which became 6.60±0.10, 6.57±0.08, 6.74±0.09 for control, T1 and T2 group, respectively at 90 day of experiment. The statistical analysis of data revealed non-significant differences between the groups. The serum total protein values in all the groups were in the normal range of 6 to 7.5 g/dl for goats [10]. The high level of total protein is safe, beneficial, and not detrimental because the levels of some chemical composition of Moringa leaves are beneficial as they impact some qualities of rumen undegradable protein, thus improving protein availability and utilization. Moringa leaves are also a good protein source that is a convenient substitute of some meals (soybean and rapeseed) for ruminants, and they can improve the microbial protein synthesis in the rumen [16].

The results obtained in present study disagree with that significant difference in serum total protein values in goat fed Moringa leaves by replacing concentrate mixture [6, 7]. However, the present findings agree with the observations that show non-significant difference in serum total protein values in goats fed Moringa leaves [3].

Table: 6 Total Serum Protein (g/dl)

Groups	DAY 0	DAY 45	DAY 90	P-value
Control group	6.62±0.11	6.75±0.12	6.60±0.10	0.59
T1 group	6.56±0.10	6.73±0.12	6.57±0.08	0.42
T2 group	6.59±0.11	6.73±0.11	6.74±0.09	0.53
P- value	0.90	0.98	0.40	

4.3 Serum Albumin

The findings of Serum albumin mean values in the groups with standard error have been presented in Table 7 and graphical analysis has been depicted in Fig. 6. The overall mean of serum albumin values at 0 day were 3.15±0.19, 3.17±0.20, 3.20±0.19 gm/dl for control, T1 and T2 group and became 3.1±0.13, 3.07±0.09, 3.06±0.12 for control, T1 and T2 group, respectively. The serum albumin values in all the groups were in the normal range of 2.3 to 3.6 gm/dl for goats [10]. The statistical analysis revealed non-significant changes in the various groups. The highest level of serum albumin was observed in T2 and lowest in the control group. The higher serum albumin levels observed in the T2 group may be due to higher albumin content of Moringa leaves than the concentrate feed. The high level of serum albumin is safe, beneficial, and not detrimental.

The results obtained in the present study disagree with that shows significant difference in serum albumin values in goat fed Moringa leaves by replacing concentrate mixture [6, 7]. However, the present findings agree with the observations that show non-significant difference in serum albumin values in goats fed Moringa leaves [3].

Table 7 Albumin (g/dl)

Groups	DAY 0	DAY 45	DAY 90	P-value
Control group	3.15±0.19	2.98±0.10	3.1±0.13	0.69
T1 group	3.17±0.20	2.92±0.16	3.07±0.09	0.52
T2 group	3.20±0.19	3.00±0.15	3.06±0.12	0.63
P- value	0.97	0.91	0.97	

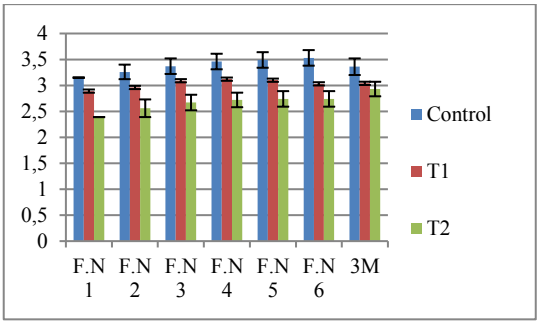

Figure. 1 Efficiency of feed utilization at fortnightly interval

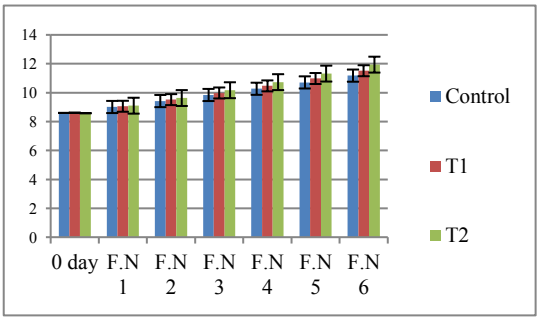

Figure. 2 Fortnightly interval body weight (kg)

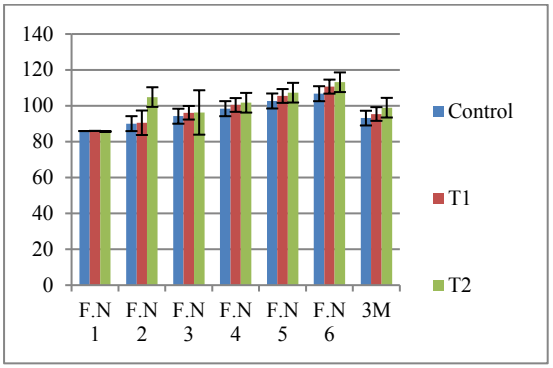

Figure. 3 Fortnightly supplemented feed intake (g)

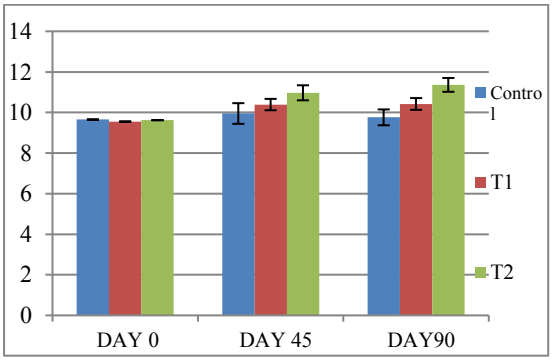

Figure. 4 Haemoglobin (g/dl)

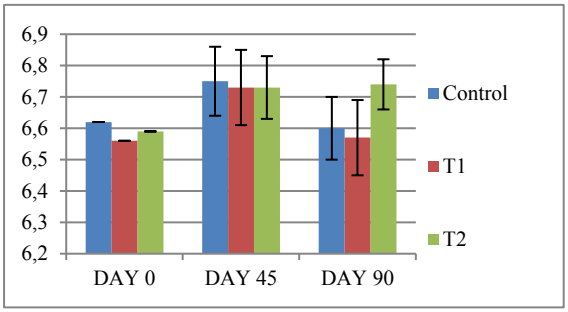

Figure. 5 Serum Total Protein (g/dl)

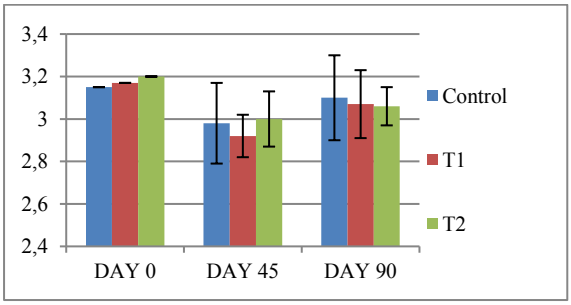

Figure. 6 Albumin (g/dl)

5 Conclusion

The results revealed that highly prized concentrate can be replaced with dried *Moringa Oleifera* leaves up to 50% and it improves daily gain and improves net return. We can increase the further percentage of Moringa leaves (dried) in different groups to know the effect on body weight, FCR, growth rate and haemato-biochemical parameters. Large scale studies on green as well as dried Moringa leaves feeding may be conducted under field and stall-feeding conditions in future. The study of the effect of Moringa leaves on growth performance should be carried out in case of large ruminants also. The study of Moringa leaf supplementation should be carried out in zoo animals for the reduction of cost of their feeding management. So, there is a need to educate farmers about dried *Moringa Oleifera* leaves feeding which can be done by extension workers in the field.

References

[1] Aye P A, Adegum M K (2013). Chemical Composition and some functional properties of Moringa, Leucaena and Gliricidia leaf meals. Agric. Biol. J. N. Am. 4(1): 71-77

[2] Ali S B, Kawitkar S B, Deshmukh A D, Dhok A P, Jawale M R, Chopde S V and Parihar N B. (2018). Performance of goats fed Moringa oleifera leaf meal incorporated in concentrate mixture. Indian Journal of Animal Nutrition, 35(2): 239-241.

[3] Ali S B. 2017. Growth performance of goats fed Moringa oleifera leaf meal incorporated in concentrate mixture. M.V.Sc. Thesis, Maharashtra animal and fishery sciences university, Nagpur.

[4] Asaolu V O, Binuomote R, Akinlade J, Aderinola O and Oyelami O. 2012. Intake and growth performance of West African Dwarf goats fed Moringa oleifera, Gliricidia sepium and Leucaenaleucocephala dried leaves as supplements to Cassava Peels. Journal of Biology, Agricultural Health, 2(10): 76-88.

[5] Association of Analytical Chemist. 2005. Official methods of analysis (18thed). Washington, D.C.U.S.A.

[6] Babiker E E, Juhaimia F A L, Ghafoora K. and Abdounb 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.
[7] Damor S V, Pawar M M, Ankuya, K J, Gami Y M, Srivastava A K, Chauhan H D and Chaudhary K R. 2017. Effect of feeding different levels of Moringa (Moringa oleifera) leaves on growth performance of Mehsana goat kids. Trends in Biosciences, 10 (18).
[8] Indian Council of Agriculture Research 2016. Handbook of Animal Husbandry. New Delhi, India.
[9] Jiwuba P D C, Ahamefule F O, Okechukwu O S and Ikwunze K. 2016. Feed intake, body weight changes and haematology of West African dwarf goats fed dietary levels of Moringa oleifera leaf meal. Agricultura, 13 (1-2):71-77.
[10] Kaneko, J.J., Harvey, J.W. and Bruss M.L. (1997). Clinical biochemistry of domestic animals. 5th Edition, Harcourt Brace and Company Asia Pvt. Ltd., Acadmic press, USA. pp. 890-893.
[11] Kholif A E, Morsy T A, Gouda G A, Anele U Y and Galyean M L. 2016. Effect of feeding diets with processed Moringa oleifera meal as protein source in lactating Anglo-Nubian goats. Animal Feed Science Technology, (217): 45-55.
[12] Lakshmipriya G, Kruthi D and Devarai S K. 2016. Moringa oleifera: A review on nutritive importance and its medicinal application. A Department of Chemical Engineering, Ordnance Factory Estate, Yeddumailaram, Indian Institute of Technology Hyderabad, Telangana and Department of Biotechnology, PES University, Bangalore, India.
[13] Nouman W, Basra S M A, Siddiqui M T, Yasmeen A, Gull T and Alcayde M A C. (2014). Potential of Moringa oleifera L. As livestock fodder crop: a review. Turkish Journal of Agriculture, 38: 1-14.
[14] Rathod P and Dixit S. 2019. Green fodder production: A manual for field functionaries. International Crops Research Institute for the Semi-Arid Tropics. Patancheru, Telangana, India, 56.
[15] Snedecor G W and Cochran W G. 2002. Statistical methods. 7th ed. The Iowa State University Press, Ames, Iowa, USA.
[16] Soliva, C. R., Kreuzer, M., Foidl, N., Foidl, G., Machmüller, A., & Hess, H. D. (2004). 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.