EFFECT OF STRATEGIC NUTRIENT SUPPLEMENTATION ON HEALTH, REPRODUCTIVE AND PRODUCTIVE STATUS OF BUFFALOES IN THE MALWA REGION OF MADHYA PRADESH

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ABSTRACT

In Malwa region of Madhya Pradesh, buffaloes have a significant contribution as dairy animals. Nutritional deficiencies cause several reproductive and metabolic problems in buffaloes. Rations of advanced pregnant buffaloes are mostly based on straw with very little concentrates and greens without any mineral supplementation. To find out the nutritional causes and in order to suggest the strategic nutrient supplementation to overcome these problems in dairy animals, the present study was conducted to know the nutrient status of buffaloes of Indore district of Malwa region of Madhya Pradesh. Twenty (20) adult healthy advanced pregnant buffaloes identical in all respect were selected randomly from the area of the study and feed intake of individual animal was measured to work out nutrient availability by considering chemical composition of dietary ingredients. The nutrient availability of individual animal was compared with the nutrient requirements given in the feeding standards to work out the nutrient deficiencies/excess/imbalance. Results indicated shortage of DCP 11 %, P 21 %, Zn 65 %, Cu 2 %, vitamin A 45 % and vitamin E 80 % in advanced pregnant buffaloes. On the basis of results obtained a strategic nutritional supplement, containing deficient nutrients, was formulated. These animals (20) were divided into two groups (a) Control/Un-supplemented (n=10) fed on existing ration (b) Treatment/Supplemented (n=10) fed on existing ration supplemented with strategic nutrients during advanced pregnancy for 2 months. The strategic nutrient supplementation in advanced pregnant buffaloes found to prevent reproductive problems, metabolic disorders and mastitis. It also improved the health status of buffaloes. However, there was no significant difference in milk yield of supplemented and un-supplemented groups.

Keywords: strategic nutrient supplement, reproductive, metabolic, mastitis, buffaloes, Malwa

INTRODUCTION

India has emerged as the largest milk producer in the world, but the productivity of the dairy animals is still dismally low. In India, many pre and post parturient disorders and low milk production in dairy animals have been attributed to several reasons. However, inadequate nutrition is the largest factor responsible for low milk production, reproductive and metabolic problems in the well defined breed of dairy animals, which received less attention than what actually it should. Most field cases of metabolic disorders and reduced fertility or of sterility of nutritional origin are usually due to multiple deficiencies (Blood and Radostitis, 2007).

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Hypocalcaemia and hypophosphatemia have been reported consistently in dairy animals as the predisposing factor for dystocia, retention of fetal membranes (Goff and Horst, 1997; Roche, 2006), and uterine prolapse (Mulligan *et al*., 2006; Pandey *et al*., 2007). The nutrient deficiency also fails to prevent many pre and post parturient disorders in dairy animals (Ranjhan, 1994; Kundu *et al*., 2005).

In Indore district of Madhya Pradesh, reproductive problems (prolapse of uterus, retention of placenta) and metabolic disorders (downers cow syndrome, pre and post haemoglobinuria) are common in buffaloes under field conditions which are most likely due to under feeding and non availability of balanced ration. It has been observed that the higher proportion of masoor/ gram straw in the ration of advanced pregnant buffaloes created an adverse Ca: P ratio, due to high level of Ca in these straws, leading to hypophosphatemia, which may be cause of haemoglobinuria in advanced pregnant buffaloes (Jain *et al*., 2012). Farmers of the region are following traditional feeding practices. Cotton seed cake is the only cake fed to lactating buffaloes in the name of concentrate along with straw (wheat straw/gram straw/masoor straw) and no mineral supplementation is being done to these animals. The most farmers are of view that "No milk - No Concentrate", only some offer little amount of concentrate/greens without any mineral mixture during advanced pregnancy. This could greatly imbalance the micro nutrient availability to animals and also their utilization.

MATERIALS AND METHODS

Twenty (average body wt. 517±6.60 kg) identical, healthy adult advanced pregnant buffaloes were selected randomly from 10 villages (Santer, Harsola, Kevti, Pipliya-malhar, Panda, Rau, Sonway, Bhaslai, Navda-Pand and Rangwasa) around Veterinary College, Mhow of Indore District. Body weights (kg) of the animals were determined by Shaeffer's formula (Sastry *et al*., 1982) through body measurement. Feed intake of each animal was calculated by weighing feed offered and residue left of each animal with the help of digital balance at both feeding times (morning and evening) for three consecutive days. The representative samples of each feed were subjected to proximate analysis (AOAC, 1995), Ca (Talpatra *et al*., 1940) and P (AOAC, 1995) and trace mineral estimations by atomic absorption spectrophotometer. Availability of DM, DCP, TDN, major elements (Ca and P), trace elements (Fe, Cu, Mn, Zn and Co) for each animal was calculated on the basis of chemical composition of feedstuffs and their intake. Selenium, β-carotene (1mg β-carotene = 400 IU vitamin A) and vitamin E intake were worked out using values given in the literature.

Finally, the nutrient availability of individual animal was compared with the standard nutrient requirements calculated for the specific body weight of each individual animal with the help of feeding standards (Kearl, 1982; NRC, 2001) and thus the deficiencies/ excess of each specific nutrient was worked out. The supplementation study was carried out in same twenty advanced pregnant buffaloes by dividing them into two groups having 10 buffaloes in each, the un-supplemented animals were offered the same diet which was being routinely followed by the farmers, while each animal of the supplemented group was supplemented with a specific amount of supplement (Table 3) in addition to the normal control diet.

This supplementation study was conduct for two months during advanced pregnancy.

During this period and post calving (one month) individual animal of both groups were examined for occurrence of common pre and post parturient reproductive (retention of placenta, vaginal/uterine prolapse) and metabolic disorders (milk fever, haemoglobinuria, downers syndrome, ketosis) on the basis of clinical symptoms and mastitis by CMT (Noorlander and Schalm (1957) (subclinical and clinical). The body condition score were measured in both groups of animals during the period of study. Milk yield was also measured for four weeks post calving. The data were analyzed as per the standard statistical methods described by Snedecor and Cochran (1994) for ANOVA, standard error, mean for body condition score and milk yield.

RESULTS AND DISCUSSION

The chemical composition of specific feed ingredients being consumed by the animals has been presented in Table 1. The feeds being offered to the animals were mainly the agricultural by-products including wheat straw, gram straw, masoor straw, soybean straw and wheat bran, green roughage was local grasses, maize fodder and MP chari, while the cake was only cotton seed cake, while at some places concentrate mixtures was also being used. Macro and micro nutrient contents of feedstuffs were presented in Table 1. The proximate composition of feedstuffs used for feeding buffaloes in the area of study is more or less in the same range as reported by other workers (Sen *et al*., 1978; Kearl., 1982; NRC, 1989; Ranjhan, 1991; NRC 2001; Mudgal *et al*., 2003; Das *et al*., 2005; Tiwary *et al*., 2007; Patil *et al*., 2014). The minerals contents of available feed stuffs were more or less within the range as reported by other workers (Sen *et al*., 1978; Kearl, 1982; NRC, 1989, 2001; Lal *et al*., 2000; Tripathi *et al*., 2002; Mudgal, 2003; Udar *et al.,* 2003; Das *et al*., 2004; Tiwary *et al*., 2007; Garg *et al*., 2008a, b; Shinde and Sankhyan, 2008; Patil *et el*., 2014).

The Ca content was within the range in available straws and concentrate feeds except in gram straw, which was much higher in calcium content in the present study as compared to values reported by other workers. The P contents in straws, concentrate feeds and green roughages were within the range as compared to values reported by other workers except masoor straw and cotton seed cake were lower than the reported values by Garg *et al*., 2008a, ; Shinde and Sankhyan, 2008; Patil *et el*., 2014. The levels of trace minerals in available feeds were varied. Iron content was higher in straws but it was within range. The Cu, Zn, Mn and Co contents in straws, green fodders and concentrate feeds were within the reported range. Zn content (38.88 to 69.00 ppm) was lower in cotton seed cake than the reported values (Sen *et al*., 1978; NRC, 1989, 2001; Garg *et al*., 2008a, 2008b).

Daily requirements and availability of nutrients in advanced pregnant buffaloes are presented in Table 2. Results indicated shortage of DCP 11%, P 21%, Zn 65%, Cu 2%, vitamin A 45% and vitamin E 80 %. Among major nutrient deficiency of DCP was marginal in advanced pregnant buffaloes. Similar observations were also recorded by earlier workers (Sinha, 1982; Mudgal *et al.*, 2003 and Tiwary *et al*., 2007). When the availability of major minerals were compared with standard requirements, calcium was shown to be supplied in excess (81%) which may be due to supply of higher amounts of leguminous straws in their ration. Leguminous straw over supplies calcium thus reduces the availability of phosphorus, as leguminous straws have a wider Ca: P (5.84:1) ratio and deficient in phosphorous

Table1. Macro and micro nutrient contents of feedstuffs (DM basis).

Feed stuffs	Wheat straw	Gram straw	Masoor straw	Soybean straw	Wheat bran	Cotton seed cake	Concentrate mixture	Local grasses	Maize fodder	MP chari
CP (%)	3.54±0.71	5.11±0.16	6.11±0.05	4.11±0.72	12.53±0.95	20.97±0.63	18.25±0.06	4.29±0.67	7.00±0.02	5.30±0.02
EE (%)	0.88±0.07	1.56±0.28	1.97±0.01	0.76±0.03	1.47±027	8.58±0.32	3.41±1.20	1.48±0.04	1.14±0.04	1.18±0.01
CF (%)	37.72±1.79	41.75±0.69	40.46±0.12	45.19±0.87	5.86±0.67	29.61±1.66	12.20±0.97	26.94±0.45	30.64±0.64	31.62±0.23
TA (%)	12.33±0.28	9.98±0.51	9.77±0.33	8.05±0.30	4.96±0.39	5.24±0.04	14.77±0.06	10.55±0.01	10.69±0.76	7.95±0.09
DCP (%)	0.28±0.01	2.32±0.01	3.60±0.09	1.19±0.41	10.15±0.02	17.82±0.02	13.14±0.00	2.44±0.09	4.27±0.02	1.32±0.06
TDN (%)	42.09±0.01	42.76±0.03	52.28±0.12	41.83±0.02	63.28±0.04	75.42±0.03	64.18±0.05	51.15±0.78	65.87±0.02	55.84±0.06
NFE (%)	45.52±0.01	41.60±0.01	41.69±0.01	41.89±0.05	75.18±0.03	35.60±0.43	51.22±0.08	56.74±0.00	50.55±0.02	53.95±0.11
Ca (%)	0.52±0.07	1.35±0.04	0.97±0.03	0.75±0.01	0.20±0.02	0.27±0.01	1.29±0.23	0.36±1.02	0.75±0.01	0.61±0.20
P (%)	0.08±0.02	0.10±0.01	0.10±0.01	0.17±0.89	0.59±0.01	0.54±0.28	1.01±0.34	0.18±0.00	0.28±0.01	0.18±0.01
Fe (ppm)	410.62±0.03	360.81±0.02	606.23±0.46	460.85±0.14	297.92±0.69	275.00±1.20	890.51±0.45	112.50±0.97	246.18±1.70	191.66±094
Cu (ppm)	5.31±0.30	8.89±0.51	4.64±0.32	10.00±0.02	11.30±0.19	8.96±0.01	18.02±0.56	8.43±0.14	6.80±0.03	5.80±0.15
Zn (ppm)	10.30±0.22	5.34±0.01	23.01±0.28	27.59±0.45	62.67±0.40	38.80±0.46	20.36±0.29	18.49±0.10	8.40±0.04	15.02±0.06
Mn (ppm)	48.09±0.06	35.49±0.01	37.51±0.04	34.03±0.07	130.01±0.05	32.27±0.01	100.65±0.02	28.90±0.23	133.82±0.02	56.11±0.31
Co (ppm)	0.16±0.02	0.68±0.01	0.64±0.03	0.17±0.00	0.21±0.01	0.48±0.01	0.90±0.32	0.10±0.12	0.20±0.02	0.11±0.07
Se[a] (ppm)	0.13	0.32	0.36	0.21	0.43	0.30	0.76	0.27	0.20	0.21
Carotene[b] (ppm)	0.20	1.00	1.00	Traces	0.10	0.20	Traces	97	285	276
Vitamin E[c] (IU/kg)	0.70	0.90	0.90	1.00	21.00	12.30	Traces	80.00	80.00	80.00

a, b, c = According to Sen *et al*. (1978), NRC (1989, 2001), Garg et al. (2008a, 2008b)

Table 2. Daily requirements and availability of nutrients in advanced pregnant buffaloes.

	Body Weight (Kg)	DM (Kg)	DCP* (g)	TDN* (Kg)	Ca* (g)	P* (g)	Fe* (mg)	Zn* (mg)	Mn* (mg)	Cu* (mg)	Co* (mg)	Se* (mg)	Vit A		Vit E** (IU)
													Vit A (IU)	Vit A*** (IU)	
Requirement	525	9.4	453	4.9	30	23	470	376	376	94	0.94	0.94	57750	200000	1128
Availability (Per head/ day)	517 **±6.60**	10.40 **±0.27**	404 **±29.95**	5.04 **±0.18**	110.83 **±5.10**	18.48 **±0.94**	3316 **±182.17**	132.18 **±6.55**	603 **±24.74**	91.98 **±5.30**	5.72 **±0.26**	1.94 **±0.12**	140400	-	223
Excess /Deficient		(+)1.00	(-)49	(+)0.14	(+)80.83	(-)4.84	(+)2846	(-)243.82	(+)227	(-)2.01	(+)4.78	(+)1.00	(+)82650	(-)90400	(-)905
Deficiency / Excess (%)			(-)11%			(-)21%		(-)65%		(-)2%				(-) 45 %	(-) 80 %

* Kearl (1982), ** NRC (2001), *** Recommended by NRC (2001) for reducing the incidence of mastitis.

Table 3. Ingredient composition of the supplements used for advanced pregnant buffaloes (Quantity / day).

Ingredient	Quantity
Soya- DOC	200 g
Sodium dihydrogen ortho phosphate dehydrate ($NaH_2PO_4.2H_20$)	30 g
Zinc oxide (ZnO)	304 mg
Copper sulphate ($CuSO_4.5H_2O$)	8 mg
Vitamin A supplement (5 lac IU/ g)	220 mg
Vitamin E supplement (50 % IU/100 g)	1810 mg

Table 4. Effect of strategic nutrient supplementation on reproductive problems metabolic disorders and mastitis.

	Un-supplemented group		Supplemented group	
No. of animals	**n=10**	**%**	**n=10**	**%**
Reproductive disorder				
1. ROP	-	-	-	0
2. Uterine prolapsed	1	10	-	0
3. Vaginal prolapsed	1	10	-	0
Metabolic disorders				
1. Haemoglobinuria	-	-	-	0
2. Downer's syndrome	-	-	-	0
3. Ketosis	-	-	-	0
Mastitis				
1. Clinical	-	-	-	0
2. Subclinical	1	10	-	0

Table 5. Effect of strategic nutrient supplementation on body condition score of buffaloes.

Weeks	Group-1 (Un-supplemented)	Group-2 (Supplemented)
	Prepartum	
1st	3.00±0.03^{f}	3.10±0.04^{g}
2nd	3.00±0.02^{ef}	3.10±0.04^{g}
3rd	3.12±.0.04^{e}	3.35±0.03^{f}
4th	3.25±0.03^{d}	3.40±0.04^{e}
5th	3.27±0.02^{d}	3.50±0.00^{d}
6th	3.42±0.04^{c}	3.60±0.03^{d}
7th	3.50±0.04^{c}	3.65±0.04^{c}
8th	3.62±0.04^{b}	3.75±0.00^{b}
9th	3.80±0.05^{a}	3.95±0.03^{a}
Overall mean **±SE**	3.33±0.31	3.47±0.41*
	Postpartum	
10th	3.08±0.06^{a}	3.12±0.05^{a}
11th	3.08±0.06^{a}	3.12±0.05^{a}
12th	3.10±0.07^{a}	3.12±0.05^{a}
13th	3.15±0.06^{a}	3.15±0.04^{a}
Overall mean **±SE**	3.10±0.01	3.13±0.03NS

Values with different superscript (a, b, c, d, e, f, g) in the same column differ significantly (P <0.05); * P <0.05, NS= Non significant

Table 6. Effect of strategic nutrient supplementation on milk yield (liters/d) of buffaloes.

Weeks	Group 1 (Un-supplemented)	Group 2 (Supplemented)
0 (5 days after calving)	3.35±0.16^{e}	3.50±0.14^{e}
1st	4.20±0.18^{d}	4.20±0.21^{d}
2nd	5.35±0.25^{c}	5.50±0.22^{c}
3rd	6.25±0.22^{b}	6.50±0.25^{b}
4th	7.05±0.21^{a}	7.30±0.26^{a}
Overall mean ±SE	5.24±0.21	5.40±0.22NS

Values bearing with different superscripts (a, b, c, d, e) in the same column do not differ significantly, NS= Non significant

by 21%. The deficiency of Zn was high whereas it was marginal for Cu and supply of Fe was in excess in the present study (Shinde and Sankhyan, 2008 and Jain *et al*., 2012).

Feeding a balanced ration to buffaloes in the last trimester of pregnancy through the breeding season is critical. Nutritional demands increase greatly in late gestation and even more in early lactation. Vitamins and minerals play a vital role in metabolism, normal growth, production and reproduction. As per the deficiency status of the nutrients, a strategic nutrient supplement was prepared using Soya De Oiled Cake (for protein and energy), sodium dihydrogen orthophosphate dihydrate (for P), zinc oxide (for Zn), copper sulphate (for Cu) and vitamin supplement (for vitamin A and E) were used. The amounts of strategic nutrient supplement added in the normal routine diet of advanced pregnant buffaloes are presented in Table 3. Measured amounts of trace minerals were supplemented by placing them in gelatin capsules. When strategic nutrient mixture was supplemented in the ration of advanced pregnant buffaloes reduced the chances of reproductive problems, metabolic disorders and mastitis in the present study (Table 4).

Similar findings were also observed by others (Sharma *et al*., 2007; Anwar *et al*., 2014 and Khan *et al*., 2015a, 2015b) that strategic mineral mixture supplementation was effective tool to check mineral deficiency and thus help to augment production and reproduction. There was significantly ($P<0.05$) improvement in body condition score (Table 5) of buffaloes during prepartum phase in the supplemented group as compared to un-supplemented group. This indicated that strategic nutrient supplementation not only improved the reproductive performance and also maintained the health of animal. BCS is generally a reflection of nutritional management (Alapati *et al*., 2010; Anitha *et al*., 2011 Funston, 2014 and Patil *et al.*, 2014). The milk yield (Table 6) was towards higher side in supplemented group, however difference among groups was non

significant statistically.

CONCLUSION

On the basis of above findings it may be concluded that the strategic nutrient supplementation in advanced pregnant buffaloes found to prevent reproductive problems, metabolic disorders and mastitis. It also improved the health status of buffaloes.

REFERENCES

Alapati, A., S.R. Kapa, S. Jeepalyam, S.M.P. Rangappa and K.R. Yemireddy. 2010. Development of the body condition score system in Murrah buffaloes: validation through ultrasonic assessment of body fat reserves. *J. Vet. Sci*., **11**(1): 1-8.

Anitha, A., S.K. Rao, J. Suresh, S.P.R. Moorthy and Y.K. Reddy. 2011. A body condition score (BCS) system in Murrah buffaloes. *Buffalo Bull.*, **30**(1): 79-96.

Anwar, F., M.S. Akhtar., C. Lal., L.A. Lodhi., M.M. Ayaz., I. Ahmad., A.A. Farooq and M. Akhtar. 2014. Effect of prepartum administration of selenium and vitamin E on subsequent postpartum performance in first calf nili-ravi buffalo. *J. Anim. Plant Sci*., **24**: 5-8.

Association of Official Analytical Chemists (AOAC). 1995. *Official Methods of Analysis*, 15th ed. Association of Official Analytical Chemists, Washington, DC.

Blood, D.C. and O.M. Radostitis. 2007. *In Veterinary Medicine*, 10th ed. Bailiere Tinland, 1613-1620.

Das, M.M., S.B. Maity and S.S. Kundu. 2004. Evaluation of masoor straw based ration in sheep and goats. *Indian J. Anim. Nutr*., **22**(3): 204-205.

Funston, R. 2014. Importance of early conception and factors influencing it, p. 63-79. *In The State of Beef Conference,* North Platte, Nebraska, USA.

Garg, M.R., B.M. Bhanderi and P.L. Sherasia. 2008b. Assessment of macro and micro minerals status of milch animals for developing area specific mineral mixture for Bharatpur district of Rajasthan. *Anim. Nutr. Feed Techn.*, **8**: 53-64.

Garg, M.R., B.M. Bhanderi, S.S. Kumar and P.L. Sherasia. 2008a. Macro and micro minerals status of dairy animals in hilly zone of kerala. *Anim. Nutr. Feed Tech.*, **8**: 13-23.

Goff, J.P. and R.L. Horst. 1997. Physiological changes at parturition and their relationship to metabolic disorders. *J. Dairy Sci*., **80**: 1260-1268.

Jain, R.K., C.M. Saksule and R.K. Dhakad. 2012. Nutritional status and probable cause of haemoglobinuria in advanced pregnant buffaloes of indore district of madhya pradesh. *Buffalo Bull.*, **31**(1): 19-23.

Kearl, L.C. 1982. *Nutrient Requirements of Ruminants in Developing Countries*. International Feed Stuffs Institute. Utah Agriculture Experimental Station. Utah Sate University, Logon, Utah, USA.

Khan, H.M., T.K. Mohanty., M. Bhakat., A.K. Gupta., A.K. Tyagi and G. Mondal. 2015a. Effect of vitamin E and mineral supplementation on biochemical profile and reproductive performance of buffaloes. *Buffalo Bull.*, **34**(1): 65-78.

Khan, H.M., T.K. Mohanty, M. Bhakat, A.K. Gupta,

A.K. Tyagi and G. Mondal. 2015b. Effect of vitamin E and mineral supplementation during peri-partum period on BCS, body weight and calf performance in murrah buffaloes. *Buffalo Bull.*, **34**(1): 79-85.

Kundu, S.S., S.K. Singh, S.K. Mahanta and G.H. Pailan. 2005. *Feeding Farm Animals*. Satish Serial Pulisher, Delhi. 503.

Lall, D., V.B. Dixit, N. Saxena, P.C. Lailer and S.S. Dahiya. 2000. Nutritional status viz a viz mineral deficiencies of buffaloes in Haryana state. *Indian Dairy Man*., **59**(9): 25-36.

Mudgal, V., M.K. Mehta, A.S. Rane and S. Nanawati, 2003. A survey on feeding practices and nutritional status of dairy animals in Madhya Pradesh. *Indian J. Anim. Nut*., **20**: 217-220.

Mulligan, F., L.O. Grady, D. Rice and M. Doherty. 2006. Production diseases of the transition cow: Milk fever and subclinical hypocalcemia. *Irish Veter. J*., **59**(12): 697-702.

Noorlander, D.O. and O.W. Schalm, 1957. Experiments and observations leading to development of the California mastitis test. *J. American Veteri. Medical. Assoc.*, **130**: 199-204.

NRC. 2001. Nutrient Requirements of Domestic Animals. *Nutrient Requirement of Dairy Cattle,* 7th ed. National Academic of Sciences. National Research Council, Washington. D.C., USA.

NRC. 1989. Nutrient Requirements of Domestic Animals. *Nutrient Requirements of Dairy Cattle, 6th* ed. National Academic of Sciences. National Research Council, Washington. D.C., USA.

Pandey, A.K., S.P. Shukla and S.P. Nema. 2007. Certain haemato-biochemical alterations during post-partum uterine prolapse in buffaloes (*Bubalus Bubalis*). *Buffalo Bull*., **26**(1): 20-22.

Patil, N., R.K. Jain and V. Mudgal. 2014. Effect of strategic nutrient supplementation on the reproductive performance of anoestrus buffaloes in the malwa region of madhya Pradesh. *Buffalo Bull*., **33**(2): 199-207.

Ranjhan, S.K. 1991. *Chemical Composition and Nutritive Value of Indian Feeds and Feeding of Farm Animals*. *In Proceedings of 7th Indian Council of Agricultural Research*, New Delhi, India.

Ranjhan, S.K. 1994. Consultant reports on the availability and requirement of feeds and fodder for livestock and poultry. Government of India, New Delhi.

Roche, J.F. 2006. The effect of nutritional management of the dairy cow on reproductive efficiency. *Anim. Repr. Sci.*, **96**(3-4): 282-296.

Sastry, N.S.R., C.K. Thomas and R.A. Singh. 1982. *Farm Animal Management and Poultry Production*, 2nd ed. Vikas Publishing House Pvt Ltd. New Delhi, India.

Sen, K.C., S.N. Ray and S.K. Ranjhan. 1978. *Nutritive Value of Indian Feeds and Feeding of Farm Animals.* Indian Council of Agricultural Research, New Delhi, India.

Sharma, K.B., R. Kumar, M. Verma and R. Sharma. 2007. Comparative studies on strategic mineral mixture supplementation in animals under different managemental conditions. (Abst.) *In The 23nd Annual Convention of ISSAR and National Symposium on Challenges in Improving Reproductive Efficiency of Farm and Pet Animals.* Orissa University of Agriculture and Technology-Bhubaneswar, India.

Shinde, A.K. and S.K. Sankhyan. 2008. Mineral contents of locally available feeds and fodders in flood prone eastern plain of Rajasthan and dietary status in ruminant. *Anim. Nutr. Feed Tech*., **8**: 35-44.

Sinha, M.N. 1982. *Gap Analysis in Relation to Feeding Recommendation*. Annual Report. National Dairy Research Institute, Karnal, India. 168-169.

Snedecor, G.W. and W.G. Cochran. 1994. *Statistical Methods*. Iowa State University Press Ames, Iowa, USA.

Talpatra, S.K., S.C. Ray and K.C. Sen 1940. Analysis of mineral constituents in biological materials. *Indian J. Veter. Sci. Anim. Husb*., **10**: 243-245.

Tiwary, M.K., D.P. Tiwari, A. Kumar and B.C. Mondal. 2007. Existing feeding practices, nutrient availability and reproductive status of dairy cattle and buffaloes in Haridwar district of Uttarakhand. *Indian J. Anim. Nutr*., **7**: 177-185.

Tripathi, M.K., A.S. Mishra, A.K. Misra, D.L. Verma, S.A. Karim and R.C. Jakhmola. 2002. Macro and micro mineral status of grazing livestock on community rangeland of semiarid Rajasthan. *Indian J. Anim. Sci*., **72**(12): 1182-1184.

Udar, S.A., S. Chopde and R.N. Dhore. 2003. Mineral profile of soil, feeds and fodder and buffaloes in Western agro-climatic zone of Vidarbha. *Anim. Nutri. Feed Techn*., **3**(2): 165-172.