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Multi-Nutrient Blocks with and without Tanniferous Leaf Meal Mixture: Formulation and Preparation under Sub-Tropical Environment of Jammu

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ABSTRACT

An experimental study was conducted on formulation, preparation and production of two types of multi nutrient blocks (MNB) with and without tanniferous leaf meal mixture (LMM) for supplementation of goats fed on wheat straw based diet. The condensed tannins (CT) containing multi nutrient blocks (MNB-CT) and MNB were formulated, prepared and developed where MNB-CT had CT containing LMM of *Psidium guajava and Eugenia jambolana* in 70:30 ratio while MNB had no CT source. Other ingredients used included mustard oil cake, molasses, urea, limestone powder, di-calcium phosphate, mineral mixture, wheat bran and common salt were 875, 825, 181.25, 175, 193.75, 100, 112.5, 37.5 and 487.5, 825, 212.5, 162.5, 200, 100, 62.5, 37.5 (g/block), respectively in MNB and MNB-CT blocks. Nutrient composition (g/ block) of MNB and MNB-CT for organic matter, crude protein, ether extract, total ash, acid insoluble ash, calcium and phosphorus were 1939, 867.25, 17.25, 561, 20.5, 140.75, 62.25 and 1965.5, 861.75, 23.75, 534.5, 21.75, 130.75, 59 g, respectively. The MNB-CT blocks had good binding ability, compactness, hardness, less brittle and remained fit for licking to the animals compared to MNB blocks. The acceptability and intakes of both types of blocks were equally good. The LMM incorporation in MNB-CT reduced the cost of production as well as deworming in *H. contortus* infected goats so it directly curtailed the cost of goat rearing. Therefore, farmers could be benefited by supplementing MNB-CT blocks to improve health and productive performance of goats in sub-tropical region of Jammu (J & K), India.

Keywords: Formulation; Goats; Multi nutrient blocks, Leaf meal mixture; Preparation

Small ruminant production is almost entirely dependent on feeds consisting of fodder and crop residues. A major constraint to animal production in J and K state is the scarcity and fluctuating quantity and quality of year round feed and fodder supply. The cereal straws (wheat and paddy straw) and other forages derived from crop residues have been used as basal feed for ruminants for many years in Asia and other developing counties. Such feed resources are of low in metabolizable energy, digestible protein (Annonymous, 1990) and mineral contents and fail to meet even the maintenance requirements unless they are supplemented with additional nutrients. To improve production, the efficiency of utilization of the available feed resources can be optimized by the use of supplements that provide the deficient nutrients. The purpose of supplements is to provide nutrients that are deficient in the basal diet and nutrients needed for production. Farmers traditionally used supplements in the form of conventional concentrate to improve nutritive value of poor quality roughages but the high prices and poor accessibility of costly conventional concentrate is prohibited.

In many parts of the world, wide ranges of shrubs and tree leaves contribute extensively to livestock feed, mainly for sheep and goats, and contain in most cases a high level of proteins. Locally available tanniferous tree leaves or leaf meal mixture (LMM) have a great value as dietary supplements (Devendra, 1990; Pathak *et al*., 2014). The use of leaf meal as a supplement (Anbarasu *et al*., 2004) or a component in conventional concentrate has been shown to improve utilization of crop residues (Dutta *et al*., 1999). Supplementation of animals on basal diets with tree leaves increased feed intake and growth rate of sheep and goats (Aschfalk *et al*. 2002; Rubanza *et al*. 2007) and presence of condensed tannins (CT) protect the dietary protein from its degradation in the rumen. Day by day increasing the demand for organic food products as a result of rapid growth in the world economies and shrinking agricultural land and future hope for feeding the human population as well as safe guarding their food security will depend on the better utilization of plant secondary metabolites containing alternative non-conventional feed resources for ruminants (Pathak *et al*., 2013). One convenient and inexpensive way for effective utilization of locally available tanniferous tree leaves and to improve the nutritive value of poor quality roughage and control gastrointestinal nematode infection in organic environment are cost effective through the provision of CT containing multi nutrient blocks.

The multi-nutrient blocks are solidified blend of feed ingredients based on use of a high level of agro-industrial by-products. The formula of conventional and non-conventional supplements includes one or more binders (quicklime, cement, bentonite, etc.), common salt as a preservative, urea as a non-protein nitrogen source, and other feed ingredients as carrier of nutrients, mainly energy, nitrogen and minerals (Mubi *et al*., 2011; 2013). They are intended to supplement ruminants on poor quality roughages. The objectives of the study were to formulate and develop multi nutrient blocks with and without CT from locally available feed resources; to assess the effect of LMM incorporation on acceptability, palatability, hardness and binding ability; to assess the effect of MNB-CT on feed intake as well as anthelmintic efficacy in *H. contortus* infected goats and to promote wider dissemination of MNB-CT technology to the end-user farmers.

MATERIALS AND METHODS

The present study was conducted in the Division of Animal Nutrition, Faculty of Veterinary Sciences and Animal Husbandry, SKUAST-J, R. S. Pura, Jammu- 181 102.

Collection, drying and processing of tree leaves

Locally available tree leaves were collected from College premises and transported to the Divisional shed in fresh state. The tree leaves were shed dried. This was done to hasten the process of drying, and to reduce reaction time of plant enzymes and phenolics. Once the tree leaves were dried, they were processed for preparation of leaf meal. The leaf meals were prepared by grinding of dried leaves in electric grinder. Four tree leaves were selected for this study based on their availability, accessibility and possibility of containing condensed tannins (CT). They were processed and screened for their chemical composition, presence of CT and the potential sources of CT for experimental study. The samples of leaf meals were stored in a cool, dark and dry place only after it has dry matter content of > 90 %. A representative sample was kept for CT analysis.

Ingredients procurement and processing

The local market was surveyed for the easy accessibility and availability of feed ingredients that could be used for formulation of multi nutrient blocks. A variety of readily available and cheap ingredients were explored that could be incorporated in the MNB and MNB-CT supplements. Feed ingredients viz. molasses, wheat bran, mustard oil cake, fertilizer grade urea, mineral mixture, lime stone powder, di-calcium phosphate and common salt were procured from local market. The mustard oil cake and dried tree leaves of *E. jambolana* and *P. guajava* were processed by grinding using a milling/grinding machine. After grinding a suitable tanniferous leaf meal mixture (LMM) was prepared and formulated. The formulated LMM of *E. jambolana* and *P. guajava* in the ratio of 70: 30 was incorporated as CT source in multi nutrient blocks for preparation LMM containing multi nutrient blocks (MNB-CT). The composition of multi nutrient block (MNB-CT) was modified by incorporating LMM as CT source as well as an alternate feed supplement or replacement of conventional feed ingredients or as a functional feed for animal health.

Preparation of Multi nutrient blocks

The MNBs and MNB-CTs were prepared by cold process as per the method described by Sansoucy (1986). All feed ingredients were weighed individually as per the calculated amount required prior to commencing mixing. For preparation of the Multi nutrient blocks (MNB and MNB-CT), urea and molasses were mixed together by stirring in a container and then left for 3-4 hrs. All feed supplements viz. mineral mixture, lime stone powder, di-calcium phosphate and common salt were mixed with each other, before mixing with other dried and grinded feed ingredients, to give a uniform distribution in the whole premix. The urea-molasses liquid was poured into the whole premix of the above homogenous mixture and mixed on cemented floor. The MNB-CT blocks were prepared by incorporating LMM as CT source and cheaper alternative feed resources by replacing costlier conventional feed ingredients. The 2.5 kg of the semi-solid mixture was then put in a manually operated multi nutrient brick making machine and pressed for 3-4 seconds by manually pressing the handle of machine.

Drying of blocks

Before feeding, the blocks were air dried in the shed so as to be hard enough for handling, hanging and licking. The MNB and MNB-CT blocks were dried in the well ventilated shed. Turning of the blocks were done twice in a week to hasten and ensure even drying. The drying was done for about 3 weeks before the strength of the blocks were assessed. The shed under which the drying took placed that door was remained closed to avoid entry of stray animals. The blocks were then stored until feeding.

Multi nutrient block assessment

The hardness and compactness of both types of blocks were measured by three persons independently three weeks after manufacturing following the method of Hassoun (1989). In our study assessment of blocks was performed after three weeks of manufacturing in place of one week as in Hassoun (1989) method because we did not used cement as binder in our experiment. Hardness was assessed by pressing with the thumb in the middle of the block. A block was characterized soft (S), medium (M) or good (G) when the thumb penetrated easily, very little or only with greater pressure, respectively. The compactness was assessed by trying to break the block by hand. A block was characterized as null (N), medium (M), fairly good or good (G) when it was broken easily, with difficulty or with great effort, respectively.

Physical characteristics

Appearance/ colour, texture, aroma and taste were determined independently by three persons according to Hadjipanayiotou (1994) methods.

Chemical and statistical analysis

Tree leaves and multi nutrient blocks were analysed for proximate composition (AOAC, 2000), fibre fractions (Van Soest *et al*., 1991) and CT (Makkar, 2000). The results obtained were subjected to analysis of variance (Snedecor and Cochran 1994) and data were analyzed using SPSS (Version 11.0, SPSS Inc, Chicago, USA).

Cost of multi nutrient blocks

The cost of blocks was calculated based on the current prices of locally available feed ingredients at the time of blocks formulation and preparation.

Experimental animal and design

Twelve non-descript male goats (26.49 ± 0.87 kg average body weight) approximately 2 years of age were randomly allocated in 3 groups (4 in each group). The MNB supplemented in first two groups i.e. in T_1 (no infection) and T_2 (*Haemonchus contortus* infection @ 1500 larvae/ goat) group, while, MNB-CT were supplemented in T_3 (*H. contortus* infection @ 1500 larvae/goat) group in completely randomized block design. The goats were individually offered measured quantities of respective concentrate mixtures at the rate of (100g/ goat/day) in the morning. Wheat straw was offered *ad libitum* to meet their maintenance requirement (NRC, 2007) and the individual multi nutrient block (MNB) was hanged in front of the manger of goats of both T1 and T2 groups, which are easily accessible to individual goat. However, MNB-CT blocks were hanged in front of the manger of individual goat of T3 group only. Offered and refusals of feed from all the goats were weighed daily and sampled at weekly intervals for subsequent analysis of dry matter to assess the average feed intake during the experimental period of 75 days.

Table 1. Chemical composition of tree leaves (on % DM basis)

Attributes	P. guajava	E. Jambo-lana	L. leuco-cephala	M. alba
Organic matter	90.95	91.84	90.85	90.66
Crude protein	9.36	9.05	24.71	19.36
Ether extract	3.76	4.08	4.79	3.77
Total Ash	9.05	8.16	9.15	9.34
Acid insoluble ash	2.03	1.63	2.06	2.98
Calcium	2.06	1.93	2.47	2.85
Phosphorus	0.21	0.06	0.27	0.19
Neutral detergent fibre	33.93	31.08	30.35	24.46
Acid detergent fibre	27.04	26.44	18.56	19.06
Condensed tannins	11.06	7.63	5.05	0.13

RESULTS AND DISCUSSION

Chemical composition of tree leaves

The chemical composition of tree leaves viz *E. jambolana*, *L. leucocephala, M. alba* and *P. guajava* leaves is presented in the table 1. A wide variation in the chemical composition of locally available tanniferous tree leaves was evident. Rumen fermentation is affected if the CP level in diet is less than 10%, however, CP level in these trees is higher than this level except *E. jambolana*. Differences in CP contents between leaves of different trees are probably due to differences in protein accumulation in them during growth (Cheema *et al*., 2011). The ether extract content of tree leaves ranged from 3.76 to 4.79 percent with the highest in *L. leucocephala* and lowest in *P. guajava*.

The calcium content (%) was found to be highest in *M. alba* (2.98) followed by *L. leucocephala* (2.47), *P. guajava* (2.06) and *E. jambolana* (1.93) leaves. Concentration of Ca in most of the tree leaves varied from 2 to 4% (Cheema *et al*., 2011). However, phosphorus content of tree leaves ranged from 0.06 – 0.27 percent, with the highest in *L. leucocephala* and lowest in *E. jambolana*. The tree leaves are rich in Ca and poor in P. The Ca: P ratio of selected tree leaves in present study was wide as compared to those recommended for ruminants (McDowell, 1997) and it should be adjusted to normal one (2:1 to 4:1) by supplementation with P for their proper utilization in the animal system (McDowell, 1997) when tree leaves are considerable part of ruminant ration.

Table 2. Ingredients and chemical composition per block on DM bases

Ingredient	MNB	MNB-CT
Ingredients composition (g/2.5 kg block)		
Mustard oil cake	875.00	487.50
Leaf meal mixture (LMM)	0.00	412.50
Molasses	825.00	825.00
Urea	181.25	212.50
Lime stone powder	175.00	162.50
Di calcium phosphate	193.75	200.00
Mineral mixture	100.00	100.00
Wheat bran	112.50	62.50
Common salt	37.50	37.50
Cost / block (₹)	36.33	31.55
Net saving/ block (₹)	-	4.78
Chemical composition (g/2.5 kg block)		
Organic matter	1939.00	1965.50
Crude protein	867.25	861.75
Ether extract	17.25	23.75
Total ash	561.00	534.50
Acid insoluble ash	20.50	21.75
Calcium	140.75	130.75
Phosphorus	62.25	59.00
Condensed tannins	-	44.00

The chemical composition of target tree leaves in the present study was comparable with the values reported by many workers (Dey *et al*., 2006; Pathak *et al*., 2015), except some species/ nutrient specific differences usually observed in such tree leaves. NDF fraction (%) of tree leaves was highest in *P. guajava* (33.93) and lowest in *M. alba* (24.46). Similarly, ADF content (%) of tree leaves ranged from (19.06-27.04). Lower values of ADF in these tree leaves indicate good potential a ruminant feed (Bakshi and Wadhwa, 2007). The CT (%) content was found to be highest in *P. guajava* (11.06) followed by *E. jambolana* (7.63), *L. leucocephala* (5.05) and lowest in *M. alba* (0.13). The wide range of CT in tanniferous tree leaves

(0.13- 11.06 %) are in conformity with the findings of earlier workers (Dey *et al*., 2006 and Pathak *et al*., 2015). The levels of CT in plants vary greatly between species, within species, stage of development, from location and from year to year.

On the basis of presence of CT content of four tree leaves, two tree leaves were selected for formulation of LMM as potential CT source and alternative feed resource (Table 1). Multi nutrient blocks with and without LMM were formulated and prepared to expand the feed resources/ feed supplement for goats.

Table 3. Hardness and compactness of MNB and MNB-CT blocks after 3 weeks of preparation

Parameters	MNB block	MNB-CT block
Hardness*	Moderate	Good
Compactness*	Fairly good	Good

*Blocks comparison of the basis of judgment of 3 panelists.

Preparation and quality assessment

Both types of blocks (MNB and MNB-CT) in the present study were prepared by using the formulation containing different feed ingredients without cement as binder given in the table 2 and both types of blocks were found good for feeding, being relatively easier to prepare, lesser breakable and requiring a relatively short time to dry. According to Sansoucy *et al*. (1988) strength (hardness and compactness) of the blocks must be consistent. If they are too soft, there may be risks of toxicity resulting from the high intake of urea. If they are too hard, the intake is too low to have any effect on the animals. The LMM as CT source was added in the MNB-CT blocks by replacing conventional concentrate ingredients and maintaining balanced nutrients in these blocks, which have good binding ability. Therefore, MNB-CT blocks were found better than MNB blocks in compactness, hardness and less brittle and remained fit for licking purpose to the animals. This showed that good compression was needed to obtain multi nutrient blocks of good strength despite the role binder's play. In our experiment no apparent deteriorations of both types of blocks were noticed when they were kept indoors under dry conditions for up to 3 months. This might be due to the sufficient pressure was provided for preparation blocks in manually operated multi nutrient brick maker which was needed for proper compaction of blocks.

Physical characteristics

The MNB-CT blocks with LMM displayed a dark green to blackish brown colour after complete drying (Figure 1) and this could be a result of the combined effect of molasses and LMM as component of MNB-CT, whereas, the MNB blocks without LMM displayed light golden brown colour (Figure 2). This could be due to the presence of molasses and conventional feed ingredients. Both types of blocks (MNB and MNB-CT) have good aroma and taste (sugury and salty) due to the presence of molasses, salt and urea as reported by Hadjipanayiotou (1996). The texture of both

Table 4. Effect of MNB and MNB-CT on feed intake and faecal egg counts by goats

Attributes	Group*			SEM	P values
	T1	T2	T3		
Body weight (kg)	26.95b ± 2.01	18.60a ± 1.29	23.09ab ± 0.70	1.27	0.009
Feed intake % body weight					
Dry matter	2.38a ± 0.13	3.27b ± 0.21	2.72a ± 0.03	0.13	0.005
Concentrate	0.34a ± 0.03	0.50b ± 0.04	0.39a ± 0.01	0.02	0.013
Wheat straw	1.78a ± 0.10	2.38b ± 0.16	1.98a ± 0.04	0.09	0.011
MNB/ MNB-CT	0.25a ± 0.01	0.39c ± 0.01	0.34b ± 0.01	0.02	0.000
Faecal egg counts	-	525.00b ± 94.84	106.25a ± 23.95	57.22	0.000

^{ab}Means with different superscripts within a row differ significantly (P<0.05)
*T_1: Negative control; T_2: Infected Control; T_3: Infected Treatment

types of blocks with and without LMM were smoother due to the oily nature of molasses as well as the ingredients used in both type of blocks were finely grinded.

Figure 1. MNB-CT block dark green to blackish colour ready for supplementation

Figure 2. MNB blocks in golden brown colour ready for supplementation

Figure 3. Showing Acceptability and palatability of MNB-CT and MNB by goats

Chemical composition

The proportion of ingredients in the MNB and MNB-CT were presented in the table 2. The suitable proportions of wheat bran, mustard oil cake and urea etc. in multi nutrient blocks were replaced with LMM of *E. jambolana* and *P. guajava* dried LMM by making iso-caloric and iso-nitrogenous. The LMM as CT source was added @ 412.50 g / 2.5 kg of MNB-CT block. The proportions and ingredients composition used for formulation of multi nutrient blocks in the present study were contradictory to those used by previous workers (Asaolu, 2012; Mohammed *et al*., 2007; Mubi *et al*., 2011, 2013; Somasiri *et al*., 2010) It depends upon the availability and quality of local feed ingredients. Many workers used cement @ 10-15 % as binder for preparation of multi nutrient blocks (Mohammed *et al*., 2007), while the MNB and MNB-CT were prepared without cement. This contradicts with what was recommended by Aarts *et al*. (1990). Among the both type of blocks, MNB-CT containing LMM showed more compactness and hardness as compared to MNB. This may be due to the presence of LMM in MNB-CT which provides good binding ability. The technique and formulation were simple and could be easily adopted and carried out by smallholder farmer. The MNB and MNB-CT blocks without cement in this study took about 3 weeks for complete drying to achieve desired compactness and hardness. This is different from what was recorded by Hassoun (1989) who reported test for hardness and compactness for multi-nutrient blocks 7 days after drying. This also did not show leaking of water from multi nutrient blocks during block making when pressure was applied. These characteristics were different from those reported by Hadjipanayiotou (1996) who used larger quantity of water (40-60 liters) for every 100 kg of mixture used.

Lime stone powder is expected to complement the expected calcium supply from feed ingredients and leaf meal mixture, as calcium is the most abundant mineral element in the body with about 98.0 % being located in the skeleton. Di-calcium phosphate was incorporated to fulfil P requirements as well as to maintain proper Ca: P ratio. Salt was added to ensure adequate Na supply. It also acts as a preservative. Urea, known to farmers as a fertilizer for crop production, has been traditionally used in making multi nutrient blocks for livestock for improving feed digestibility and providing protein. Ruminant feed supplementation with urea has been reported to result in a greater feed intake due to a greater supply of ammonia to the rumen microbes (Dong *et al*., 2003).

Acceptability, average consumption and performance

All experimental goats were trained and well adopted for licking of multi nutrient blocks for two week before the start of experimental study. After proper individual adaptation, the acceptability of both types of blocks (MNB and MNB-CT) by experimental goats were accessed in all three groups (T_1, T_2 and T_3), which were found equally good (Figure 3). Results of average body weights, feed intake and faecal egg counts (FECs) were presented in the table 3. Significantly (*P<0.05*) lower body weight was recorded in infected control (T_2) group as compared to negative control (T_1) group, however, average body weight in infected treatment (T_3) group has an intermediate position between T_1 and T_2 groups. The feed intake percent of body weight (viz. dry matter, concentrate and wheat straw, etc.) was significantly higher in T_2 group as compared to T_1 and T_3 groups, whereas MNB intake percent of body weight was found to be highest in T_2 group followed by MNB-CT intake in T_3 group and the lowest MNB intake was recorded in T_1 group. Higher intake of supplements (*P<0.000*) in both infected groups (T_2 and T_3) as compared to negative control (T_1) which clearly indicated that the infected animal demanded more nutrients in readymade form to get rid from *H. contortus* infection or to repair the damage tissues in infected animals. The average FECs were significantly (*P<0.000*) lower in MNB-CT supplemented T_3 group as compared to MNB supplemented T_2 group. MNB-CT supplementation caused about 80 percent reduction in FECs and never touches the threshold level (300 FECs) in T_3 group. The lower FECs in T_3 group which might be due to the anthelmintic efficacy of CT present in MNB-CT. Present results are confirmatory with findings reported by earlier worker in sheep supplemented with CT containing LMM (Pathak *et al*., 2013; 2014).

Cost of multi nutrient blocks

Table 2 showed the cost of both types of multi nutrient blocks. The cost of MNB block without LMM is higher than those with LMM (MNB-CT block), due to the high cost of conventional concentrate ingredients in MNB blocks while these costlier ingredient was replaced by LMM in MNB-CT. Therefore, a unit of 2.5 kg blocks costs about ₹. 36.33 and 31.55 for MNB and MNB-CT, respectively, which was clear cut saving of ₹. 4.78 per MNB-CT block along with added advantages of CT as natural anthelmintic and functional feed supplement.

CONCLUSION

The MNB-CT blocks maintaining acceptability, palatability and binding ability which enhances its overall effectiveness and improved animal performance. In addition, it gives an opportunity to reduce overall cost and control *H. contortus* loads in goats by lowering FECs. MNB-CT offers advantages in terms of easy preparation, storage, transport and use by the farmers. In addition it also provides opportunities for farmers to manage supplementary feeds throughout the year based on their available feed resources.

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REFERENCES

Aarts, G.R., Sansoucy, R. and Levieux, G.P. 1990. Guide for manufacture and utilization of molasses-urea blocks. Mimeograph, FAO, Rome, Italy.

Anbarasu, C., Dutta, N., Sharma, K and Rawat, M. 2004. Response of goats to partial replacement of dietary protein by a leafmeal mixture containing *Leucaena leucocephala*, *Morus alba* and *Tectona grandis*. *Small Rum. Res.*, **51**: 47-56.

Anonymous, 1990. AOAC, Officieal Methods of Analysis, 15th ed. Association of official Analytical Chemists, Washington, DC.

AOAC, 2000. Official methods of analysis (16th ed.). Association of Official Analytical Chemists. Washington, DC.

Asaolu, V.O. 2012. Development of moringa multi- nutrient block as a dry season feed supplement for ruminants. *Livest. Res. Rural Dev.*, **24**: 3.

Aschfalk, A., Steingass, H., Müller, W. and Drochner, W. (2002) Merremia ridentata as a supplementary feed to the grass Panicum maximum for young West African dwarf sheep. *Trop. Anim. Health Prod.,* **34**: 145–150.

Bakshi, M.P.S. and Wadhwa, M. 2007. Tree leaves as complete feed for goat kids. *Small Rum. Res.*, **69**: 74-78.

Cheema, U.B., Sultan, J.I., Javaid, A., Akhtar, P. and Shahid, M. 2011. Chemical composition, mineral profile and *in* *situ*digestion kinetics of fodder leaves of four native trees. *Pak. J. Botany*, **43(1)**: 397-404.

Devendra, C. 1990. The use of shrubs and tree fodders by ruminants. In Shrubs and Tree Fodders for Farm Animals (Ed. C. Devendra). Proceedings of a workshop in Denpasar, Indonesia. IDRC, Ottawa, Canada. pp. 42-60.

Dey, A., Dutta, N., Sharma, K. and Pattanaik, A.K. 2006. Evaluation of condensed tannins from tropical tree leaves and its impact on *in vitro* nitrogen degradability of groundnut cake. *Anim. Nutr. Feed Technol.*, **6(2)**: 215-222.

Dong, S.K., Long, R.J., Kang, M.Y., Pu, X.P. and Guo, Y.J. 2003. Effect of urea multinutritional molasses blocks supplementation on liveweight change of yak calves and productive and reproductive performances of yak cows. *Can. J. Anim. Sci.*, **83 (1)**: 141 -145.

Dutta, N., Sharma, K. and Hassan, Q.Z. 1999. Effect of supplementation of rice straw with Leucaena leucocephala and Prosopis cineraria leaves on nutrient utilization by goats. *Asian-Aus. J. Anim. Sci.*, **12**: 742-746.

Hadjipanayiotou, M. 1996. Urea Blocks Made of a variety of by-products and binders*. Livest. Res. Rural Dev.,* **8(5)**: 16-18.

Hadjipanayioutou, M. 1994. Voluntary Intake and Performance of Ruminant Animals Offered Poultry Litter Silage. *Livest. Res. Rural Dev.*, **6(2)**: 24.

Hassoun, P. 1989. Manufacture of urea blocks without molasses. Mimeograph, FAO, Rome, Italy.

Makkar, H.P.S. 2000. Quantification of tannins in tree foliage. *A laboratory manual*. Joint FAO/IAEA working document, IAEA, Viena. pp 1-26.

McDowell, L.R. 1997. *Minerals for Grazing Ruminants in Tropical Regions*. University of Florida. Gainesville.

Mohammed, I.D., Baulube, M. and Adeyinka, I.A. 2007. Multinutrient blocks 1: Formulation and production under a semi-arid environment of North East Nigeria. *J. Biol. Sci.*, **7(2)**: 389 – 392.

Mubi, A.A., Mohammed, I.D. and Kibon, A. 2013. Effects of multinutrient blocks supplementation on the performance of Yankasa sheep fed with basal diet of rice straw in the dry season of Guinea Savanna Region of Nigeria. *Arch. Appl. Sci. Res.*, **5(4)**:172-178.

Mubi, A.A., Kibon, A. and Mohammed, I.D. 2011. Effects of Multinutrient Blocks Supplementation on the Performance of Grazing Yankasa Sheep in the Wet Season of Guinea Savanna Region of Nigeria. *Int. J. Sust. Agric.*, **3(3)**: 103-106.

NRC, 2007. *Nutrient Requirements of Small Ruminants; Sheep, Goats, Servids and New World Camelids*. National Academic Press, Washington DC.

Pathak, A. K. Dutta, N. Banerjee, P. S. Goswami, T. K. and Sharma, K. 2014. Effect of condensed tannins supplementation through leaf meal mixture on voluntary feed intake, immune response and worm burden in *Haemonchus contortus* infected sheep. *J. Parasit. Dis.,* DOI 10.1007/s12639-014-0455-1. Published online, 18 April 2014.

Pathak, A. K., Dutta, N., Banerjee, P. S., Pattanaik, A. K., Sharma, K. 2013. Influence of dietary supplementation of condensed tannins through leaf meal mixture on intake, nutrient utilization and performance of *Haemonchus contortus* infected sheep. *Asian-Aus. J. Anim. Sci.*, **26(10)**: 1446-1458.

Pathak, A. K., Dutta, N., Pattanaik, A.K., Singh, A., Narang, A. and Sharma, K. 2015. Effect of Condensed Tannins Supplementation from Tanniferous Tree leaves on Methane Production and Efficiency of Microbial Biomass Production in in-vitro Gas Production Test. *Anim. Nutr. Feed Technol.,* **15**(1): January, 2015 (In Press).

Rubanza, C.D.K., Shem, M.N., Bakengesa, S.S., Ichinohe, T. and Fujihara, T. 2007. Effects of Acacia nilotica, A. polyacantha and Leucaena leucocephala leaf meal supplementation on performance of Small East African goats fed native pasture hay basal forages. *Small Rum. Res.,* **70**:165–173.

Sansoucy, R. 1986. The Sahel: Manufacture of molasses-urea blocks. *World Anim. Rev.,* **57**: 40-48.

Sansoucy, R., Aarts, G. and Leng, R.A. 1988. Molasses-urea blocks as a multi nutrient supplement for ruminants. In: Sugarcane as feed. Sansoucy, R., Aarts, G. and Preston, T.R. (eds.) FAO Animal Health and Production Paper No.72, 263-279.

Somasiri, S.C., Premaratne, S., Gunathilake, H.A.J., Abeysoma, H.A. and Satsara, J.H.M.N. 2010. Development of leaf meal blocks as an animal feed. *Trop. Agric. Res.*, **21(4)**:412– 420.

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. *J. Dairy Sci.*, **74**: 3583-3597.