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Block of mineral salt in the diet of sheep and lambs and their effects on health and performance

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Abstract

The objective of the study was to assess the effects of consumption of mineral salt blocks on the performance and the hematologic and biochemical parameters of sheep and lambs animals kept in tropical conditions. The study was divided into two field experiments. The first experiment used a total of 44 hair sheep of the Santa Ines breed, which were maintained under *Brachiaria brizantha cv.* Marandu grazing system. Animals were randomly assigned to two treatments to received mineral supplementation as: a) powder or b) block of mineral salt; and consumption and hematological and biochemical blood parameters were assessed. In the second experiment, lambs divided equally, similar to experiment 1, and performance and carcass quality parameters were assessed. Sheep and lambs consumed less mineral supplementation in multi-nutritional block format (P<0.05); however, the hematological and biochemical blood parameters were not affected by the form of the mineral supplementation offered (P>0.05). Carcass characteristics were also not affected by the form of mineral supplementation form (P>0.05). Multi-nutritional block was well accepted by sheep and lambs and did not affect health and performance of the animals; thus, it could be recommended as an alternative to the powder mineral supplementation. The product was easy to use as a supplement for grazing or stall-fed animals.

Key words: ovine, mineral, feedlot, hematological parameters, performance

INTRODUCTION

Sheep farming is growing worldwide (FAOSTAT, 2016), including in tropical areas, where production of dry forage is high; however, it has a lower content of nutrients in comparison with forage of temperate climates. Overcoming nutritional deficiency of animals fed tropical forages is a challenge, especially during dry seasons. The grazing method is used to maximize forage production and reduce feeding costs. However, due to the high nutritional needs of lambs in the growing stage, they can be stall-fed at finishing, as they are slaughtered young and have a greater nutritional need than ewes do.

Supplements to grazing sheep are used to enhance animal performance, as well as to improve animal health (PEREIRA et al., 2017). Supplementation with minerals is critical to animal performance and health due to mineral deficiencies in the soil-plant system, which directly affect animal nutrition. Mineral deficiency negatively influences animal growth, reproduction, immune system, cellular replication, skeletal progress, and energetic metabolism (WANG et al., 2009; HAENLEIN; ANKE, 2011; OVERTON; YASUI, 2014). The mineral supplementation is traditionally offered as powder, which limits its adequate use due to its hygroscopic characteristics.

Multi-nutritional block is an alternative for mineral supplementation for sheep production systems. The use of minerals in block influence positively parameters, such as feeding efficiency, milk production, reproductive performance (KIOUMARSI et al., 2011; WANG et al., 2016). The use of mineral blocks is easy and efficient, and sheep can receive the necessary requirements of oligoelements to ensure health and optimum productivity, with reports of various benefits for reproduction, reduction of mortality rate, greater economic return (WANG et al., 2016).

We hypothesized if sheep and lambs have good intake of mineral salt in block and if its consumption is beneficial to their health, performance and skeletal quality. The objective of this study was to assess the effects of mineral supplementation in a block format salt on the consumption, performance, skeletal characteristics and hematological and biochemical parameters of sheep and lambs reared under tropical conditions.

MATERIAL AND METHODS

The experiment protocol for the present experiment was approved by the Animal Ethics and Well-being Committee of the University of São Paulo, No. 8755210515, issued on July 7, 2015. The study was divided into two experiments. The first experiment comprised pregnant sheep reared under the grazing system and the second with stall-finished lambs. Both were conducted in the Faculty of Animal Science and Food Engineering of the University of Sao Paulo, Pirassununga, SP, Brazil. The town is located at latitude 21° 59’ S and 47° 26’ W at altitude 634 m. The climate of the region is considered subtropical with dry and well-defined winters and hot and rainy summers.

Experiment 1: Ewes in breeding

It was used 44 sheep, Santa Ines breed, aged 2-5 years, pregnant, kept on pasture of *Brachiaria brizantha cv.* Marandu with no restriction of forage. The stocking rate was 22 animals per ha, during the period of greatest availability of forage, with a available amount of forage of 8 kg DM/animal/day, in rotational grazing, with a minimum height of forage of 25 cm. The height of the forage was measure with ruler every three days and forage volume was measured by cutting, drying and weighing the forage corresponding to 1 cm². The samples were taken from different sites in the area (BARBERO et al., 2015).

The chemical composition forage and the amount of minerals in the mineral supplements evaluated are described in Table 1. The chemical analysis of feed was measured according to (AOAC, 1995) (DM: dry matter - ID 930.15; MO: CP: crude protein - as 6.25 × N - ID 954.01; and ADF: Acid detergent fiber - ID 973.18) and Mertens (2002) (NDF: neutral detergent fiber). ADF and NDF were determined without the addition of α-amylase and sodium sulfite, and with the residual ash. ADF was determined by a sequential extraction of NDF residue.

The experimental treatments were based on the material form of mineral supplementation (powder or in block). Mineral supplementation was offered freely and the residue was weighed on a precision electronic scale every other day. The mineral supplementation was supplied in plastic troughs with covering and water was available without restriction. No other additional feed was offered, only forage and minerals.

Sanitary control of internal parasites in sheep was accomplished through a dose of anthelmintic prior to the testing period, with monitoring every 21 d using the FAMACHA method (PETERSSON, 2014; CAMPBELL et al., 2017). In the same time-span, sheep were weighed on electronic scales and their physical condition was assessed on a scale 1-5, according to the method proposed by Kenyon et al. (2014), where 1 is a very thin animal, 2 thin, 3 normal, 4 fat and 5 very fat.

Blood samples were obtained in the morning by venipuncture of the external jugular with disposable needles (25x8mm) attached to the adapter, in plastic vacuum tubes (4 ml). The tube containing EDTA as an anticoagulant was used for complete blood count. The tube without anticoagulant was used to obtain serum to assess the biochemical parameters. Sampling was done on the first and last day of the experiment.

To determine the number of red blood cells, hematocrit, hemoglobin level and total number of white blood cells, with commercial kits. The blood samples in natura were used to produce two blood films to measure white blood cell differential. Hematological values were divided into three parts: i) Eritogram (hematocrit, hemoglobin rate, and red blood cell morphological assessment and count); ii) Leukogram (white blood cell morphological assessment, total count and differential); iii) Platelet (morphological assessment and count of platelets assisting in hemostasis interpretation) (MICHEL, 2012).

The blood contained in the tube without anticoagulant was immediately spun in a centrifuge at 3.000 rpm for 20 min to obtain serum, which was pipetted in plastic Eppendorf micro tubes, wrapped and stored at -20°C. At the end of the experiment, blood biochemical properties. The serum was thawed at ambient temperature and analyzed using Mindray BS 120, China, with commercial kits from Labtest, Brasil (Glucose; Lactate; CK; AST; Cholesterol; Triglycerides; Calcium; Phosphorus; Urea; Creatinine; Total Proteins; Albumin GGT; Calibra H; Qualitrol 1H).

The experimental analysis was carried out using a randomized block design, the age of the sheep was one parameter to be blocked. The weight, body condition and mineral consumption experimental data were analyzed using the MIXED procedure of SAS, the means compared by the Tukey test, with differences greater than 5% probability accepted.

Experiment 2: Lambs in finishing phase

It was used 20 whole lambs, with initial weight of 31.40 kg and 100 d of age, resulting from industrial crossing of Dorper, Texel and Santa Ines breeds. The animals were kept in individual stalls, under shade and slatted floor, with free access to their feeding trough, mineral supplement and water. The confinement period lasted 33 d and the animals received a dose of anthelmintic for sanitary control of internal parasites at the beginning, as well as all animals were also vaccinated for clostridial diseases.

The diet consisted of whole grain corn (80%) and protein pellets (20%). The bromatological composition of the ingredients are listed in Table 2. The experimental treatment was based on the mineral composition of the diet, using two different mineral supplement treatments formats: powder or block. The mineral composition of the powder mineral supplement is described in Table 1. The corn and soybean amount were offered and leftovers were weighed daily to ensure free choice. Both minerals supplements were weighed every 2 d to measure intake and ensure free choice.

Lambs were weighed every 7 d, on electronic scales with 10-gram precision. The animal body condition score was evaluated on a scale 1-5, according to the method described by (Kenyon et al. 2014). Blood samples were taken at the end of the experimental period to monitor the general health of animals using a complete blood tests and biochemical blood analysis. The samples and analysis of blood tests, biochemical and enzymes were conducted similarly to experiment 1.

Lambs were slaughtered in commercial slaughterhouses, under sanitary inspection. After slaughter, carcasses were weighed while hot, 30 min after slaughter, and cold, after 24 h under refrigeration at 2º C. The results were used to calculate hot dressing percentage (HDP) and cold dressing percentage (CDP).

A randomized design was used for the experimental analysis, with two treatments and ten repetitions each. Data of body weight, body condition, and consumption of dry matter of grains and minerals were analyzed using the MIXED procedure of SAS. The means were compared using the Tukey test and treated as different when above 5% probability.

RESULTS

Experiment 1: Ewes in breeding

There was no change in scores for body weight and body condition of sheep at the beginning and end of the experiment (Table 3). There was a difference in the amount of mineral supplement ingested (P=0.0176) by Santa Ines sheep, with average values of 22.52 grams of mineral supplement in powder per sheep per day against 13.55 grams of mineral in block per animal per day.

The type of mineral supplement influenced, respectively, salt in powder and in block, white blood cells (P=0.0132) with averages of 11.68 $x10^3$/dL and 9.2 $x10^3$/dL, glucose (P= 0.0045) with averages 66.85 and 57.85 mg/dL, creatinine (P= 0.0008) with averages 1.10 and 0.96 mg/dL, total protein (P= 0.0102) with averages 6.51 and 7.02 g/dL, and GGT (P= 0.0167) with averages 55.27 and 43.17 U/L (Table 4). However, the form of mineral supplement did not interfere (P> 0.05) characteristics of red blood cells, hemoglobin, hematocrit, MCV, MCHC, platelets, lactate, cholesterol, urea, AST, Ca and P. The values of the hematological and biochemical parameters of the blood (Table 4) are within the accepted range for sheep, with no changes of energetic values (glucose, lactate, cholesterol), protein values (urea, creatinine, protein) and in liver and kidney functions (AST, GGT).

Experiment 2: Lambs in finishing phase

The form of mineral supplement offered (powder or block) did not affect (P>0.05) consumption of dry fodder, weight gain, initial and final body condition scores, weight and carcass yields. Nevertheless, salt consumption was different between the groups (P=0.385), with an average consumption of 33 g for salt in powder and 9 g in block (Table 3).

Despite the difference in mineral supplement consumption, the hematological parameters, such as white blood cells, red blood cells, hematocrit, MCV, MCHC, platelets were not influenced by the mineral supplement form (P>0.05). The biochemical and enzymatic parameters, such as glucose, lactate, cholesterol, AST, and protein were not affected (P>0.05) by the salt from (Table 5). Values of creatinine, urea and GGT were not influenced (P<0.05) by the salt form. Average values for the groups treated with salt in powder and block, respectively, were 0.82 and 0.78 mg/dL for creatinine, 20.75 and 24.75 mg/dL for urea, and 120.80 and 86.88 U/L for GGT; however, the values were outside the reference ranges for the species.

DISCUSSION

Experiment 1: Ewes in breeding

Sheep consumed less mineral supplement in block format than in powder, probably due to its high sodium content; however, the animals accepted the product. On average, sheep consumed 40% more of mineral supplement in powder than in block. Differences in consumption due to the physical form of the mineral supplement can be found in the literature (RAGEN et al., 2015a; RAGEN et al., 2015b), with differences even larger than those found this study.

The results of red blood cell count are used to evaluate anemia, which is characterized by a decrease in these parameters. In this study, sheep were treated on pasture exposed to nematodes, still, the animals did not develop anemia. Altered values in the white blood cell count can indicate infectious diseases, inflammatory and/or as a result of stress (JONES; ALLISON, 2007). The results of the white blood cell counts were different between the groups; however, within the reference range for the species thus we conclude that the animals did not develop any infection. To complete the hemogram, the platelet counts are directly linked to changes in blood coagulation; however, the values obtained are expected for healthy animals.

Glucose is the least important indicator to monitor the energetic status of ruminants, due to the strong homeostatic control that the organism maintains over its concentration and its sensibility to stress (BRITO et al., 2006; PEIXOTO; OSÓRIO, 2007; PEIXOTO et al., 2010) to prevent many tissues of these animals from using free fatty acids and ketone bodies as energetic sources and for their livers also have a high gluconeogenesis function. However, the energetic deficit must be very intense to reduce glucose concentration in the blood (PEIXOTO; OSÓRIO, 2007). To offset the lack of glucose, triglycerides are activated, resulting in increased plasmatic levels of non-esterified fatty acids (NEFA). Splitting the NEFA increases concentration of the beta-Hydroxybutyric acid in the plasma (PEIXOTO; OSÓRIO, 2007). Thus, other blood metabolites, such as βHB, free fatty acids (FFA) and ketone bodies are physiological products of the metabolism of carbohydrates and lipids of ruminants (LIMA et al., 2015; RASKIN; WARDROP, 2012).

The mineral supplement form influenced glucose and creatinine levels; however, these energetic parameters remained within expected levels for this species. Total proteins have multiple functions, such as keeping the blood osmotic pressure and viscosity, transporting nutrients, metabolites, hormones and excretion materials, pH regulation in the blood and participation in blood coagulation (WEISS; WARDROP, 2010). Total protein count was higher for the animals treated with mineral salt in block; however, in both treatments, the average remained within the recommended range.

Clinical enzymology is a great help in diagnosis, especially in relation to enzymes in the blood stream, several of which are included in the study of metabolic blood panel (KANEKO et al., 2008). Enzymes are proteins produced inside the cells and accelerate chemical reactions in other substances, but remain inherently unaltered. Thus, in normal conditions, enzymes have low plasmatic activity. Blood levels of an enzyme can be increased after cell death or other damage to cells. Increase in enzymatic activity in plasma allows to draw conclusions about the area and extent of cellular damage, since many enzymes are organ-specific.

A brief description of some enzymes linked to hepatic metabolism: i) GGT acts in transferring amino acids and peptides through the cell membrane and signals hepatic insufficiency; ii) ALT is found mainly in the liver and can indicate hepatocyte regeneration, cardiomyopathy and muscle injuries; iii) AST is found in the liver, red blood cells and in the cardiac muscle, and usually indicates muscle injury when accompanied by CK and LDH. GGT was different in each treatment; however, within expected ranges thus we can state that the animals did not develop any liver damage.

Experiment 2: Lambs in finishing phase

Despite differences in the consumption of mineral supplement in powder and in block (P=0.0385), there was no difference in performance and carcass characteristics of lambs (P>0.05), probably because diets were very similar in both treatments. Jing et al. (2017) conducted a study with ram lambs on pasture with no supplementation and supplemented with mineral blocks or concentrate and reported a difference in weight gain between treatments, with the animals fed on salt block having an intermediate performance. Similar to this present study, Campbell et al. (2017), assessed the difference between mineral salt in block and in powder in the diet of lambs and found no difference in weight gain in stall-feeding, nor in feed conversion or consumption of dry fodder. However, the quality of the mineral salt and its balanced use can improve performance characteristics and carcass weight (GARG et al., 2008; KEADY et al., 2017).

The mineral supplement format did not affect hematological and biochemical blood parameters; however, creatinine, urea and GGT did not fall into the range of expected values for the species (MEYER; HARVEY, 2004; KANEKO et al., 2008; WEISS; WARDROP, 2010). Protein metabolism in catabolic state, assessed in the blood flow, such as urea and creatinine, indicate nephropathy, as the kidneys are the most active organs in excreting these products. In this study, we found reduced values of creatinine and increased values of urea, which could indicate renal problems in the lambs. GGT indicates changes in the liver and was affected in both treatments. NDF rate in the diet was reduced (11%), which may have altered protein metabolism and changed creatinine, urea and GGT. In studies with Santa Inês and Dorper breeds, the reference values for lambs in the finishing stage are 0.65 to 1.2 mg/dL for creatinine, 31.67 to 52 mg/dL for urea, and 93 U/L for GGT (MADUREIRA et al., 2013; TEIXEIRA et al., 2014; LIMA et al., 2015). The results presented here show that the lambs used in this study can be assessed as not having any renal alterations, but with hepatic problems.

Offering mineral supplement in block can be an interesting nutritional strategy as it offers various advantages, such as added minerals, proteins, energy and vitamins, which can be used as multi-nutrients (SALEM; NEFZAOUI, 2003), easiness of use and reduced costs in relation to conventional concentrates (JING et al., 2017).

Table 1. Bromatological composition of *Brachiaria brizantha* (Hochst.) Stapf., Marandu and levels in multi-nutrition blocks and commercial mineral powder

Bromatological composition	Brachiaria sp	
	Marandu	
Dry matter (g/kg)	360	
Crude protein (g/kg of DM)	67.2	
Ether extract (g/kg of DM)	15.2	
Nitrogen free extract (g/kg of DM)	516.4	
FDN (g/kg of DM)	731.7	
FDA (g/kg of DM)	398.9	
Mineral matter (g/kg of DM)	70.7	
Calcium (g/kg of MS)	4.1	
Phosphorous (g/kg of MS)	3	
Level in multi-nutrition blocks and commercial mineral powder		
	Mineral salt powder	Multi-nutritional blocks
Calcium	145g/kg	77 g/kg
Phosphorous	85g/kg	
Sodium	135g/kg	971 g/kg
Manganese	1.400mg/kg	1.046 mg/kg
Selenium	25mg/kg	33 mg/kg
Cobalt	60mg/kg	66 mg/kg
Zinc	4.000mg/kg	1.235 mg/kg
Red Iron oxide		985 – 1.602 mg/kg
Copper		377 mg/kg

DM = Dry Matter.

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Table 2. Bromatological composition of the ingredients in the diets of stall-fed lambs.

Ingredient	Corn (Grain)	Commercial Protein Pellet	Diet total
Dry matter (g/kg)	0.880	0.880	0.880
Crude protein (g/kg of DM)	0.100	0.320	0.144
Ether Extract (g/kg of DM)	0.043	0.015	0.037
FDN (g/kg of DM)	0.100	0.180	0.116
FDA (g/kg of DM)	0.030	0.150	0.054
Ash (g/kg of DM)	0.160	0.190	0.160
Ca (g/kg of DM)	0.020	0.040	0.02
P (g/kg of DM)	0.035	0.010	0.01

DM = Dry Matter.

Table 3. Fodder intake, performance of sheep and lambs fed with two forms of mineral salt.

Mineral				
	Powder	Block	SEM	P
Sheep				
Mineral salt intake (kg)	0.0225B	0.0135A	0.0084	0.0176
Initial body weight (kg)	50.50	51.60	0.0190	0.0890
Final body weight (kg)	54.80	56.50	0.1890	0.0725
Conditional body score (1-5)	3.5	3.75	0.0020	0.9890
Conditional body score (1-5)	4.00	4.25	0.0100	0.8756
Lamb				
Dry matter intake (kg)	0.5171	0.5140	0.0050	0.3074
Mineral salt intake (kg)	0.033 B	0.009 A	0.0061	0.0385
Initial body weight (kg)	30.90	31.90	0.8720	0.5490
Final body weight (kg)	36.03	37.96	0.9870	0.3705
Average daily weight gain (kg)	0.146	0.173	0.0130	0.2078
Initial body condition score	3.25	3.26	0.1012	0.9000
Final body condition score	3.90	4.00	0.1120	0.6960
Hot carcass weight (kg)	17.54	18.86	0.4275	0.2200
Cold carcass weight (kg)	17.16	18.36	0.4261	0.2611
Hot carcass yield (%)	45.85	49.64	0.5290	0.4277
Cold carcass yield (%)	47.75	48.38	0.5004	0.3768

SEM = standard error of the mean, P = probability

Table 4. Mean values of hematological parameters and biochemical analysis of sheep fed with different forms of mineral salt in the last week in pasture *Brachiaria brizantha* (Hochst.) Stapf., Marandu.

Mineral				
	Powder	Block	SEM	P
Leukocytes ($x10^3$/dL)	11.68	9.2	0.8955	0.0132
Red blood cells($x10^6$/dL)	10.37	10.29	0.4348	0.8444
Hemoglobin (g/dL)	11.43	11.70	0.4430	0.5443
Hematocrit (%)	34.97	35.36	1.2198	0.7525
MCV (fL)	34.05	34.51	1.2090	0.5602
MCHM (%)	32.58	33.02	0.3380	0.2079
Platelets ($x10^3$/dL)	486.04	442.04	55.478	0.4266
Glucose (mg/dL)	66.85	57.85	2.2230	0.0045
Lactate (mg/dL)	28.32	21.43	4.7597	0.2058
Creatinine (mg/dL)	1.10	0.96	0.0363	0.0008
Cholesterol (mg/dL)	60.13	62.56	2.8816	0.4437
Urea (mg/dL)	21.90	23.52	1.3003	0.2411
Protein (g/dL)	6.51	7.02	0.1894	0.0102
AST (U/L)	120.55	129.82	6.9143	0.2229
GGT (U/L)	55.27	43.17	4.8384	0.0167
Ca (mg/dL)	8.9	9.1	0.1613	0.8080
P (mg/dL)	6.1	6.3	0.1920	0.7987

MCV - Mean corpuscular volume; MCHM = Mean corpuscular hemoglobin concentration. AST = Aspartate Aminotransferase; GGT = Gamma Glutamyl Transferase, Ca = calcium total, P = phosphorus. SEM = standard error of the mean, P = probability

Table 5. Mean values of hematological parameters and biochemical analysis of lamb fed with different forms of mineral salt.

	Mineral			
	Powder	Block	SEM	P
Leukocytes (x10^3/dL)	7.30	8.30	0.9143	0.3016
Red blood cells(x10^6/dL)	11.75	12.00	0.9620	0.7919
Hemoglobin (g/dL)	11.51	11.60	0.8569	0.5443
Hematocrit (%)	34.36	34.58	2.2696	0.9209
MCV (fL)	30.11	28.97	1.8176	0.5691
CHCM (%)	9.88	9.61	0.7162	0.5448
Platelets (x10^3/dL)	664.90	587.11	51.6308	0.2437
Glucose (mg/dL)	74.48	79.34	2.8695	0.1083
Lactate (mg/dL)	19.30	15.29	3.2108	0.3862
Cholesterol (mg/dL)	70.79	72.15	7.9539	0.8657
Creatinine (mg/dL)	0.82	0.78	0.0562	0.4350
Protein (g/dL)	6.02	6.07	0.2531	0.8383
Urea (mg/dL)	20.75	24.75	2.4008	0.1271
AST (U/L)	201.20	159.11	43.5383	0.3472
GGT (U/L)	129.80	86.88	21.1167	0.0635
Ca (mg/dL)	9.3	9.5	0.1120	0.7458
P (mg/dL)	6.8	6.5	0.1520	0.7149

MCV - Mean corpuscular volume; MCHM = Mean corpuscular hemoglobin concentration. AST = Aspartate Aminotransferase; GGT = Gamma Glutamyl Transferase, Ca = calcium total, P = phosphorus. SEM = standard error of the mean, P = probabilityss

CONCLUSIONS

Mineral supplement in blocks was accepted by sheep and lambs and did not cause any harm to the animal health or performance thus its use can be recommended. The product was easy to use as a supplement for animals, either pasture-fed or stall-fed.

Conflict of interest statement

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article.

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