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Original Research

Effect of Supplementation of Mineral Mixture on Haemato-Biochemical Profile of Goats

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Abstract

A study was conducted to evaluate the effect of supplementation of commercial and formulated mineral mixture on haemato-biochemical profile of goats. Twenty healthy goats were selected as Control (T1) and did not receive any mineral supplementation. Forty goats showing deficiency of minerals were divided into two groups and supplemented with commercial (T2) and formulated mineral mixture (T3). The haemato-biochemical parameters were analysed at 0-, 30-, 60- and 90-day post supplementation of mineral mixture. Mineral supplementation significantly increased Hb, PCV and TEC values (P<0.01) and decreased TLC values in both the treatment groups, while, status of lymphocytes, eosinophils, monocytes and basophils remained unaffected. Total protein, albumin, A:G ratio, blood glucose, ALP concentrations increased significantly (P<0.01), however, globulin, ALT, AST, BUN, urea and creatinine remained unaffected in both the groups. The results indicated an improvement in haemato-biochemical parameters with better recovery in T3 group. It can be concluded that supplementation of formulated mineral mixture is inevitable for goats to maintain the haemato-biochemical parameters.

Keywords: Commercial, Formulated, Goat, Minerals

Introduction

Minerals play an important role in growth, health and reproduction of livestock and its deficiency is responsible for poor growth, decreased production, reproductive disorders and decrease in immunity, which ultimately affects their productivity as well as general health (Underwood, 1981; Sharma *et al*., 2003). Large number of livestock around the world thrives on mineral deficient diets which culminate in mineral imbalances in the body leading to several physiological and pathological consequences (Prasad and Gowda, 2005). Health and production of livestock is thus greatly influenced by optimal level of major and trace minerals in the body (Sharma *et al*., 2009). Supplementation of proper concentration of various macro and microelements not only improve the productivity potential as well as reproductive status of animals but in excess concentration it may be harmful for body condition. Therefore, minerals must be provided to animals in optimal amount and concentrations as well as according to their requirements. Minerals that are not sufficient in ration of animals need to be supplemented through mineral mixture. Keeping in view above points, present study was planned to evaluate the efficacy of commercial and formulated mineral mixture supplementation on haematological and biochemical parameters in goats.

Materials and Methods

Twenty healthy adult female goats were randomly selected from organized goat farm and designated as Healthy Control (T_1) and did not receive any mineral supplementation throughout the study period. Forty adult female goats were also taken showing deficiency of minerals for this trial. Important clinical manifestations of mineral deficient goats observed were partial to complete anorexia, shuffling gait, tremor, pallor mucous membranes, poor exercise tolerance, weakness, weakening of bones, loss of body condition, abnormal appetite, craving for non-eatables like sand and stones, urine drinking, dry and rough hair coat, change in colour of hair coat and alopecia. These deficient goats were classified into two groups designated as T_2 and T_3 treatment groups, having 20 goats in each group for evaluation of efficacy of commercial and formulated mineral mixture supplementation on haemato-biochemical parameters. In T_2 treatment group, goats were supplemented with commercial mineral mixture and goats of T_3 group were supplemented with formulated mineral mixture based on the extent of mineral deficiency observed. Critical levels of serum minerals were used to determine mineral deficiency status in this study and if concentrations fall below critical levels, goats were considered to be deficient. The efficacy of newly formulated mineral mixture was compared to mineral mixture available commercially and evaluated in selected mineral deficient goats under field condition. Commercial (Type-II) and formulated mineral mixture (Type-II) was given to experimental animals @10g/day mixed with feed. The blood samples of goats were observed to contain adequate amount of sodium, potassium, cobalt and manganese. Wide spread deficiency of copper followed by zinc, calcium and phosphorus and marginal deficiency of magnesium and iron were observed in goats. The overall prevalence of serum calcium, phosphorus, magnesium, copper, iron and zinc deficiency in goats was 22.85, 14.85, 8.28, 37.14, 4.85 and 28.57 per cent, respectively. Based on the degree of deficiency of minerals observed in goats, specification of commercial mineral mixture was modified by incorporating deficient minerals at higher levels and excluding excess minerals from the formulation. The ingredients used in formulated mineral mixture included di-calcium phosphate, calcium carbonate, zinc oxide and copper sulphate. The formulated mineral mixture used in the study provides 27.59 g/100g calcium, 13.93 g/100g phosphorus, 0.77 g/100g zinc and 0.15 g/100g copper to meet out the deficiency of these minerals prevailing in the goats.

The blood samples were collected at 0-, 30-, 60- and 90-day post supplementation of mineral mixture and observations were recorded for haemato-biochemical parameters in healthy control and treatment groups. Blood samples were analyzed for determination of haematological parameters *viz*., haemoglobin, packed cell volume, total erythrocyte count, total leukocyte count and differential leukocyte count as per method of Jain (1986). Serum samples were analysed for total serum protein. Total serum protein, albumin, aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, blood glucose, blood urea nitrogen and creatinine were determined by the IDEXX VetTest Chemistry Analyzer using test kits supplied by IDEXX Laboratories, as per the manufacturer's subscribed procedure. Serum globulin was estimated in g/dl as a difference between total protein and albumin. Albumin and Globulin ratio (A:G) was derived after dividing concentration of Albumin by concentration of Globulin in g/dl. Urea was calculated by multiplying blood urea nitrogen (mg/dl) values with factor 2.14. The data obtained were statistically analyzed and compared as per the standard statistical procedures suggested by Snedecor and Cochran (1994).

Result and Discussion

The effect of supplementation of commercial and formulated mineral mixture was evaluated by observing alteration in haematological and biochemical parameters on 0, 30, 60 and 90 days of the mineral supplementation.

Haematological Parameters

The mean values of haemoglobin in mineral supplanted goats of T_2 and T_3 groups was significantly lower than that of control healthy group T_1 on day 0 of trial (Table 1).

Table 1: Haematological parameters in goats of different treatment groups

Parameters	Period (Days)	Treatment Groups			Significance
		T_1	T_2	T_3	
Haemoglobin (g/dl)	0	9.62±0.26^{b}	7.26±0.13^{a}	7.38±0.16^{a}	**
	30	9.75±0.18^{c}	8.58±0.10^{a}	9.21±0.13^{b}	**
	60	9.65±0.21^{a}	9.37±0.16^{a}	10.28±0.15^{b}	**
	90	9.78±0.22^{a}	10.08±0.14^{a}	10.97±0.20^{b}	**
	Overall (Mean ±SE)	**9.70±0.14^{b}**	**8.82±0.05^{a}**	**9.46±0.07^{b}**	**
Packed cell Volume (%)	0	29.50±0.80^{b}	21.95±0.48^{a}	22.55±0.35^{a}	**
	30	29.85±0.73^{b}	25.80±0.58^{a}	26.65±0.64^{a}	**
	60	28.65±0.62^{ab}	27.15±0.67^{a}	29.70±0.68^{b}	**
	90	29.25±0.58^{a}	28.80±0.60^{a}	32.90±0.57^{b}	**
	Overall (Mean ±SE)	**29.31±0.47^{c}**	**25.92±0.22^{a}**	**27.95±0.22^{b}**	**
TEC (million/cumm)	0	10.26±0.25^{b}	8.32±0.19^{a}	8.43±0.18^{a}	**
	30	9.91±0.24^{b}	9.13±0.16^{a}	9.56±0.15^{ab}	**
	60	10.38±0.26^{b}	9.54±0.18^{a}	9.98±0.16^{ab}	**
	90	10.04±0.19	10.00±0.16	10.46±0.17	**
	Overall (Mean ±SE)	**10.14±0.11^{c}**	**9.25±0.08^{a}**	**9.61±0.10^{b}**	**
TLC (thousand/cumm)	0	9.08±0.16^{a}	10.85±0.18^{b}	10.48±0.23^{b}	**
	30	9.12±0.15^{a}	10.50±0.17^{c}	9.80±0.18^{b}	**
	60	9.46±0.20^{a}	10.12±0.16^{b}	9.58±0.15^{a}	**
	90	9.35±0.17^{a}	9.98±0.16^{b}	9.30±0.16^{a}	**
	Overall (Mean ±SE)	**9.25±0.09^{a}**	**10.36±0.09^{c}**	**9.79±0.11^{b}**	**
Neutrophil count (%)	0	38.40±0.92^{a}	40.75±0.89^{b}	40.35±0.90^{b}	*
	30	37.65±0.93	40.15±0.87	39.95±0.92	NS
	60	38.25±0.98	40.50±0.70	39.65±0.76	NS
	90	38.15±0.97	39.85±0.95	39.15±0.79	NS
	Overall (Mean ±SE)	**38.18±0.56^{a}**	**40.31±0.59^{b}**	**39.77±0.58^{b}**	*
Lymphocyte count (%)	0	52.90±0.98	50.85±1.18	50.75±0.96	NS
	30	54.05±1.11	51.50±1.00	52.35±1.05	NS
	60	53.55±0.95	51.20±0.86	52.45±0.92	NS
	90	53.90±1.10	52.00±1.03	53.20±0.83	NS
	Overall (Mean ±SE)	**53.60±0.93**	**51.38±0.1.12**	**52.18±0.89**	**NS**
Eosinophil count (%)	0	4.50±0.24	4.35±0.25	4.40±0.28	NS
	30	4.25±0.26	4.05±0.27	4.15±0.27	NS
	60	4.40±0.30	4.20±0.28	4.00±0.22	NS
	90	4.10±0.23	4.30±0.19	3.95±0.23	NS
	Overall (Mean ±SE)	**4.31±0.15**	**4.23±0.12**	**4.13±0.14**	**NS**
Monocyte count (%)	0	3.65±0.20	3.40±0.31	3.90±0.20	NS
	30	3.15±0.22	3.60±0.28	3.05±0.22	NS
	60	3.25±0.28	3.50±0.25	3.35±0.32	NS
	90	3.35±0.26	3.20±0.24	3.05±0.20	NS
	Overall (Mean ±SE)	**3.35±0.11**	**3.43±0.13**	**3.34±0.09**	**NS**
Basophil count (%)	0	0.55±0.14	0.65±0.13	0.60±0.11	NS
	30	0.60±0.15	0.70±0.15	0.50±0.14	NS
	60	0.55±0.11	0.60±0.15	0.55±0.14	NS
	90	0.50±0.11	0.65±0.13	0.65±0.15	NS
	Overall (Mean ±SE)	**0.55±0.07**	**0.65±0.07**	**0.58±0.06**	**NS**

Means with different superscripts in a row differ significantly (P<0.05 and P<0.01)

Similar trend was observed till day 30 of trial, which was followed by highly significant (P<0.01) increase in haemoglobin concentration in goats of T_3 group and group T_2 on day 60 of trial. Non-significant increase in

haemoglobin concentration in T_2 group and significant increase ($P<0.01$) in T_3 group was observed on day 90 of trial period. The increased haemoglobin concentration was observed in formulated and commercial mineral mixture supplemented groups than in control at the end of therapeutic trial. The increase was also on higher side in formulated mineral mixture supplemented group than commercial mineral mixture supplemented group. Increased haemoglobin values due to mineral supplementation were also reported by Sharma *et al*. (2002), Kadus (2004), Samanta *et al*. (2005) and Singh *et al*. (2010). Similarly, Tiwari *et al*. (2000), Dey and Sanyal (2004), Samanta *et al*. (2005) and Yadav *et al*. (2017) reported significantly higher haemoglobin in mineral supplemented group probably due to better interaction of trace minerals and utilization of dietary iron. Hence, it could be opined that supplementation of trace minerals particularly copper and zinc may have indirect role in haemoglobin synthesis.

Almost similar trend was recorded in PCV as observed in case of haemoglobin in all the treatment groups. The mean values of PCV in mineral supplanted goats of T_2 and T_3 groups was significantly ($P<0.01$) lower than T_1 group on day 0 of trial. Similar trend was observed till day 30 of trial. Significant increase in packed cell volume ($P<0.01$) in T_3 group was observed on day 90 of trial period. However, at this period, the mean values of PCV in T_1 and T_2 groups were comparable. Rajora *et al*. (1995), Katoch and Mandial (2003), Kadus (2004), Sharmin *et al*. (2004) and Tufani and Haque (2007), Singh *et al*. (2010) reported a significant decrease in PCV in mineral deficient animals, which later returned to normal as a result of mineral supplementation. Findings of present study indicated, positive role of formulated and commercial mineral mixture supplementation to bring the PCV of mineral deficient animals at par with that of control animals.

On day 0 of the study, the mean TEC in goats of group T_2 and T_3 was significantly ($P<0.01$) low as compared to control healthy goats. On day 30 of trial, significantly ($P<0.01$) lower TEC in T_2 group and non-significant increase in TEC was recorded in T_3 group in comparison to healthy control. A non-significant increase in TEC was noticed in goats of T_3 group supplemented with formulated mineral mixture as compared to T_1 and T_2 group on day 60 of trial. On day 90 of trial period, the mean values of TEC group in T_1, T_2 and T_3 groups were comparable. Significant increase in TEC at the end of therapeutic trial in both mineral deficient groups of goats could find support from the results of Sharma *et al*. (2002) in buffaloes, Sharmin *et al*. (2004) and Tufani and Haque (2007). On day 0 of the trial period, the mean TLC in goats of group T_2 and T_3 was significantly ($P<0.01$) high as compared to control healthy goats. Similar trend was observed till day 30 of trial. The mean values of TLC in T_3 groups were decreased and comparable with the values of T_1 group on day 60 and 90 of trial. However, a significant ($P<0.01$) difference in TLC was recorded in T_2 group as compared to T_1 and T_3 on day 60 and 90 of trial period. A significant decrease in TLC was noticed in goats of T_2 andT_3 group on day 90 of trial compared to 0 day values. Significant decrease in TLC values after treatment in the present study is in concurrence with the findings of Senathiraja and Pandey (2002).

The results did not reveal any significant effect of mineral mixture supplementation on neutrophil, lymphocyte, eosinophil, monocyte and basophil count in different treatment groups recorded at 0-, 30-, 60- and 90-days period and are in agreement with the observation of Unny *et al.* (2001) in goats.

Biochemical Parameters

The results revealed highly significant ($P<0.01$) effect of commercial and formulated mineral mixture supplementation on total protein in different treatment groups over a trial period (Table 2). The mean values of total protein in mineral supplanted goats of T_2 and T_3 groups was significantly lower than that of control healthy group T_1 on day 0 of trial. Similar trend was observed till day 30 of trial. Comparable values of total protein in T_1, T_2 and T_3 groups on day 60 and 90 of trial period indicated improvement of total protein as a result of mineral mixture supplementation. Total serum protein concentration was similar in different treatment group before the onset of experiment, but the concentration of total serum protein was increased, when mineral supplements was given to the animals. Kalita *et al*. (2000), Samanta *et al*. (2005), Pandey *et al*. (2017) and Yadav *et al*. (2017) indicated the role of minerals supplementation on increased serum protein levels.

There was a steady improvement in albumin values in goats of T_2 and T_3 groups as a response of treatment on day 30, 60 and 90 of trial in comparison to values observed on day 0 of trial. Higher albumin level on day 90 compared to 0 day values. The findings of Siddique *et al*. (1989), Kalita *et al.* (2000), Pandey *et al.* (2017) and Yadav *et al.* (2017) also corroborates with the results of present investigation. Supplementations of formulated and commercial mineral mixture had no effect on serum globulin among the treatment groups and are in accordance to the findings of Siddique *et al*. (1989), Rao *et al*. (2004), Datta *et al*. (2007), Gouda *et al*. (2017), Waghmare *et al*. (2017) and

Pandey *et al*. (2018). The A: G ratio in the entire treatment group was comparable and indicated improvement in A: G ratio as a result of mineral mixture supplementation. Niaz *et al*. (2017) also reported improvement in A: G ratio on supplementation of area specific mineral mixture in Ganjam goats.

Table 2: Biochemical parameters in goats of different treatment groups

Parameters	Period (Days)	Treatment Groups			Significance
		T_1	T_2	T_3	
Total protein (g/dl)	0	7.36±0.12^b	5.90±0.07^a	5.96±0.10^a	**
	30	7.22±0.11^b	6.35±0.11^a	6.58±0.08^a	**
	60	7.16±0.16	6.83±0.10	7.06±0.13	**
	90	7.46±0.14	7.27±0.11	7.39±0.12	**
	Overall (Mean±SE)	**7.29±0.08^b**	**6.58±0.05^a**	**6.74±0.06^a**	**
Albumin (g/dl)	0	3.80±0.07^b	2.64±0.08^a	2.57±0.08^a	**
	30	3.89±0.06^b	2.98±0.11^a	3.10±0.09^a	**
	60	3.97±0.07^b	3.41±0.10^a	3.52±0.08^a	**
	90	4.01±0.10^b	3.65±0.08^a	3.72±0.08^a	**
	Overall (Mean±SE)	**3.91±0.04^b**	**3.17±0.03^a**	**3.23±0.04^a**	**
Globulin (g/dl)	0	3.56±0.12	3.26±0.10	3.39±0.14	NS
	30	3.34±0.11	3.37±0.13	3.48±0.11	NS
	60	3.19±0.18	3.41±0.15	3.54±0.18	NS
	90	3.44±0.17	3.62±0.12	3.67±0.16	NS
	Overall (Mean±SE)	**3.38±0.09**	**3.41±0.07**	**3.52±0.08**	**NS**
Albumin: Globulin ratio	0	1.09±0.05^b	0.84±0.05^a	0.80±0.06^a	**
	30	1.19±0.05^b	0.93±0.08^a	0.92±0.06^a	**
	60	1.35±0.11^b	1.06±0.08^a	1.05±0.07^a	**
	90	1.24±0.08	1.04±0.05	1.06±0.06	**
	Overall (Mean±SE)	**1.22±0.05^b**	**0.96±0.03^a**	**0.96±0.03^a**	**
Glucose (mg/dl)	0	59.70±0.98^b	50.85±1.01^a	50.30±0.79^a	**
	30	61.75±1.34^b	54.45±0.84^a	55.35±0.84^a	**
	60	62.95±1.21^b	56.75±0.87^a	58.15±0.93^a	**
	90	60.75±1.17	58.95±1.20	58.65±1.19	**
	Overall (Mean±SE)	**61.28±0.41^b**	**55.25±0.48^a**	**55.61±0.40^a**	**
ALT (IU/L)	0	21.45±0.60	20.05±0.69	19.75±0.65	NS
	30	21.20±0.79	20.30±0.61	20.45±0.61	NS
	60	21.50±0.56	20.90±0.70	21.30±0.64	NS
	90	20.95±0.49	22.20±0.59	21.85±0.67	NS
	Overall (Mean±SE)	**21.28±0.28**	**20.86±0.43**	**20.84±0.40**	**NS**
AST (IU/L)	0	86.45±1.59	84.70±1.61	84.95±1.51	NS
	30	86.30±1.23	86.55±1.81	87.05±1.46	NS
	60	85.65±1.50	87.55±1.55	88.20±1.19	NS
	90	86.90±1.51	88.30±1.31	87.95±1.40	NS
	Overall (Mean±SE)	**86.32±0.73**	**86.77±0.88**	**87.03±0.75**	**NS**
Alkaline phosphatase (IU/L)	0	93.80±1.06	91.25±1.44	90.75±1.38	NS
	30	94.25±0.98	96.70±1.18	97.35±1.02	NS
	60	92.95±1.13^a	102.40±1.21^b	105.65±1.14^b	**
	90	93.50±1.20^a	103.10±1.12^b	108.20±1.49^c	**
	Overall (Mean±SE)	**93.62±0.56^a**	**98.36±0.55^b**	**100.48±0.54^c**	**
Blood urea nitrogen (mg/dl)	0	11.45±0.41	12.05±0.44	11.85±0.38	NS
	30	11.65±0.41	11.80±0.41	11.40±0.43	NS
	60	12.10±0.45	12.35±0.45	11.70±0.43	NS
	90	11.95±0.39	11.75±0.41	11.60±0.47	NS
	Overall (Mean±SE)	**11.79±0.22**	**11.99±0.21**	**11.64±0.23**	**NS**
Urea (mg/dl)	0	24.50±0.87	25.79±0.95	25.36±0.81	NS
	30	24.93±0.87	25.25±0.89	24.40±0.92	NS
	60	25.89±0.96	26.43±0.96	25.04±0.92	NS
	90	25.57±0.84	25.15±0.88	24.82±1.01	NS
	Overall (Mean±SE)	**25.23±0.46**	**25.65±0.44**	**24.90±0.50**	**NS**
Creatinine (mg/dl)	0	0.86±0.03	0.94±0.04	0.91±0.03	NS
	30	0.83±0.03	0.90±0.03	0.87±0.03	NS
	60	0.89±0.03	0.86±0.05	0.91±0.03	NS
	90	0.82±0.03	0.83±0.03	0.81±0.03	NS
	Overall (Mean±SE)	**0.85±0.01**	**0.88±0.02**	**0.87±0.01**	**NS**

Means with different superscripts in a row differ significantly (P<0.05 and P<0.01)

After therapeutic trial, there was significant increase in blood glucose level in all the treated groups of mineral deficient goats. The blood glucose level was significantly higher in mineral supplemented groups than control on 90-day post- supplementation. The increase in glucose level was probably due to increased availability of micro-nutrients, which might have provided more gluconeogenic precursors (Sahoo *et al*., 2016 and Yadav *et al*., 2017). Supplementation of either commercial or formulated mineral mixture did not reveal any significant effect on serum ALT and AST concentration in goats. Rao *et al*. (2004), Chaudhary *et al*. (2015), Yadav *et al*. (2017) and Pandey *et al*. (2018) also reported no change in activities of serum ALT and AST enzymes after supplementation of mineral mixture. Alkaline phosphatase level in goats of group T_2 and T_3 increased significantly ($P<0.01$) on day 60 and 90 of the study as compared to group T_1. Sharma *et al*. (2011) reported higher ALP activities in growing heifers supplemented with specific minerals than control group getting no mineral supplementation. The overall mean values for blood urea nitrogen, urea concentration and creatinine level were similar in different treatment groups after supplementation of formulated and commercial mineral mixture and further confirmed by Kalita *et al*. (2000), Rao *et al*. (2004), Mudgal *et al*. (2008), Shinde *et al*. (2012), Gouda *et al*. (2017), Niaz *et al*. (2017), Waghmare *et al*. (2017) and Yadav *et al*. (2017) in different species.

Conclusion

The results of study indicated an improvement in haematological and biochemical parameters as an effect of mineral supplementation with better recovery in T_3 treatment group supplemented with formulated mineral mixture. It can be concluded that supplementation of formulated mineral mixture is inevitable for goats in arid regions to maintain the haemato-biochemical parameters under field condition.

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Conflict of Interests

There is no conflict of interest.

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References

1. Chaudhary, R. K., Patel D.C. and Parnerkar S. (2015). *Life Sciences Leaflets,* 62, 28-35.
2. Datta, C., Mondal, M. K., and Biswas, P. (2007). Influence of dietary inorganic and organic form of copper salt on performance, plasma lipids and nutrient utilization of Black Bengal (*Capra hircus*) goat kids. *Animal Feed Science and Technology*, 135(3-4), 191-209.
3. Dey, A.K. and Sanyal, S. (2004). Effect of dietary copper on haemotological constituents in Black Bengal goat. *Environment and Ecology*, 22, 510-511.
4. Gouda, D., Sethy, K., Swain, R.K., Mishra, S.K., Behera, K., Debata, N.R. and Mishra, B. (2017). Effect of area specific mineral mixture and hormonal interventions on growth, blood chemistry and mineral status of the reproductive disorders cross bred cattle. *The Pharma Innovation Journal*, 6(10), 284-286.
5. Jain, N.C. (1986). Schalm's Veterinary Haematology, 4th Edn. Lea and Febiger, Philaldelphia.
6. Kadus, S.B. (2004). *Studied on mineral status of soil, plants and animals in Chhattisgarh region with special reference to sodium.* M.V.Sc. thesis, Indra Gandhi Krishi Vishwa Vidyalaya, Durg, India.
7. Kalita, D.J., Bisoi, P.C. and Mohapatra M. (2000). Effect of calcium and phosphorus supplementation on serum constituents of Black Bengal goat. *Indian Veterinary Journal*, 77, 19-22.
8. Katoch, A. and Mandial, R. K. (2003). Clinico haematological, biochemical and therapeutic studies on anaemia in cattle. *Indian Journal of Veterinary Medicine*, 23(2), 75-78.
9. Mudgal, V., Grag, A.K. and Dass, R.S. (2008). Effect of zinc, copper and selenium supplementation on growth rate and nutrient utilization in buffalo (*Bubalus bubalis*) calves. *Indian Journal of Animal Nutrition*, 25(3), 272-277.

10. Niaz, F., Sethy, K., Swain, R.K., Behera, K., Mishra, S.K., Karna, D.K. and Mishra, C. (2017). Combined effect of concentrate and area specific mineral mixture supplementation on the performance of Ganjam goat in its native tract. *The Pharma Innovation Journal*, 6(10), 320-323.
11. Pandey, V.K., Gendley, M.K., Tiwari, S.P. and Prusty, S. (2017). Effect of supplementation of area specific mineral mixture on serum mineral status of cattle in different agro-climatic zones of Chhattisgarh State. *Journal of Animal Research*, 7(5), 827-835.
12. Pandey, V.K., Gendley, M.K., Tiwari, S.P. and Prusty, S. (2018). Effect of area specific mineral mixture on serum biochemical parameters and milk yield in dairy cattle. *International Journal of Agricultural Science*, 10(1), 4965-4968.
13. Prasad, C.S. and Gowda, N.K.S. (2005). Importance of trace minerals and relevance of their supplementation in tropical animal feeding system. *Indian Journal of Animal Science*, 75 (1), 92-100.
14. Rajora, V.S. Pachauri, S.P., Gupta, G.C. and Upadhyay, A.K. (1995). Use of iron preparation in anaemia associated with anorexia in dairy cattle. *Indian Journal of Veterinary Medicine*, 15(1), 1-4.
15. Rao, S.B.N., Singh, N. Dutta, T.K., Nawab Singh, Agnihotri, M.K. (2004). Effect of trace mineral supplementation on growth rate nutrient utilization, blood biochemical profile and tissue chemical composition of male kids. *Indian Journal of Small Ruminants*, 10(20), 112-116.
16. Sahoo, J.K., Das, S.K., Sethy, K., Mishra, S.K., Swain R.K., Mishra, S.K., Swain, R.K. and Mishra, P.C. (2016). Mineral mixture on haemato biochemical, serum minerals and ovarian status of reproductive status of reproductive disordered crossbred cattle in Jatani block of Odisha. *International Journal of Livestock Res*earch, 7(5), 98-104.
17. Samanta, C.C., Mondal, M.K. and Biswas, P. (2005). Effect of feeding mineral supplement on the reproductive performance of anoestrous cows. *Indian Journal of Animal Nutrition*, 22(3), 177-184.
18. Senathiraja, S. and Pandey, N.N. (2002). Clinico haematological changes in copper deficient goats induced by dietary excess of molybdenum. *Indian Veterinary Journal*, 79,199-201.
19. Sharma, J., Kumar, A, Tiwari, D.P. and Mondal, B.C. (2011). Effect of dietary supplementation of calcium, copper amd manganese on nutrient utilisation, growth, blood-biochemical and mineral profile in crossbred heifers. *Indian Journal of Animal Science*, 81(5), 493-97.
20. Sharma, J., Kumar, A., Tiwari, R., and Kumar, P. (2009). Area specific mineral mixture and importance. *Vets Communications*, 4, 3-8.
21. Sharma, M.C., Joshi, C. and Sarkar, T.K. (2002). Therapeutic efficacy of mineral supplement in macro-minerals deficient buffaloes and its effect on haemato-biochemical profile and production. *Asian-Australasian Journal of Animal Sciences,*15(9), 1278-1287.
22. Sharma, M.C., Joshi, C. and Sarkar, T.K. (2003). Status of macro-minerals in soil, fodder and serum of animals in Kumoun hills. *Indian Journal of Animal Science*, 73(3), 308-311.
23. Sharmin, M.L., Miah, M.A., Myenuddin, M. and Shahjalal, M. (2004). Effects of haematinics on body weight and certain haemotological values in Black Bengal. *Bangladesh Journal of Veterinary Medicine*, 2, 55-57.
24. Shinde, A.K., Sankhyan, S.K., Kumar, D. and Regar, R.K. (2012). Effects of supplementation of copper and zinc on nutrient intake, utilization, blood profile, wool yield and semen quality of Malpura rams. *Indian Journal of Small Ruminants*, 18(2), 191-197.
25. Siddique, A., Mannon, M.A. and Hussain, M.A. (1989). Some biochemical studies on the blood of goats naturally infested intestinal parasites. *Indian Veterinary Journal*, 66, 502-504.
26. Singh, T., Mehta, M.K., Jain, R.K. and Jain A. (2010). Effect of supplementing deficient trace minerals on haematological parameters and plasma micro mineral status in kids. *Animal Nutrition and Feed Technology*, 10(2), 115-119.
27. Snedecor, G.W. and Cochran. W.G. (1994). Statistical Methods. 8th Edn. Oxford & IBH Publishing Co. Calcutta.
28. Tiwari, S.P., Jain, R.K., Mishra, U.K., Misra, O.P., Patel, J.R. and Rajagopal, S. (2000). Effect of trace mineral (mineral capsules) supplementation on nutrient utilization and rumen fermentation pattern in Sahiwal cow (*Bos indicus)*. *Indian Journal of Animal Science*, 70, 504-07.
29. Tufani, N.A. and Haque, S. (2007). Comparative efficacy of different mineral preparation in crossbred calves. *Indian Journal Veterinary Medicine*, 27(2), 135-137.
30. Underwood, E.J. (1981). The mineral nutrition of livestock. 2nd Edition. CAB International USA.
31. Unny, N.M., Pandey, N.N. and Dwevedi, S.K. (2001). Clinico haematological studies in experimental secondary copper deficiency in goats. *Indian Journal of Veterinary Medicine*, 21(1), 14-17.

32. Waghmare, S., Dass, R.S., Garg, A.K., Dhayagude, R.S., Chaturvedi, V.K. and Mohanta, R.K. (2017). Effect of copper methionine supplementation on haemato-biochemical profile, hormones, serum copper status and immunity in male kids. *Indian Journal of Animal Nutrition*, 34(2), 178-186.
33. Yadav, P., Choudhary, S, Kaushik, P.K., Choudhary, S.D., Yadav, M.K., Meel, S and Godara, R.S. (2017). Effect of supplementation of trace minerals on haematological parameters and mineral profile of Gir cows. *The Veterinary Practitioner*, 18(2), 293-296.

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