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Effect of different selenium sources on nutrient digestibility, performance and antioxidant status in Mecheri lambs

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ABSTRACT

An experiment was conducted to determine the effect of different selenium sources on nutrient digestibility, performance and antioxidant status in Mecheri lambs. Mecheri lambs (30) were distributed randomly into five equal groups (Control, T_1, T_2, T_3 and T_4) with six lambs in each, on the basis of average body weight (14.1±1.1 kg). The animals in T_1, T_2, T_3 and T_4 were given sodium selenite (0.30 ppm), selenocysteine (0.30 ppm), nano selenium (0.30 ppm) and nano selenium (0.15 ppm), respectively for 120 days. The result revealed that DM, OM, CP, EE, CF, NDF, ADF and NFE digestibility were significantly higher for lambs in group T_2 and T_3 than other groups. T_3 group showed highest nitrogen intake, retention and balance. There was no difference in daily intake, faecal and urinary excretion and balance of Ca and P. There was no effect on DM intake but T_3 and T_4 group showed significant difference in body weight gain, average daily gain and feed conversion ratio between the experimental groups. All sources of Se showed no effect on biochemical parameters. However, T_3 group showed significantly lower MDA content in blood and significantly higher activity of GSH-Px and SOD compared to other groups. In conclusion, dietary supplementation of Nano-Se at 0.30 ppm can be used more efficiently to improve the nutrient digestibility, growth performance and antioxidant status in Mecheri lambs.

Keywords: Biochemical, Digestibility, Growth performance, Nano selenium

Selenium is an essential trace element for animal health, immune function, productivity and reproductive performance in farm animals and is found in both organic and inorganic forms in nature (Mehdi *et al.* 2016). The deficiency of Se causes low sperm quality, scouring, lowered wool production, white muscle disease, exudative diathesis, abnormalities in the spermatozoal mitochondrion, low ATP concentrations and lower GSH-Px activities (Mohapatra *et al*. 2014). Therefore, selenium supplementation (Sodium selenite, selenate, Se-enriched yeast) is commonly used in ruminant nutrition. Selenium supplements could increase live weight gains, wool production and growth rate (Mahima *et al*. 2006). Recently, Se nano particles have attracted considerable attention. The nanotechnology development holds unique properties for selenium Nano-particles (Nano-Se), because of its novel characteristics such as high surface activity, great specific surface area, a lot of surface-active centres, strong adsorbing ability and high catalytic efficiency (Skalickova *et al.* 2017).

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Selenium forms several seleno-enzymes such as glutathione peroxidase, superoxide dismutase, which serve as antioxidant and prevent the cellular damage from the free radicals produced by oxidative metabolism (Saha 2017). Shi *et al*. (2009) reported no effect of nano particles (NP) on growth performances in buck fed 0.3 ppm Se NPs. But in another study, they found increase in body weight and average daily gain in Taihang black goat fed 0.3 mg/kg Se NPs (Shi *et al*. 2011). National Research Council (NRC 2007) recommended a dietary level of 0.30 ppm of selenium for cattle, sheep and pig. However, little is known about influence of nano-Se on ruminant nutrition. Since the uptake of each source of selenium supplement varies and considering the fact that previous studies investigated the effects of organic, inorganic and Nano-Se separately, the present study aimed at evaluating the effects of various sources of selenium supplements on nutrients digestibility, productive performance, biochemical and antioxidant indices of Mecheri lambs.

MATERIALS AND METHODS

A total 30 numbers of 4 months old Mecheri lambs of averaged body weight (14.1±1.1 kg) were used in this experiment. The experiment was carried out at Mecheri Sheep Research Station, Pottaneri, Salem after taking approval from Institutional Animal Ethics Committee

(08/LA/IAEC/2021). Experimental station is situated on Salem–Mettur highway about 35 km west of Salem and 15 km east of Mettur at a longitude of 77°56'E, latitude of 11°45'N and altitude of about 650 feet above MSL. The average maximum and minimum temperatures were 34.3°C and 21.9°C, respectively. These animals were divided into five groups with six animals in each, in a randomized block design on the basis of their body weight. They were randomly distributed into the following treatments: Control (C)- Basal diet without selenium supplementation, T_1- Basal diet with inorganic selenium (Sodium selenite 0.30 ppm Sigma-Aldrich Chemicals, USA, minimum assay 99%), T_2- Basal diet with organic selenium (Selenocysteine 0.30 ppm, Sigma-Aldrich, USA, minimum assay 95%), T_3- Basal diet with Nano-Se (0.30 ppm), T_4- Basal diet with Nano-Se (0.15 ppm).

Nano-Se was synthesized by using two different methods and sources, viz. sodium selenite and pure selenium powder at the Department of Animal Nutrition, Madras Veterinary College, Chennai, India. In the first method, Nano-Se was prepared by water phase solution method using selenium powder and sodium hydroxide as outlined by Razi *et al*. (2011) while in the second method, Nano-Se was prepared using sodium selenite and ascorbic acid according to the modified method of Le *et al*. (2010).

All the experimental lambs were housed in a well-ventilated animal shed with provision of individual feeding and watering. Lambs were fed the respective diet at 4% of their body weight and with 0.50% extra allowance throughout 120 days of experimental feeding. Lambs were fed with concentrate mixture and sorghum stover to cover their nutritional requirements as per NRC (2007). The feed intake was recorded daily. The animals were weighed before feeding and watering in the morning on two consecutive days at the start of experimental feeding and after the completion of trial.

Proximate principles (DM, CP, EE, CF, NFE and TA) of concentrate mixture, green fodder (berseem and maize) were performed according to AOAC (2005). Fibre fraction of feed samples was analysed by Van Soest and Robertson (1985). Chemical composition of concentrate mixture and sorghum stover is presented in Table 1. About 10 ml of blood was collected in vacutainer tubes from jugular vein of each lamb and the heparinized plasma samples were stored at -20°C in eppendorf tubes for subsequent analysis. Glutathione peroxidase, superoxide dismutase (SOD) and malondialdehyde activities (MDA) were analysed using commercial kits (Labkit, Chemelex, S.A., Spain). A metabolic trial for a period of 5 days was conducted after end of 120 days period and proper records of water intake, feed offered and residue left, faeces and urine voided were maintained. The data were subjected to one-way ANOVA using the following model:

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

where, Y_{ij}, observation associated with each parameter; μ, overall mean; T_i, effect of i^{th} treatment group (i=1, 2, 3, 4 & 5); and e_{ij}, random error.

Table 1. Chemical composition of sorghum stover and concentrate mixture (% DM basis)

Parameter	Sorghum stover	Concentrate mixture
Moisture	9.88	11.44
Dry matter	90.12	88.56
Crude Protein	6.54	18.79
Ether extract	1.85	2.76
Crude fibre	31.62	6.25
Organic matter	90.39	91.47
Nitrogen free extract	47.76	59.44
Neutral detergent fibre	70.38	32.43
Acid detergent fibre	48.60	15.67
Hemicellulose	31.34	39.80
Cellulose	32.33	6.80
Total ash	9.61	8.53
Calcium	0.37	1.28
Phosphorus	0.30	0.83

The differences between the means were tested using Duncan's multiple range test. All the statistical procedures were carried out as per the procedures of Snedecor and Cochran (1989). Significant differences are declared at $P < 0.05$.

RESULTS AND DISCUSSION

The data related to nutrient digestibility is reported in Table 2. It shows that the digestibility coefficients of DM, OM, CP, EE, CF, neutral detergent fibre (NDF), acid detergent fibre (ADF) and NFE were significantly higher ($P< 0.05$) for lambs in group T_2 and T_3 as compared to control and other groups. Highest digestibility coefficient was found in T_3. Present findings related to nutrient digestibility are similar to Shi *et al.* (2011) and Xun *et al*. (2012) who reported improved rumen fermentation and feed utilization by Nano-Se supplementation in sheep. In contrast, Serra *et al*. (1994) reported that addition of 0.2 mg Se (Na_2SeO_3 and Na_2SeO_4, per kg DM) in sheep had no effect on digestibility of NDF. In the present study, increased nutrient digestibility was due to Nano-Se induced increase in production of proteolytic enzymes, increased activity of protein decomposing bacteria, increased microbial fermentation and ruminal *p*H in lambs (Kumar *et al.* 2008). Moreover, Nano-Se increases propionate production, mean ruminal *p*H, ammonia N content, and total volatile fatty acids.

Nitrogen, calcium and phosphorus balance as influenced by dietary treatments are presented in Table 3. All the experimental lambs showed positive nitrogen balance. It was also found that compared to control and other experimental groups, T_3 groups showed highest nitrogen intake, retention and balance which is essential for the growth of sheep. Better nitrogen balance in T_3 group may be due to increased rumen microbial enzyme activity (nitrate reductase, glutamine synthetase and glutamate synthase) which subsequently improved rumen fermentation and feed utilization (Rios *et al*. 2010). The daily intake, faecal and urinary excretion and balance of Ca and P were non-

Table 2. Effect of supplementation of different selenium sources on nutrient digestibility in lambs

Parameter	Treatment group					SEM	P-value
	C	T_1	T_2	T_3	T_4		
Dry matter	52.60[a]	53.06[a]	56.05[b]	56.76[b]	54.12[a]	0.30	0.031
Organic matter	61.23[a]	62.06[a]	64.30[b]	65.10[b]	62.44[a]	0.55	0.020
Ether extract	57.44[a]	57.90[a]	61.22[b]	62.33[b]	59.10[a]	0.36	0.019
Crude protein	69.60[a]	70.34[a]	72.70[b]	73.20[b]	71.06[a]	0.92	0.032
Crude fibre	55.46[a]	56.18[a]	58.21[b]	59.30[b]	56.60[a]	0.79	0.043
Nitrogen free extract	69.20[a]	70.50[a]	72.10[b]	73.28[b]	70.30[a]	0.67	0.035
Neutral detergent fibre	51.10[a]	52.20[a]	54.50[b]	56.03[b]	52.38[a]	0.93	0.031
Acid detergent fibre	44.05[a]	44.75[a]	46.66[b]	48.78[b]	45.12[a]	0.75	0.025
Hemicellulose	43.37[a]	43.98[a]	46.70[b]	46.87[b]	44.12[a]	0.65	0.027
Cellulose	51.03[a]	52.33[a]	55.44[b]	56.45[b]	52.70[a]	0.32	0.019

[a, b] Means bearing different superscript in a row differ significantly (P<0.05).

significant (P>0.05) among the experimental groups. This finding is in accordance with Kumar *et al.* (2008).

Effect of Se supplementation on performance is presented in Table 4. T_3 and T_4 group showed significant difference (P<0.05) in body weight gain, average daily gain and feed conversion ratio while there was no variation (P>0.05) in DM intake between the experimental groups. This is at par with the findings of Shi *et al*. (2011), Yaghmaie *et al*. (2017) and Ibrahim and Mohamed (2018). In contrast, Ghaderzadeh (2016) showed that Nano-Se did not show any significant effect on performance in the male Moghani lambs and boar goat. The improved performance because of Se supplementation might be attributed to its involvement in regulating several enzymatic systems that interfere in energetic metabolism, synthesis of prostaglandins, metabolism of the essential fatty acid apurinic and a pyrimidinic base (Saleh 2014). Besides, Sodium selenite and Nano-Se enhanced serum T_3 concentration and participated in modulating mRNA expression of IGF-I and insulin receptor, which consequently enhanced the growth performance in goats (Aghwan *et al*. 2013).

Effect of supplementation of Se on biochemical and antioxidant parameters are presented in Table 5. There was no significant difference (P>0.05) between all the groups on blood glucose, total protein, albumin, triglyceride, cholesterol, creatinine, aspartate amino transaminase (AST), alanine amino transaminase (ALT) and alkaline phosphatase (ALP) levels. Dietary Nano-

Table 3. Effect of supplementation of different selenium sources on N, Ca and P balance (g/day) in lambs

Parameter	Treatment group					SEM	P-value
	C	T_1	T_2	T_3	T_4		
Nitrogen balance							
N intake (g/d)	9.34[a]	9.51[a]	9.82[a]	11.08[b]	9.86[a]	1.02	0.03
Faecal N (g/d)	4.85	5.07	4.88	4.98	5.33	0.07	0.76
N retention (g/d)	4.49	4.44	4.94	6.10	4.53	0.23	0.67
Urinary N (g/d)	2.96	2.84	2.98	2.84	2.74	0.39	0.88
Total N loss (g/d)	7.81	7.91	7.86	7.82	8.07	0.15	0.59
N balance (g/d)	1.53[a]	1.60[a]	1.96[a]	3.26[b]	1.79[a]	1.19	0.021
Ca balance							
Ca intake (g/d)	10.58	10.82	11.41	11.34	11.78	0.13	0.93
Faecal Ca (g/d)	3.82	3.97	3.34	2.88	3.55	0.25	0.66
Ca retention (g/d)	6.93	6.91	8.16	8.34	8.48	0.11	0.59
Urinary Ca (g/d)	2.32	2.34	3.54	3.89	3.73	0.32	0.12
Total Ca loss (g/d)	6.14	6.31	6.88	6.77	7.28	0.65	0.32
Ca balance (g/d)	4.44	4.51	4.53	4.57	4.50	0.02	0.9
P balance							
P intake (g/d)	3.48	3.38	3.20	3.01	3.42	0.11	0.56
Faecal P (g/d)	1.50	1.46	1.12	1.17	1.13	0.19	0.95
P retention (g/d)	1.98	1.92	2.08	2.84	1.29	0.01	1.21
Urinary P (g/d)	0.88	0.67	0.86	0.64	1.12	0.06	0.32
Total P loss (g/d)	2.38	2.13	1.98	1.81	2.25	0.09	0.65
P balance (g/d)	1.10	1.25	1.22	1.21	1.17	0.05	0.79

[a, b] Means bearing different superscript in a row differ significantly (P<0.05).

Table 4. Effect of supplementation of different selenium sources on performances in lambs

Parameter	Treatment group					SEM	P-value
	C	T_1	T_2	T_3	T_4		
Initial body weight	13.50	13.83	14.40	14.73	14.23	0.14	1.04
Final body weight	22.70 [a]	23.57 [ab]	24.17 [ab]	25.97 [c]	25.27 [bc]	0.43	0.008
Net gain (Kg)	9.20 [a]	9.73 [a]	9.77 [a]	11.23 [b]	11.03 [b]	0.76	0.0065
ADG (g)	76.67 [a]	81.11 [a]	81.39 [a]	93.61 [b]	91.94 [b]	0.97	0.003
DMI (g/day)	751.00	749.58	746.66	750.33	749.50	0.30	0.91
Feed Conversion Ratio	9.94 [a]	9.03 [b]	9.37 [ab]	8.01 [c]	8.20 [c]	0.54	0.007

[a, b, c] values bearing different superscripts in a row differ significantly (P<0.05).

Table 5. Effects of supplemental selenium sources on biochemical and antioxidant parameters in lambs

Parameter	Treatment group					SEM	P-value
	C	T_1	T_2	T_3	T_4		
Glucose (mg/dL)	72.22	70.89	67.11	71.15	69.62	1.11	0.42
Total protein (g/dL)	62.26	55.76	65.37	60.02	59.06	0.51	0.149
Albumin (g/dL)	38.56	45.95	41.37	36.50	40.94	0.50	0.565
Triglyceride (mg/dL)	109.08	106.23	117.64	122.29	124.77	0.21	0.99
Cholesterol (mg/dL)	144.26	138.24	135.97	130.01	132.20	0.34	1.12
ALP (IU/L)	133.59	127.84	128.76	125.99	129.68	0.65	0.87
AST (IU/L)	103.04	103.60	101.10	97.21	96.10	0.70	0.64
ALT (IU/L)	12.50	15.00	16.67	13.67	14.17	0.95	1.4
Creatinine (mg/dL)	1.06	1.12	1.03	1.06	0.96	0.08	0.54
GSH-Px (U/L)	92.13[a]	102.43[a]	112.50[a]	133.01[b]	117.78[a]	1.11	0.021
SOD (U/gHb)	7.20 [a]	7.60 [a]	7.56 [a]	7.90[b]	7.55 [a]	0.46	0.032
MDA (µmol/l)	0.58 [a]	0.61 [a]	0.58 [a]	0.42 [b]	0.51 [a]	0.78	0.036

[a, b] values bearing different superscripts in a row differ significantly (P<0.05)

Se supplementation (0.30 ppm) significantly (P<0.05) decreased MDA content in blood. Among the selenium treated groups, the significantly highest activity of GSH-Px and SOD was observed in the T_3 group compared to other groups. This result is similar to the findings of Sushma *et al.* (2015) and Shi *et al*. (2018). In the present experiment increased antioxidant activity might be due to increased ability of nano particles to trap free radicals with greater antioxidant effect and have an increased adsorptive ability due to interactions between the nanoparticles and NH, C=O, COO-, and C-N functional groups of proteins (Zhang *et al*. 2007)

It can be concluded that lambs supplemented with Nano-Se recorded significantly higher body weight gain, average daily gain and better feed conversion efficiency compared to other groups. Based on the present study, it can be concluded that dietary supplementation of Nano-Se at 0.30 ppm should be used more efficiently to improve the nutrient digestibility, growth performance and antioxidant status in Mecheri lambs.

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