European Journal of Applied Sciences 7 (5): 226-234, 2015
ISSN 2079-2077

DOI: 10.5829/idosi.ejas.2015.7.5.22787

The Comparative Nutrient Utilization and Economic Efficiency of Mineral Supplements with Concentrates in Sheep

[1]*Muluken Zeleke,* [2]*Yisehak Kechero and* [3]*Mohammed Y. Kurtu*

[1]Bonga Agricultural Research centre, P.O. Box 101, Bonga, Ethiopia
[2]Department of Animal Sciences, Arba Minch University, P.O. Box 21, Jimma Ethiopia
[3]School of Animal and Range Sciences, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia

Abstract: The study was carried out to assess the comparative effects of supplementing local mineral soils with concentrates on dry matter intake, feed conversion efficiency, weight gain performance, serum mineral concentration, apparent digestibility of nutrients and economic feasibility in an Ethiopian Adilo sheep breed. Twenty four male lambs were divided in to four groups of six animals based on their initial body weight in randomized complete block design. Treatments comprising of without mineral supplement (WM), *bole ad libitum* (WB) and *makaduwa ad libitum* (WM) and commercial mineral mix in 50 g/day /head (CM) were randomly assigned to each group. The macro mineral contents of *bole* (%) were Ca 0.14, Mg 0.20, P 0.02, K 0.31 and Na 3.01. *Makaduwa* (%) had Ca 0.15, Mg 0.16, P 0.04, K 0.40 and Na 4.86. Total DM intake (g/day/head) was significantly higher for WM (609.9)(P<0.001). Apparent digestibility of DM, OM and CP of all mineral received treatments were significantly higher (P<0.001) than control group. Body weight gain (BWC)(Kg/day) was 2.87, 4.19, 3.90 and 5.59 for WM, WB, MM and CM, respectively. Serum mineral concentration was within the normal range for Ca, Mg, Cu and Zn for those fed mineral supplements than control group. With regard to the economic benefits, WB returned high net income (24.75ETB) compared with other treatments, pointing to the need to identify the underlying causes for this difference and adaptation of sheep to *bole* efficiency athwart the year.

Key words: Digestibility · Mineral soil · Serum mineral · Sheep

INTRODUCTION

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 factors for productivity of sheep, feed scarcity and quality are the core problems [1, 2]. Deficiency of minerals has been reported in sheep under grazing and grazing plus concentrate supplementation conditions [3]. Local mineral deficiencies and imbalances are likely to become more apparent and more critical [4]. Poor body conditions, slow live weight gain, low fertility and high mortality are normally observed in mineral-deficient animals [4, 5]. Mineral supplementation plays a vital role in increasing the nutritive value of low-quality roughages and crop-products in developing countries [4]. Supplementary need of minerals and concentrate mixture to sheep of various ages under grazing has also been advocated [3]. Feeds, mineral soils and water are the major mineral sources for sheep in Ethiopia [6]. *Bole* (an Ethiopian name for soil lick) is one of widely spread mineral resource, cheap and well licked by animals once they accustomed to it. *Makaduwa* is also a type of lick soil used in many places of southern Ethiopia. The supplementation of mineral soil lick may have some positive contributions and may be valuable if explored as mineral supplements. The present study is, therefore, planned to study the effect of feeding different mineral supplements with concentrates on nutrient use and economic feasibility in sheep.

MATERIALS AND METHODS

The Study Area: The study was conducted at Humbo district of Wolayta zone, southern Ethiopia. Humbo district is located at 350 km south of Addis Ababa,

Corresponding Author: Yisehak Kechero, Department of Animal Sciences, Arba Minch University, P.O. Box 21, Arba Minch, Ethiopia.

Ethiopia. The district is located at an altitude of 1100 to 2300 meter above sea level as well as 6°40’N latitude and 37°50’E longitude.

Experimental Design: Twenty four an intact Adilo sheep breed yearlings were used for the trial. Randomized complete block design with four feed treatments consisting of six sheep per treatment were used to conduct the experiment. All treatment groups fed hay *ad libitum* and 300 g/day/head concentrate mix of wheat bran and peanut cake in 40 to 60 ratios as basal diet. Treatments comprising of without mineral supplement (T1=NM), bole *ad libitum* (T2=WB) and makaduwa *ad libitum* (T3=WM) and commercial mineral mix (CMM=WCM) in 50 g/day /head (T4) were randomly assigned to each group.

Dry Matter Intake: Daily feed offered to the experimental animals and the corresponding refusals of every animal were measured and recorded during the collection period. Both basal and supplement diets were offered separately and intake was determined by the difference between the amount of feed given and refused every day (24 hours) on DM basis. Samples were taken from batches of feed offered and orts, thoroughly mixed and sub-sampled (10%) for laboratory analysis. The sub-samples were kept frozen (-20 °C) until laboratory analyses.

Body Weight Change and Feed Conversion Efficiency: Initial body weights of each animal were determined by taking mean of two consecutive day’s weight after overnight fasting. A body weight change was determined as a difference between the final and initial body weight. Average daily body gain was calculated as the difference between the initial and final body weights of sheep divided by the number of feeding days. The feed conversion efficiency of experimental animals were determined by dividing the average daily body weight gain to the amount of feed consumed by the animal each day.

Digestion Trial : At the end of feeding trial all animals were transferred to metabolic pens for fecal collection after three days of acclimatization period. Fecal collection was carried out for ten (10) consecutive days. 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.* [7] the apparent digestibility coefficient (DC) of nutrients was calculated by using the following equation.

$$DC = \frac{\text{Amount of nutrient in feed} - \text{Amount of nutrient in feces}}{\text{Amount of nutrient in feed}}$$

Chemical Analysis of Soil, Serum, Feed and Fecal Samples: Soil pH was measured by using a pH meter in a 1:2.5 soil: water ratio. Minerals such as Ca, Mg, Fe, Mn, Zn and Cu were determined by atomic absorption spectrometer [8]. Sodium and K were analyzed by using UV spectrophotometer. Available P was determined following the standard Olsen extraction method [9]. 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. Non oven dried but thawed and well mixed feces were used directly for N analyses. Feed offered and refusals as well as feces excreted in during digestibility trail were subjected to chemical analysis. The acid detergent fiber (ADF)[8] and neutral detergent fiber (NDF) [10] components of feed and feces were also determined. All chemical analyses were carried out in duplicate.

Blood samples were collected from all experimental sheep by using 10 ml sodium heparinized test tubes by puncturing of jugular vein at the beginning and end of experiment. The collected blood samples were immediately centrifuged to separate plasma from serum. Then separated serum were kept in cold storage (-20°C) until mineral analysis. The mineral concentrations (K, Ca, Mg, Fe, Mn, Zn, Fe and Cu) in serum were analyzed using atomic absorption spectrophotometer (Model 210 VGP, USA). Sodium and P were determined by using UV spectrophotometric method [8].

Partial Budget Analysis: At the end of the feeding trial, the selling price of experimental sheep was determined by inviting four well experienced sheep market dealers. Based on price of each dealer, the average selling price for each treatment was calculated. In the analysis, the total return (TR) was determined by calculating the difference between selling and purchasing prices of sheep. The partial budget method measures profit or losses [11], which are the net benefits or differences between gains and losses for the proposed change and includes calculating net return (NR), i.e., the amount of money left when total variable costs (TVC) are subtracted from the total returns (TR): ***NR = TR-TVC***

Total variable costs include the costs of all inputs that change due to the change in production technology. The change in net return (ΔNR) was calculated by the difference between change in total return and the change in total variable costs (ΔTVC): $\Delta NR = \Delta TR - \Delta TVC$

The marginal rate of return (MRR) measures increases in net income in net return (Δ*NR*) associated with each additional units of expenditure (Δ*TVC*). This is expressed in percentage as: MRR (%) = $(\Delta NR)/(\Delta TVC) \times 100$

Statistical Analysis: A two way-analysis of variance was followed using SAS [12]. The ANOVA procedure was followed completely randomized block design (RCBD). The treatment means were separated by Tukey's HSD test. Mean differences were considered significant when $P \leq 0.05$, whereas $0.05<P<0.10$ was considered to show a statistical tendency for differences. The appropriate statistical model used for data analysis was depicted here under:

$$Y_{ij} = \mu + \alpha_i + \beta_j + \sum_{ij}$$

where: Y_{ij} = response variable due to treatment, block and interaction between treatment and block (random error); μ = overall mean; α_i = treatment effect; βj = block effect; $\sum_{ij}$= random error

RESULTS AND DISCUSSION

Dry Matter Intake of Feed Ingredients: Dry matter intake (DMI) of feed ingredients is summarized in Table 1. The average values of DMI were different (P<0.001) among the treatments; however, there was no difference (P>0.05) between bole (WB) and Makaduwa (WM) received animal groups. Animals fed mineral soil (WB and WM) had higher total DMI than control group (NM) which fed no mineral soils (P<0.001). The lower DMI in control group might be associated with lack of mineral supplementation. Sheep received commercial mineral mix (CM) had the highest total DMI compared to other treatment groups (P<0.001). This might be due to higher level of minerals in commercial mineral mix that abounding better mineral to rumen microbial activity.

The essentiality and role of minerals in rumen microbes have been well recognized in numerous studies. According to Hungate [13] micro flora in the digestive tract requires nutrients including minerals. Church [14] reported that microbial growth and various fermentation processes in the rumen require an adequate supply of minerals. Deficiency of minerals, particularly sulfur, phosphorus, magnesium and certain trace minerals limit the growth of rumen micro-organisms [15]. The same author stated that mineral deficiency reduces growth efficiency of rumen microbes and also decrease feed intake. It is also well recognized that deficiency of both major and trace minerals causes depression in feed consumption [16]. Feed intake expected to maximize if it provides most of essential nutrients required by rumen microbes and the tissue of the animal.

The effects of increasing microbial population and feed use efficiency after providing the required nutrients would increase the rate of nutrient digestion. As the rate of breakdown of digesta increases, retention time in the rumen may decrease leading to increased feed intake [17]. In the current study, animals fed with no mineral supplements had a lower feed intake due to slow nutrient digestion and low digesta passage rate in the digestive tract compared to mineral supplemented ones. The average DM intake in this study was agreed to the

Table 1: Dry matter intake of sheep fed different feed ingredients with or without mineral supplements

	Treatments, Mean					
Parameters	NM	WB	WM	CM	SEM	Prob.
Hay DMI (g/d)	310^c	320^b	322^b	328^a	0.801	0.001
CM DMI (g/d)	300	300	300	300	0	0.12
Bole DMI (g/d)	0^b	25^a	0^b	0^b	0.022	0.001
Makaduwa DMI (g/d)	0^b	0^b	22.4^a	0^b	0.016	0.001
CMM DMI (g/d)	0^b	0^b	0^b	50^a	0.003	0.001
Total DMI (g/d)	610^c	645^b	644^b	678^a	0.481	0.001

[a,b,c]means within a row not bearing a common superscript are significantly different(P<0.05); NM, treatments without mineral supplement; WB, treatments with *bole*; WM, treatment with *makaduwa*; CM, treatment with commercial mineral mix; DMI, dry matter intake; SEM, standard error of mean; prob., significant level

Table 2: Apparent digestibility coefficients of nutrients in sheep fed different mineral supplements

	Treatments, mean					
Digestibility (%)	NM	WB	WM	CM	SEM	Prob.
DM	72.2^{d}	74.7^{c}	74.9^{b}	75.7^{a}	0.131	0.001
OM	75.2^{b}	75.2^{b}	75.1^{b}	76.1^{a}	0.140	0.001
CP	81.1^{d}	82.8^{c}	82.5^{b}	83.2^{a}	0.180	0.035
ADF	56.2^{b}	56.3^{ab}	56.3^{ab}	56.8^{a}	1.300	0.048
NDF	61.4^{c}	61.5^{b}	61.5^{b}	61.9^{a}	0.102	0.01

^{a,b,c,d}Means with different superscripts in rows are significantly different (P<0.05); DM, dry matter; OM, Organic matter; CP, Crude protein; ADF, acid detergent fiber; NDF, neutral detergent fiber; NM, treatments without mineral supplement; WB, treatments with *bole*; WM, treatment with *makaduwa*; CM, treatment with commercial mineral mix; SEM, standard error of mean; prob., significant level

630 g animal's day^{-1} described by Yisehak *et al.* [18] for lambs in the same weight range. The findings of this study disagree with Daniel [19] who reported that mineral supplement did not affect DM intake in lambs fed hay as a basal diet.

Apparent Digestibility of Nutrients: The digestibility of DM and CP were greater (P<0.05) for CM compared to other treatment groups (Table 2). A difference in the digestibility of DM among treatments is in consistent with DM intake, which might be associated with the relatively greater mineral content in supplemented groups rather than in control (WM). Galtavo [20] 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 Sharma *et al* [21]. Dermauw *et al.* [22] also investigated the improved digestibility of DM in ruminants after dietary addition of minerals (Ca, P, S and Zn). This could be due to role of minerals in growth of rumen microbes. Magnesium, calcium, potassium, sodium and phosphate are required by Bacteroides succinogenes and probably are required for many rumen bacteria [23]. Fellner *et al.* [24] reported that calcium seems to be essential for the growth of Fibrobacter succinogenes in the rumen and involved in metabolic process for activate exo-enzymes such amylase.

Digestibility of CP among treatments indicated as follows: CM (83.16%) > WM (82.51%) > WB (82.78%) > NM (81.10%)(P<0.001). In agreement with current study, Karsil *et al.* [25] 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 rumen. In addition, Shirley [26] stated that mineral supplements increase a rumen liquid dilution rate which increases protein synthesis in the rumen. In contrast with this, according to Daniel [19], the apparent digestibility of DM, CP, NDF, OM, EE and TC were not affected by the mineral supplements.

The digestibility of NDF in current study was also different (P<0.01), where CM (61.85%) was higher than other groups but there was no variation (P>0.01) between WB (61.46%) and WM (61.54%). The lower value (61.37%) 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 [26], minerals stimulate cellulose digestion by promoting rumen microorganisms. Durand and Komisarczuk [23] stated that minerals stimulate microbial activity which increases cellulose digestion.

Body Weight Parameters and Feed Conversion Efficiency: Live weight gain (g/day) of sheep during the experimental period is presented in Table 3. The greatest body weight of sheep was recorded in CM (5.59 kg) compared to other treatment groups (P<0.001). This could be due to well-balanced mixture of minerals and differences in digestibility of DM and CP among treatments. Complete mineral supplementation increases the weight gain of animals [27]. The highest weight gain per animal was recorded for sheep fed commercial mineral mix (CM) while the lowest was observed for sheep fed no mineral supplementation (NM). Mohammed *et al.* [28] reported that weight gains of Arsi sheep increased by an average of 19±8 g/day when fed natural mineral lick offered as a free choice.

Feed conversion efficiency (FCE) of sheep observed in treatment CM were higher (*P*<0.001) than other treatment groups. Feeding of complete mineral mix resulted in enhanced average daily weight gain and feed conversion ratio [29].

Table 3: Body weight parameters and feed conversion efficiency of sheep fed different mineral supplements with concentrate mixes

	Treatments, Mean					
Parameters	NM	WB	WM	CM	SEM	Prob.
IBW (Kg)	17.03	16.9	17	16.9	0.16	0.115
FBW (Kg)	19.9^{c}	21.1^{b}	20.9^{b}	22.5^{a}	0.33	<0.001
BWC (Kg)	2.87^{d}	4.19^{b}	3.9^{c}	5.59^{a}	0.12	<0.001
ADG (g/d)	41^{d}	59.9^{b}	55.7^{c}	79.9^{a}	1.16	<0.001
FCE,%	6.7^{d}	9.3^{b}	8.7^{c}	11.8^{a}	0.007	<0.001

^{a,b,c,d} means within a row bearing a common superscript are significantly different; BWC, body weight change; ADG, average daily weight gain; FBW, final body weight; FCE, feed conversion efficiency (g ADG/g feed); IBW, initial body weight; SEM, standard error of mean; NM, treatment without mineral supplement; WB, treatment with *bole*; WM, treatment with *makaduwa*; CM, treatment with commercial mineral mix; Prob., significance level

Table 4: Serum mineral concentration (ppm) of sheep fed different mineral supplements with concentrate mixes

	Treatments, Mean					
Minerals	NM	WB	WM	CM	SEM	Prob.
Ca	115^{c}	116^{b}	117^{b}	119^{a}	3.531	<0.001
P	20^{d}	33.4^{c}	35^{b}	43^{a}	1.7	<0.001
Mg	27.1^{d}	41.1^{a}	33^{b}	31.3^{c}	1.06	<0.001
K	140^{d}	143^{b}	142^{c}	207^{a}	4.03	<0.001
Na	2692^{d}	2766^{a}	2743^{b}	2704^{c}	6.23	<0.001
Cu	0.5^{d}	0.9^{b}	0.8^{c}	1.14^{a}	0.87	<0.001
Fe	2.61^{c}	4.13^{a}	2.73^{c}	3.24^{b}	0.12	< 0.001
Mn	0.01^{d}	0.06^{c}	0.12^{b}	0.85^{a}	0.05	<0.001
Zn	0.94^{d}	1.08^{c}	1.15^{b}	1.68^{a}	0.58	0.001

^{a,b,c,d} means within a row bearing a common superscript are significantly different; NM, treatment without mineral supplement; WB, treatment with *bole*; WM, treatment with *makaduwa*; CM, treatment with commercial mineral mix; SEM, standard error of mean; Prob., significance level

Serum Mineral Concentration: The highest and lowest Ca concentrations were recorded for CM (119.0 ppm) and NM (115ppm), respectively (Table 4). There was no difference (P>0.001) between WB (115.8 ppm) and WM (117ppm). According to Underwood and Suttle [30], healthy sheep can contain from 90 to 120 ppm of Ca in serum. Current study also agrees with the report of Kaneko [31] where normal level of serum Ca in healthy lamb ranging from from 11.9 to 12.4 mg/dl (119 to 124 ppm) ....and Puls [32] from 90 to130 ppm. Findings of this study is also closer to the value of Latimer *et al.* [33], who reported that normal range of Ca in serum of sheep ranges from 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 *et al.* [34], which causes calcifications of soft tissues and depress feed intake. In contrast with present study, Sisay [29] reported that Ca level of serum ranges from 231.00 ppm 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 [30].

The P concentration in serum in NM (20 ppm), WB (33.4 ppm), WM (35.0 ppm) and CM (43.0 ppm) varied (P<0.001) between treatment groups. In exception with CM, others are below the normal range of P in serum of sheep ranges from 40 ppm to 80 ppm set by Latimer *et al.* [33]. 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 [39]. Thus, deficiency of P in mineral soil supplements and low in the serum of sheep could be the good indicator of deficiency of P in the study area.

Concentration of Mg in serum of sheep was WB (27.1ppm), WB (41.1ppm), WM (33.0 ppm) and CM (31.3 ppm), respectively. The Mg concentration recorded in WB (41.1ppm) was higher (P<0.01) than other treatments.

Analysis of serum samples from all treatment groups indicated the presence of 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 line with those obtained by Sisay[29] 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 [36], normal range from 20 to 27 ppm set by Latimer *et al.* [29] and from 19 to 30 ppm set by Pulse[32]. However, concentration of Mg in current study is below toxic level (> 60ppm) which causes diarrhea in sheep [37].

Table 5: Partial budget analysis of sheep fed different mineral supplement with concentrate mix and hay as basal feed

	Treatments, mean			
Parametres	NM	WB	WM	WCM
Purchase price sheep (ETB)	650	650	650	650
Hay consumed(Kg/sheep)	27.8	28.8	28.9	29.5
PN consumed (Kg/sheep)	10.8	10.8	10.8	10.8
WB consumed (Kg/ sheep)	16.2	16.2	16.2	16.2
Bole consumed (Kg/sheep)	-	2.25	-	-
Makaduwa consumed (Kg/sheep)	-	-	2.01	-
CMM consumed (Kg/sheep)	-	-	-	4.5
Feed Costs, cost of hay (ETB/sheep)	20.8	21.6	21.7	22.1
Cost of PN (ETB/sheep)	86.4	86.4	86.4	86.4
Cost of WB (ETB/sheep)	40.5	40.5	40.5	40.5
Cost of *bole* (ETB/sheep)	-	6.8	-	-
Cost of *makaduwa* (ETB/sheep)	-	-	10.1	-
Cost of CMM (ETB/sheep)	-	-	-	315
TVC(ETB/sheep)	148	155	159	464
Sheep selling price (ETB/sheep)	790	830	830	850
Total return (TR) (ETB/sheep)	140	180	180	200
Net return(NR) (ETB/sheep)	-7.7	24.8	21.4	-264
Change in total return (ΔETB/sheep)	-	40	40	80
Change in net income (ΔNI)	-	32.5	29.1	-256
Change of total variable cost (ΔTVC)	-	7.6	11	316
MRR (ΔNI/ ΔTVC)	-	4.3	2.7	-0.8

ETB, Ethiopian birr; NI, change in net income; TVC, change of total variable cost; MRR, marginal rate of return; NR, net return; PN, peanut; TR, total return; WB, wheat bran. NM, Hay ad libitum+300g CM; WB, Hay ad libitum + 300g CM + *bole* ad libitum; WM, Hay ad libitum+300g CM+ *makaduwa* ad libitum; CM, Hay ad libitum+300g CM+50g CMM

The K concentration of CM (207.0 ppm) was higher (P<0.001) than other treatments groups. The results of serum K concentration for all treatments except CM are below normal range suggested by Jackson [38], from 152 to 210.6 ppm. This could be due to low K concentration in concentrates and mineral soils. In agreement with McDowell [36], 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 NM, WB, WM and CM was 2692, 2766, 2743and 2704, respectively. The concentration was found to be different (P<0.001) among treatments where the highest and lowest serum Na concentrations were recorded in WB (2766.2) and in NM (2692 ppm), respectively. The Na concentration in treatment group is above the range from 1420ppm to 1600ppm set by Latimer *et al.* [33]. The results of current study are greater than the report of Sisay [29] where serum Na is 2023 ppm in sheep and, lower than report of Jackson [38], 3266 ppm to 3450 ppm. The variation could be due to bioavailability and interaction of Na in feeds used [39] and genetic difference of animals [40].

The Cu concentration (ppm) of NM, WB, WM and CM 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 CM. The treatments which fed *bole* (0.9 ppm) and *makaduwa* (0.8 ppm) were higher (P<0.001) than NM (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 [41]. Comparing to the critical deficiency, serum values for sheep suggested by McDowell [42] 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.

As indicated in Table 4 Fe concentration in serum of sheep ranged from 2.61 ppm in WB to 4.13ppm in CM. Treatment group which fed *makaduwa* had higher (P<0.001) Fe value than animals fed *bole* in WM, this could be due to higher Mg concentration in bole interfere Fe absorption. Similarly Grace [43] reported that when feeding diet of sheep which contain 140-200 ppm Mg was depressed serum Fe concentration. The mean serum Fe concentration observed in this study is comparable with report of Sisay [29]. The current finding is above the normal range from 0.7 to 2.0 ppm set by Pulse [43]. This could be due to excess concentration of Fe (Table 4) in mineral soil supplement when compared with recommended requirement of sheep.

As indicated in the present study that CM had higher ($P<0.001$) serum Mn concentration than other treatment group. This finding is comparable with report of Sisay [29] who stated that after supplementation of different mineral soil Mn concentration in serum of sheep ranges from 0.06 to 0.09 ppm. According to Puls [42], Mn concentration in NM and WB are within adequate recommended range from 0.006 to 0.07 ppm. However, Mn concentration in WB and CM was 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 [42].

The serum Zinc level of CM (1.68) was higher ($P<0.001$) than other treatments groups. Animals which fed *makaduwa* (WM, 1.15 ppm) had a higher Zn concentration than WB (1.08) and control group NM (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 Herdt and Hoff [43]. The serum Zn concentration found in the present study is below critical level of 2ppm suggested by McDowell [44].

Partial Budget Analysis: Partial budget analysis of sheep feed minerals with concentrate mix is presented in Table 5. The analysis considered partial budget was used to calculate the potential profitability of supplementing minerals. The result of this study indicated that the higher total return in CM (200 ETB) obtained from sheep fed commercial mineral mix followed by WM. The least total return of 140ETB was obtained from sheep without mineral supplementation. The difference in the net return among treatments was mainly due to the difference in selling price of animal in each treatment. The higher profit obtained in WB is due to the lower cost of bole (3ETB/kg) and the negative profit obtained in CM is due to the higher cost of commercial mineral mix (70 ETB/kg).

CONCLUSION

Feed utilization, average daily gain and feed conversion efficiency were higher for those groups of sheep received bole and commercial mineral supplements. Serum mineral concentration is within normal range for Ca, Mg, Na, Cu, Fe, Mn and Zn is meet normal standard range for those fed mineral supplement than control group. Supplementation of *bole* with 300g concentrate mix feeding hay *ad libitum* is potentially profitable and economically beneficial than other mineral supplements in feeding of sheep under condition of this experiment. In the future dietary inclusion of chemical form minerals, *bole* and *makaduwa*, the interaction of mixing with other feeds and graded level of supplementation effect of feedings on reproduction and production performance of sheep should be conducted.

ACKNOWLEDGEMENTS

The authors would like to thank the southern nations, nationalities and people's regional state institute of agricultural research, Ethiopia for funding this particular study project.

REFERENCES

1. Markos Tibbo, 2006. Productivity and health of indigenous sheep breed and cross breeds in the central Ethiopia Highlands. PhD Thesis presented to Swedish University of Agricultural Science, Uppsala, pp: 4.
2. Kebede, B., Y. Kechero and A. Beyene, 2014. Polyethylene glycol improves the utilization of a high tannin forage in sheep. Livestock Research for Rural Development. Volume 26, Article #214. Retrieved October 13, 2015, from http:// www.lrrd.org/ lrrd26/ 12/kebe26214.html
3. Samanta, A. and G. Samanta, 2002. Mineral profile of different feed and fodders and their effect on plasma profile in ruminants of West Bengal. Indian Journal of Animal Nutrition, 19: 278-281.
4. Suttle, N.F., 1991. Mineral supplementation of low quality roughages. In: Proceedings of Symposium on Isotope and Related Techniques in Animal Production and Health. International Atomic Energy Commission, Vienna, pp: 101-104.
5. McDowell, L. R. Conard, J. H, Ellis, G. L. and Loosli, J. K., 1983. Minerals for Grazing Ruminants in Tropical Regions. Department of Animal Science Department, Center for Tropical Agriculture. University of Florida, Gainesville, Florida.
6. Miles, E. H. and McDowell, L. R., 1983. Mineral deficiencies in the Llanos rangelands of Colombia. World Animal Review, 46: 2-10.
7. McDonald, P. J. Greenhalgh, F. D., Morgan, C. A., Edwards, R., Liam Sincliar, Robert Wilkinson, 2010. Animal nutrition. 7th ed. Prentice Hall, NY, USA.

8. AOAC (Association of Official Analytical Chemists), 2000. Official Methods of Analysis, Association of Official Analytical Chemists, Washington, DC, USA, 18th edition, 2000.
9. Baruah, T.C. and H.P. Barthakur, 1997. A Text Book of Soil Analysis. Vikas Publishing house pvt plt. Masjid Road, Jangpura, New Delhi, India, pp: 334-345.
10. Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74(10): 3583-3597.
11. Boehlje, M.D. and V.R. Eidman, 1984. Farm Management. John Wiley and Sons, New York, USA.
12. SAS (Statistical analysis system), 2012. Statistical Analysis System, Release 9.4SAS/STAT Program. SAS Institute Inc., Carry, NC, USA.
13. Hungate, R.E., 1966. The Rumen and Its Microbes 3rd Ed. Academic Press, New York.
14. Church, D.C., 1975. Digestive Physiology and Nutrition of Ruminants. O & B Books, Corvalis, Oregon.
15. Leng, R.A., 1991. Application of biotechnology to nutrition of animals in developing countries. FAO Animal Production and Health Paper. FAO(Food and Agriculture Organization), Rome, Italy.
16. Shirley, L.R., 1986. Nitrogen and Energy Nutrition of Ruminants. Acadamic Press Inc. New York.
17. Van Soest, P.J. and J.B. Robertson, 1985. Analysis of Forage and Fibrous Feeds. A Laboratory Manual for Animal Science, Cornell University, USA, pp: 613.
18. Kechero Yisehak, Kebede Biruk, Beyene Abegaze and Geert P.J. Janssens, 2014. Growth performance, nutrient digestibility and carcass evaluation of Bonga sheep fed tannin rich diet (*Albizia gummifera*) with or without polyethylene glycol. Tropical animal health and production-Springer, DOI 10.1007/s11250-014-0605-6
19. Daniel, B.M. and G. Gherman, 2014. Mineral Mixtures from Solid Salt Residues for Lambs. PE, Brazil.
20. Galatov, A.N., 1991. Efficiency of feed utilization for wool production in relation to breed of young rams and mineral availability in diets. Zootekhniya, pp: 46-47.
21. Sharma, L.C., P.S. Yadav, A.B. Mandal and K.R. Sunaria, 2004. Mineral Status of some Vital Organ of Lambs as Influenced by their Dietary Levels. Animal Nutrition and Feed Technology, 2: 151-160.
22. Veronique Dermauw, Yisehak Kechero, Ellen Dierenfeld, Gijs Du Laing, Johan Buyse, Birgit Wuyts and Geert P.J. Janssens, 2011. 14th International symposium on Trace Elements in Man and Animals, pp: 266-266.
23. Durand, M. and S. Komisarczuk, 1988. Influence of major minerals on rumen microbiota. Journal of Nutrition, 118: 249-60.
24. Fellner, V. and J.W. Spears, 2005. Effect of Calcium Propionate and Ruminal Soluble Calcium and Microbial Fermentation.
25. Karsil, M.A. and J.R. Russell, 2001. Effect of some dietary factors on ruminal microbial protein synthesis. Turk. Vet. J. Anim Sci., 25(l): 681-686.
26. Shirley, L.R., 1986. Nitrogen and Energy Nutrition of Ruminants. Acadamic Press Inc. New York.
27. Van Eys, J.E., S. Silitonga, I.W. Mathius and W.L. Johnson, 1985. On-farm trials of mineral supplementation for small ruminants in West Java, Indonesia. Research Methodology for Livestock on Farm Trials, pp: 153-171.
28. Mohammed Y. Kurtu, E.M. Mugerawa and D. Edo, 1989. Effect of supplementation with lake soil on the growth of Arsi sheep. ……….???
29. Sisay Tilahun, Vijchulata, P., P. Chairatanayuth and S. Swasdiphanich, 2007. Effects of Natural Mineral Soils on Body Weight and Liver Minerals of Black Head Somali Sheep in Ethiopia.
30. Underwood, E.J. and N.F. Suttle, 1999. The Mineral Nutrition of Livestock (3rd Ed). CAB International, UK.
31. Kaneko, J.J., 1989. Clinical Biochemistry of Domestic Animals. 4th Ed. Academic Press, pp: 146-159,612-647.
32. Puls, R., 1994. Mineral Levels in Animal health. Diagnostic Data. Sherpa International. Canada.
33. Latimer, K.S., E.A. Mahaffey and K.W. Prasse, 2003. Duncan and Prasse's Veterinary Laboratory Medicine: Clinical Pathology. 4th ed., Iowa, Iowa State Press, pp: 173-174.
34. Littledike E.T., D. Glazier and H.M. Cook, 1976. Electrocardiographic changes after induced hypercalcemia and hypocalcemia in cattle. Animal Journal Veterinary Research, 137: 383-388.
35. McDowell, L.R. and G.C. Valle, 2000. Major minerals in forages. pp 373-375. In: D.I. Givens, E.Owen, R.F.E. Axford and H.M. Omed. Forage Evaluation in ruminants Nutrition. Biddles Ltd, Guildford and King's Lynn, UK.

36. NARC., 2012. Animal Nutrition Programme. Animal Sciences Institute, National Agricultural Research Centre, Islamabad.
37. Jackson, G.G. and D.C. Peter, 2002. Clinical Examination of Farm Animals. Blackwell Science Ltd
38. McDowell, L.R., 2003. Minerals in Animal and Human Nutrition. 2nd Ed. Amsterdam: Elsevier.
39. Suttle, N., 20110. Selenium.In The Mineral Nutrition of Livestock. 4th Edition. Edited by Suttle N. Oxfordshire: Cabi; 2010:377-425.
40. CMN, 1973. Treating Mineral Disorders in Dairy Cattle. Committee on Mineral Nutrition. Center for Agriculture Publishing and Documentation, Wageningen, Netherlands, pp: 116-118.
41. Grace, N.D. and J. Lee, 1990. Effect of Co, Cu, Fe, Mn, Mo, Se and Zn supplementation on the elemental content of soft tissues and bone in sheep grazing ryegrass/white clover pasture. New Zealand Journal of Agricultural Research, 33: 635-647.
42. Herdt, T.H. and B. Hoff, 2011. The use of blood analysis to evaluate trace mineral status in ruminant livestock. Vet. Clin. North Am. Food Anim. Pract., 27: 255-283.
43. McDowell, L.R., 1997. Minerals for Grazing Ruminants in Tropical Regions. Animal Sciences Department, Center for Tropical Agriculture. University of Florida. Bulletin 3rd Ed. pp: 83.