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Effect of Feeding Mineral Soil Licks with Concentrates on Apparent Digestibility of Nutrients and Serum Mineral Concentration in Case of Doyogena Sheep

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Abstract
The study was carried out to study the effect of different mineral supplements with concentrate on dry matter (DM), organic matter (OM), crude protein (CP), crude fat (CF), neutral-detergent fiber (NDF) and acid-detergent fiber (NDF) in local sheep breed. Three treatment mineral supplements are local mineral soil bole, local mineral soil makaduwa and commercial mineral mix. Twenty four male yearling lambs were divided in to four groups of six animals based on their initial body weight in randomized complete block design. The treatments used were; without mineral supplements (MM), bole ad libitum (BM) and commercial mineral mix (CMM) in 50g/day/head were randomly assigned to each group. Apparent digestibility trail was carried out for 15 days after 21 day quarantine and 15 days acclimatization for experimental environment. Apparent digestibility of DM, OM and CP group of all treatments was significantly higher ($P<0.001$) than control group. Serum mineral concentration is within normal range for Ca, Mg, Cu and Zn for those fed mineral supplement than control group pointing to the need to identify the underlying causes for this difference and adaptation of sheep to mineral soil efficiency athwart the year
Keywords: Mineral soil, Digestibility, Serum, Doyogena sheep

1. INTRODUCTION

Ethiopia is believed to have the largest livestock population in Africa [1]. This livestock sector has been contributing considerable share to the national economy of the country, for instance through export commodities of live animals, hides and skin to earn foreign exchange to the country. However, livestock productivity is very low and lags behind the growth of human population leading to a net decline in per capita consumption of livestock products [2].

Small ruminants are important components of livestock sector and are critical sources of cash income, meat, milk and wool for smallholder keepers in different farming system and agro-ecological zones of Ethiopia [3 & 4]. They are sources of risk mitigation during crop failures, monetary saving and investment in addition to many other socio-economic and cultural functions due to high fertility, short generation interval and their ability to produce in limited feed resource and their adaptation to harsh environmental conditions [5 & 6].

Sheep population in Ethiopia is estimated to be 24.2 million heads. Sheep are distributed and adapted across the diverse ecological zones of the country [1]. Out of these, about 73-75% is kept on small scale mixed farms in the highland areas while the remaining is found in the lowlands [4].

In many parts of the world, sheep productivity is limited primarily through shortage of available energy and protein, infectious and parasitic disease and genetic inadequacies in the animal [7]. Sheep in Ethiopia are raised under traditional communal grazing or browsing system and generally the productivity of sheep is very low. Among the various limiting factor for productivity of sheep, feed scarcity and quality are a core problem. Sheep productivity is also constrained by disease, lack of infrastructure, market information and trained personnel [5].

The major feed resources for small ruminants in Ethiopia are green forages from natural pasture, crop residues and feed grain/ other concentrates [8]. Large numbers of livestock in many parts of the world consume diets that do not meet exacting requirements [9]. Deficiency of minerals in sheep under grazing and grazing plus concentrate supplementation has been reported [10]. Miles and McDowell [11] reported that overgrazed pastures in Ethiopia are deficient in Calcium (Ca), Phosphorus (P), Sodium (Na), Zinc (Zn), Copper (Cu), cobalt (Co), sulfur (S) and selenium (Se), but their Iron (Fe) and Magnesium (Mn) levels are too high.

Mineral deficiencies are considered to be one of the nutritional constraints to animal productivity. Local mineral deficiencies and imbalances are likely to become more apparent and more critical [12]. Mineral imbalances (deficiencies or excesses) in soils and forages have long been held responsible for low production and reproductive problems among grazing ruminants in the tropics. Poor body conditions, slow live weight gain, low fertility and high mortality are normally observed in mineral-deficient animals [13&12].

Feeds, mineral soils and water are the major mineral sources for sheep in Ethiopia (Miles and McDowell, 1983). *Bole* (an Ethiopian name for soil lick) is one of widely spread resource, cheap and well licked

by animals once they accustomed to it. *Makaduwa* is also a type of lick soil used in Wolayta Zone, Southern part of Ethiopia [14]. The feeding strategies are either by trekking animals to natural mineral soil area or by bringing the mineral soil to animals holding pen [14]. In some areas where farmers located far away from natural mineral soil area are purchasing it from local markets [15]. According to Tolera and Said [16] in some parts of Ethiopia, supplementation with multi-nutrient mineral blocks and local mineral soils may provide an adequate or even excess amount of essential minerals.

Mineral supplementation play vital role in increasing the nutritive value of low-quality roughages and crop-products in developing countries [12].Supplementary need of minerals and concentrate mixture to sheep of various ages under grazing has also been advocated [10]. The animals must be supplied with a diet that is palatable and non-toxic and which contain the required minerals, as well as other nutrients, in adequate amounts, proper proportion and available forms [17]. Thus, it is necessary to provide supplementary minerals to promote efficient and profitable livestock production in warm climate regions.

The supplementation of mineral soil may have some positive contribution and may be valuable if explored as mineral supplements, but there is little information available on the techniques of supplementation and marketing system of minerals soils and effect of mineral soilsupplementation on growth performance, digestibility of nutrient and economic efficiency indicators on sheep. The present study is, therefore, carried out the following objectives:

1. To study the effect of feeding different mineral soil licks on apparent digestibility of nutrients in Doyogena sheep.
2. To evaluate the serum mineral concentration of Doyogena sheep fed different mineral soil licks with concentrate

3. MATERIAL AND METHODS

3.1 The Study Area

The study was conducted at Humbo district of Wolayta zone. Humbo district is located at 350 km south of Addis Ababa, Ethiopia. The district is located at an altitude of 1500 to 2300 meter above sea level and 6°40'N latitude and 37°50'E longitude (Figure 1). The Mean annual rainfall and temperature of the study area is 1123.15 mm and 22.0°C, respectively. The district has total area of 86,646 hectare (ha) which is 70% of the lowland and 30% of midland [18].

3.2 Experimental animal and management

Twenty four intact yearling male Doyogena breed was purchased from *Gununo* local market to conduct a digestibility experiment. The age of the animal was subjectively determined by looking at their dentation and asking the owners. The sheep was quarantined for 21 days in the experimental area. During quarantine period, all sheep were dewormed using Ivermectin against common external parasite (tick, mite and mange) and internal parasites, and vaccinated for pasteurellosis and anthrax with 1ml ovine pasterurellosis vaccine and 0.5 ml anthrax vaccine per sheep, respectively. Following quarantine period, sheep were identified by ear tags and kept in pen for 15 days to acclimatize to the environment of the experimental site. The pens was thoroughly washed and disinfected before introducing the sheep.

3.3 Feed preparation and feeding

Natural pasture hay was harvested, dried and stored under shed to keep the quality, chopped to approximately a size of 2-3 cm and used as basal diet or control diet throughout the experimental period. The mineral soil *bole* and *makaduwa* were purchased from Gununo local markets where as commercial mineral mix was purchased from Markos Animal Drug Pharmacy, Addis Abeba. Hay, *bole* and *makaduwa* were offered *ad libitum* by allowing a minimum of 25% based on previous day's intake. Commercial mineral mix (CMM) was fed 50 g/day/animal based on the recommended level set by manufacturer. Wheat bran (WB) and Peanut (PN) were purchased from food complex milling and oil factory, respectively, mixed at a ratio of 40% PN: 60% WB offered at 300g DM/head/day. The concentrate was mixed in a way that the CP content of mixture is on average 18 % CP on dry matter basis for the fulfillment of protein requirement of growing sheep with body weight of 15-20 kg [7]. Individual feed troughs for natural pasture hay and mineral supplements as well as water troughs were provided separately for each experimental animal.

3.4 Experimental Design and Treatments

Randomized complete block design (RCBD) with four treatments each consisting of six sheep per treatments was used to conduct the experiment. After 21 days of quarantine period, the experimental lambs were blocked in to four treatment groups based on initial body weight. Treatments were composed of mineral supplements such as *bole* and *makaduwa ad libitum,* commercial mineral mix (50g/ day/head) to each sheep at no any mineral supplement (T1), *bole* (T2), *makaduwa* (T3) and commercial mineral mix (T4) to experimental sheep fed natural

pasture hay basal diet (Table 2). Lambs within a block were randomly assigned to one of the four dietary treatments and placed in an individual pens.

CM=concentrate mix, CMM=Commercial mineral mix

T	Hay	CM (g/day/head) on DM basis			
			Bole	*Makaduwa*	CMM (g/day/head)
T1	*Ad libitum*	300	0	0	0
T2	*Ad libitum*	300	*Ad libitum*	0	0
T3	*Ad libitum*	300	0	*Ad libitum*	0
T4	*Ad libitum*	300	0	0	50

3.5 Measurements

3.5.1 Digestibility trial

The digestibility trail was conducted at the end of the quarantine and acclimatization period of experimental feed. Animals were transferred to metabolic pens fecal collection after days of acclimatization period to accustom the animals to the idea of carrying of fecal collection bag. Then feces were collected for 10 consecutive days and weighed every morning for each animal before feed offer. Each day's collection of feces per animal were weighed and 10% of the feces was sub-sampled and stored at -20°C, and pooled over collection period (10% aliquot), from which a sub sample was taken at the end of the trail, after thawing and properly mixing the feces. The feces samples were dried at 100°C for 24 hour. According to McDonald *et al.* (2010) the apparent digestibility coefficient (DC) of nutrients was calculated by using the following equation.

$$\text{DC (\%)} = \frac{\text{Total amount of nutrient in feed} - \text{Total amount of nutrient in feces}}{\text{Total amount of nutrient in feed}} \text{x100}$$

3.6 Serum Collection

Blood samples were collected from all experimental sheep by using 10 ml sodium heparinized test tubes by puncturing of jugular vein at the end of experiment. The collected blood samples were immediately centrifuged to separate plasma from serum. Then separated serum will be kept in cold storage (-20℃) until for mineral analysis.

3.7 Chemical analysis of soil, fecal and serum samples

Soil pH was measured by using a pH meter in a 1:2.5 soil: water ratio. Minerals; Ca, Mg, Fe, Mn, Zn and Cu were determined by atomic absorption spectrometer. Sodium and Potassium were analyzed by using flame photometrically. Available phosphorus was determined following the standard Olsen extraction method [21].

Frozen feces were allowed to thaw, mixed/agitated, sub-sampled and oven-dried at 60°C for 48 hours for partial dry matter determination. The partially dried samples were ground to 1 mm screen using Wiley mill and stored in an airtight plastic container at room temperature (avg.20°C) until proximate chemical analysis following the official procedures [22]. Non oven dried but thawed and well mixed feces were used directly for N analyses. Feed offered and refusal as well as feces excreted in during digestibility trail will be subjected to chemical analysis. The acid detergent fiber (ADF) and neutral detergent fiber (NDF) components of feed and faeces were determined according to the procedures of Van Soest*et al* [23]. All chemical analyses will be carried out in duplicate.

The mineral concentrations (Ca, Mg, Fe, Mn, Zn, Fe and Cu) in serum were analyzed by using an atomic absorption spectrophotometry (Model 210 VGP, USA). Sodium and K were determined by using flame photometry and P was determined by using photometric method according to [24].

3.8 Statistical Analysis

A two way analysis of variance (ANOVA) was followed for the experimental (feeding trial) data using SAS 9.2 [25]. The ANOVA procedure followed randomized block design (RCBD). The treatment means were separated by least significant difference (LSD). Mean differences were considered significant when $P \leq 0.05$, whereas $0.05 < P < 0.10$was considered to show a statistical tendency for difference. The appropriate model used for data analysis was depicted here under:

$Y_{ij} = \mu + T_i + B_j + e_{ij}$

Where: Y_{ij} = response variable

μ = overall mean

T_i = treatment effect

B_j = block effect

e_{ij}= random error

4. Result and Discussion

4.1 Chemical Composition of Treatment Feeds

The chemical compositions of the treatment feeds are given in Table 2. The CP content of the peanut cake was 51% of DM, which was higher than CP content reported [19] and Devendra and Burns [20] who reported 34.89% and 49.55%, respectively. However, it was comparable to that of Getenet [21] and Solomon [22] who reported CP content of 54.37% and 50.18% on DM basis, respectively. This may be because of the difference in method of extraction [23]. The wheat bran had 20.1% CP which was higher than the value reported by Tesefaye et al. [24] 16.3% and Getenet [21]17.19%, but comparable to that of Alemu [19] (19.9%). ADF in wheat bran was comparable to that of peanut cake and wheat bran whereas the level of ADL was the lowest.

Table.2. Chemical composition of hay, peanut cake, wheat bran and peanut cake wheat bran mixture.

	Chemical composition (%DM)						
	DM	OM	CP	NDF	ADF	ADL	ASH
Hay	93.12	83.22	6.56	74.29	48.12	9.84	9.90
Wheat bran	90.56	85.15	20.1	44.13	12.74	3.52	5.41
Peanut	93.37	88.76	51	19.51	14.96	6.39	4.61
Peanut cake and wheat bran mixtures	92.79	87.47	41.60	26.81	11.99	4.00	5.32

The hay used in this experiment had low CP (6.56%), high NDF (74.29%) and lignin (9.84%) contents. Daubenmire [24] reported the highest content of CP in natural stands of Hyperrhenia rufa was 7.4%, which can fall to 1.4 % in the dry season, far below subsistence level. Therefore, the CP content of the hay used in this study, which predominantly consisted 21 of Hyperrhenia rufa, was within the range of values reported. As the plant mature the cell wall constituent increases and, therefore, the structural carbohydrate such as cellulose and lignin increases and the percentage of the protein normally decreases [25].

4.2 Apparent Digestibility of Dry Matter and Nutrients

The effect of different types of mineral supplements on apparent DM and nutrient digestibility of experimental feedstuffs are shown in Table 1. In the current study the digestibility of DM (%) are T1 (72.15), T2 (74.74), T3 (74.88) and T4 (76.71). The digestibility of DM was significantly greater (P<0.05) for T4 as compared to other treatment groups. Difference in the digestibility of DM among treatments is consistent with DM intake, which might be associated with the relatively greater mineral content in supplemented groups than control (T1). Galtavo [26] observed significant improvements in digestibility of DM and CP in young rams supplemented with minerals. An improvement in DM digestibility also reported in supplementation of minerals in diet of rams [27]. This is also in agreement with the report of Pulina [27] addition of minerals (Ca, P, S and Zn) can improve the digestibility of DM. This could be due to the role of minerals in rumen microbe's growth. Magnesium, calcium, potassium, sodium and phosphate are required by Bacteroide succinogenes and probably are required for many rumen bacteria [28]. Fellner [29], reported that calcium seems to be essential for the growth of *Fibrobacter succinogenes* in the rumen and involved in metabolic process to activate exo-enzymes such amylase.

There is statistically significant difference in CP digestibility among treatments. Digestibility of CP is T4 (73.10%) = T3 (76.78%) = T2 (76.51%) > T1=(79.16%). Treatment groups which supplemented with minerals is statistically higher (P<0.001) than others. Crude protein digestibility is improved by mineral soil supplementation when compared with the control group. In agreement with the current study, [28] reported that concentration of minerals contribute to the efficiency of protein digestibility. This illustrates the presence of an optimal balance of nutrient to support the growth and activity of rumen microbes. This could significantly influence the proteolysis process in the rumen that digests proteins in the rumen. In addition, [30] stated that mineral supplements increase a rumen liquid dilution rate which increases protein synthesis in the rumen. In contrast with this, according to [31], the apparent digestibility of DM and CP, NDF, OM, EE and TC were not affected by the mineral supplements. Digestibility of CP is not significantly (P>0.05) different with mineral supplementation [32].

Table 1. Apparent dry matter and nutrient digestibility of sheep fed different mineral supplements.

	Treatments				SEM	Sig
Digestibility (%)	T1	T2	T3	T4		
DM	72.15^{c}	74.74^{b}	74.88^{b}	76.71^{a}	0.13	***
OM	73.16^{b}	75.18^{a}	75.11^{a}	78.10^{a}	0.14	**
CP	73.10^{c}	76.78^{b}	76.51^{b}	79.16^{a}	0.18	***
ADF	54.21^{b}	56.26^{ab}	56.30^{ab}	56.81^{a}	1.30	**
NDF	56.37^{c}	61.46^{b}	61.54^{b}	64.85^{a}	0.10	**

^{a,b,c,d}Means with different superscripts in row are significantly different (P<0.05); ns: not significant ; ***P<0.001; **P<0.01; SEM: standard error of mean; ADF: acid detergent fiber CP: Crud protein; DM: dry

matter; NDF: neutral detergent fiber; OM: Organic matter; T1= Hay ad libitum+300g CM; T2=Hay ad libitum + 300g CM + Bole ad libitum; T3= Hay ad libitum+300g CM+ Makaduwa ad libitum; T4= Hay ad libitum+300g CM+50g CM

The digestibility of NDF in the current study is statistically ($P<0.01$) different, T4 (64.85%) is higher than other groups but there is no significant ($P>0.01$) variation between treatment T2 (61.46%) and T3 (61.54%). The lower value (56.37%) of NDF digestibility recorded in control group which did not receive mineral supplementation. This could be due to the improvement of cellulose digesting bacterial growth by mineral supplementation. According to Shirly [30], minerals stimulate cellulose digestion by rumen microorganisms. Durand and Komisarczuk [28], stated that minerals stimulate microbial activity which increase cellulose digestion.

4.3 Serum Mineral Concentration

The highest and lowest ($P<0.001$) Ca concentrations were recorded for T4 (119.0 ppm) and T1 (114.7 ppm), respectively. There is no significant difference ($P>0.001$) between T2 (115.8 ppm) and T3 (116.9 ppm). According to Underwood and Suttle [34], healthy sheep can contain from 90 to 120 ppm of Ca in serum. Current study is also agreed with the report of Kaneko [35] normal level of serum Ca in healthy lamb from 11.9 to 12.4 mg/dl (119 to 124 ppm) and Puls [36] from 90 to130 ppm. Finding in this study is also nearer to the value of Latimer [37], who reported that normal range of Ca for in serum of sheep is 9.3 to 11.7 mg/dL (93 to 117 ppm). The concentration of Ca in all treatment groups is below moderate hyper calcium level from 120 to 150 ppm set by Littledike [38] which causes calcifications of soft tissues and depress feed intake. In contrast with present study, Sisay [39] reported that Ca level of serum ranges from 231.00ppm to 243.50 ppm in sheep which fed different mineral soil sources. The variation in serum Ca concentration between animals might be associated with endocrine secretions [34].

The P concentration in serum in T1 (20 ppm), T2 (33.4 ppm), T3 (35.0 ppm) and T4 (43.0 ppm) is significantly vary ($P<0.001$) between treatment groups. In exception with T4, others are below the normal range of P in serum of sheep ranges from 40 ppm to 80 ppm set by Latimer [38]. This could be due to low P concentration of mineral soils supplements. For grazing livestock, more devastating economic result of P deficiency is reproductive failure [40]. Thus, deficiency of P in mineral soil supplements and low in the serum of camels could be the good indicator of deficiency of P in the study area.

Concentration of Mg in serum of sheep for T1(27.1ppm), T2(41.1ppm), T3(33.0ppm) and T4(31.3ppm). The Mg concentration recorded in T2 (41.1ppm) was significantly higher ($P<0.01$) than other treatments. Analysis of serum samples from all treatment group indicated adequate amount of Mg in the serum. This could be due to higher Mg concentration in *bole* than other treatment feeds. This finding is in close with Sisay [39] who reported that serum Mg concentration of sheep which feed different mineral soils range from 25.70 to 41.8 ppm. The value of current finding is above the critical level from 10 to 20 ppm for sheep set by McDowell [41], normal range from 20 to 27 ppm set by Latimer [37] and from 19 to 30 ppm set by Puls [36]. However, concentration of Mg in current study is below toxic level (>60ppm) which causes diarrhea in sheep [42].

Potassium concentration (ppm) of T1(140.0), T2(143.0), T3(142.1) and T4(207.0). The K concentration of T4 (207.0 ppm) is significantly higher ($P<0.001$) than other treatments groups. The results of serum K concentration for all treatments except T4 are below normal range suggested by Jackson [43], from 152 to 210.6 ppm. This could be due to low K concentration in concentrates and mineral soils. In agreement with McDowell [4], concentrate feed contain low K (0.5%) compared to the requirement and low serum K caused by deficiency of K concentration in feed.

The Na concentration (ppm) of T1, T2, T3, and T4 is 2691.7, 2766.2, 2743.4 and 2704.1 respectively. The concentration was found to be significantly ($P<0.001$) different among treatments where the highest and lowest serum Na concentrations were recorded in T2 (2766.2) and in T1 (2691.7 ppm), respectively. The Na concentration in treatment group is above the range from 1420ppm to 1600ppm set by Latimer [37]. The results of current study are greater than the report of Sisay [39] where serum Na is 2023 ppm in sheep and, lower than report of Jackson [43], 3266 ppm to 3450 ppm. The variation could be due to bioavailability and interaction of Na in feeds used [38] and genetic difference of animals [41].

The Cu concentration (ppm) of T1, T2, T3 and T4 is 0.5, 0.9, 0.8 and 1.14 respectively. The higher ($P<0.001$) serum Cu concentration (1.1 ppm) was determined for sheep who received T4. The treatments which fed *bole* (0.9 ppm) and *makaduwa* (0.8 ppm) were significantly higher ($P<0.001$) than T1 (0.5 ppm). The serum concentrations reflect the dietary Cu status, although the normal range is wide. For instance, for sheep normal range is between 0.6 and 1.5 ppm (CMN, 1973). Comparing to the critical deficiency, serum values for sheep suggested by McDowell [41] is 0.65 ppm for Cu, the value in current study was above the critical standard value and below toxicity level 1.2 ppm set by the same author.

The concentration of Fe in serum of sheep in T1(2.61), T2(4.13), T3(2.73) and T4(3.24). As indicated in Table 19 Fe concentration in serum of sheep ranged from 2.61 ppm in T2 to 4.13ppm in T4. Treatment group

which fed *makaduwa* had significantly higher (P<0.001) value than animals which fed *bole* in T3, this could be due to higher Mg concentration in bole interfere Fe absorption. Similarly Grace [44] reported that when feeding diet of sheep which contain 140-200 ppm Mg was significantly depressed serum Fe concentration. The mean serum Fe concentration observed in this study is comparable with report of Sisay [39]. The current finding is above the normal range from 0.7 to 2.0 ppm set by Pulse [36]. This could be due to excess concentration of Fe (Table.15) in mineral soil supplement when compared with recommended requirement of sheep.

Manganese serum concentration (ppm) of current study was 0.01, 0.06, 0.12 and 0.85 for T1, T2, T3 and T4, respectively. It has indicated in the present study that T4 had significantly higher (P<0.001) serum Mn concentration than other treatment group. This finding is comparable with report of Sisay [39], who stated that after supplementation of different mineral soil Mn concentration in serum of sheep range from 0.06 to 0.09 ppm. According to Puls [36], Mn concentration in T1 and T2 are within adequate recommended range from 0.006 to 0.07 ppm. However Mn concentration in T2 and T4 above the adequate range, this could be due to higher Mn concentration *bole* (167ppm) and CMM (840 ppm). The increments of dietary Mn concentration from 123-147 ppm increases Mn concentration by 25% in tissues of animal [44].

The concentration of Zn (ppm) in serum of T1, T2, T3 and T4 is 0.94, 1.08, 1.15 and 0.58 respectively. The serum Zinc level of T4 (1.68) was significantly higher (P<0.001) than other treatments groups. Treatment which fed *makaduwa* T3 (1.15 ppm) is significantly higher than T2 (1.08) and control group T1 (0.94 ppm). Sheep supplemented with commercial mineral mix had high Zn concentration in blood than sheep supplemented with mineral soil. Current finding is within the range from 0.55 to 1.2 ppm set by [35]. The serum Zn concentration found in the present study is below critical level of 2ppm suggested by McDowell [41].

Table 2. Serum mineral concentration (ppm) of sheep fed different mineral supplement

	Treatments,Mean					
Parameter	T1	T2	T3	T4	SEM	Sig
Ca	114.7^{c}	115.8^{b}	116.9^{b}	119.0^{a}	3.53	***
P	20^{d}	33.4^{c}	35.0^{b}	43.0^{a}	1.70	***
Mg	27.1^{d}	41.1^{a}	33.0^{b}	31.3^{c}	1.06	***
K	140.0^{d}	143.0^{b}	142.1^{c}	207.0^{a}	4.03	***
Na	2691.7^{d}	2766.2^{a}	2743.4^{b}	2704.1^{c}	6.23	***
Cu	0.5^{d}	0.9^{b}	0.8^{c}	1.14^{a}	0.87	***
Fe	2.61^{c}	4.13^{a}	2.73^{c}	3.24^{b}	0.12	***
Mn	0.01^{d}	0.06^{c}	0.12^{b}	0.85^{a}	0.05	***
Zn	0.94^{d}	1.08^{c}	1.15^{b}	1.68^{a}	0.58	***

SEM=standard error of mean; Sig=Significance level;T1= Hay ad libitum+300g CM; T2=Hay ad libitum + 300g CM + bole ad libitum; T3= Hay ad libitum+300g CM+ makaduwa ad libitum; T4= Hay ad libitum+300g CM+50g CMM.

5. Conclusion

According to the result of current study, it is concluded that feeding mineral soils bole and makaduwa with concentrate can enhance significantly (P<0.001) apparent digestibility percentage of DM, OM and CP group of all treatment than control group in Doyogena sheep. Serum mineral concentration is within normal standard range for Ca, Mg, Na, Cu, Fe, Mn and Zn for those fed mineral supplement than control group.

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