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INFLUENCE OF ALUMINOSILICATES SUPPLEMENTATION ON CHARACTERISTICS OF DIGESTION AND RUMINAL FERMENTATION OF STEERS

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Abstract: This paper aimed to evaluate the effect of different levels of a commercial additive composed by aluminosilicates, named Beefplus, on intake and apparent digestibility of nutrients, and metabolism of nitrogenous compounds. Five male Nellore cattle, with ruminal fistula, were distributed in a 5×5 Latin square, consisting of five treatments (levels of aluminosilicates: 0.0; 0.5; 1.0; 1.5 and 2.0%, in DM basis) and five experimental periods, of 15 days each, totaling 75 days of experiment. The basal diet consisted of 40% corn silage and 60% concentrate made with cornmeal and soybean meal. Adaptation to the diet occurred from the 1st to the 10th day of each period, in the subsequent five days (from the 11th to the 15th day), total feces collections were performed. During the collection period, samples of silage, concentrates, and leftovers were made for further analysis. There was no effect of aluminosilicates levels (P>0.05) on nutrient intake and digestibility. There was no effect (P>0.05) of the addition of aluminosilicates on the metabolism of nitrogenous compounds. It was concluded that the addition of aluminosilicates does not alter nutrient intake and digestibility.
Keywords: additives, nutrition, ruminants

INTRODUCTION

Beefplus is a nutritional additive composed of Glauconite, an aluminosilicate family mineral, which is a green-colored rock of sedimentary origin, rich in iron and potassium.

Aluminosilicates consist of aluminum, silicon, and oxygen with the general formula Al_2SiO_5. These minerals can gain or lose water and exchange cations without changing their three-dimensional structure (Newman, 1969).

Aluminosilicates have adsorptive properties, the ability to bind reversibly to ammonium, and the ability to not react with nutrients or body fluids, considering they are inert in the digestive system (Ivkovic et al., 2004). The high affinity for water and cations can help pH control and improve the use of nitrogen in the rumen (Mumpton e Fishman, 1977).

Zeolite is an example of an aluminosilicate widely used in ruminant nutrition. There are few studies using glauconite in animal feed and the objective of this study was to evaluate the influence of aluminosilicates supplementation on intake and digestibility of nutrients, on pH and ammonia concentration in rumen and production and efficiency of microbial protein synthesis in beef cattle.

MATERIALS AND METHODS

CHARACTERIZATION OF THE EXPERIMENTAL AREA

The Animal Care Committee of the Federal University of Minas Gerais (CEUA/UFMG) approved all animal procedures under the protocol 15/2017. This study was conducted at UFV (University of Viçosa), campus Florestal, between May and August. UFV-Florestal is located in the city of Florestal (19 ° 53 '20 "S 44 ° 25' 58" W), in Minas Gerais, 60 km from the capital, Belo Horizonte. The climate in Forestal is tropical, the average temperature is 21.5°C, the maximum temperature is 23°C, and the minimum is 10.4°C (climatic data: INMET). The laboratory analyzes were performed at Animal Nutrition Laboratory of the Department of Animal Science of Veterinary School of the University of Minas Gerais (UFMG).

ANIMALS, DIETS AND EXPERIMENTAL DESIGN

Five Nellore steers (397 kg±32.10 kg live weight) fitted with ruminal cannulas were used in a 5x5 Latin square design to evaluate the influence of aluminosilicates supplementation (0, 0.5, 1.0, 1.5 and 2.0%, on DM basis) on intake and digestibility of nutrients. The source of aluminosilicates supplied was the company VerdeAgritech, which donated the commercial product called Beefplus, made from glauconite rocks.

Diets contained 40% forage (corn silage) and 60% concentrate, and they calculated using BR-Corte (Valadares et al., 2016).

Steers were housed in individual pens ($18m^2$) in an indoor facility, with a concrete floor covered with automatic waters and single feed bunks.

All steers received ad libitum access to a basal diet for 21 days before the initiation of the trial. Aluminosilicates were weighed using a precision model Shimadzu AY220 and were added to the basal diet at the time of feeding. The ingredients and chemical composition of experimental diets are shown in Table 1 and Table 2. The basal diet was fed in two equal proportions at 7 hours and 16 hours daily.

Experimental periods consisted of 15 days, with nine days for dietary treatment adjustment and five days for sample collection. During the collection period, feces from all steers were taken and weighed, twice daily. Feed, leftovers and fecal samples from each steer were prepared for analysis as follows: samples were first oven-dried at 55°C and then ground in a laboratory in Willey mill.

Spot urine collection was performed on the last day of the collection period, four hours after feeding, during spontaneous urination, 10 mL of urine diluted in 40 mL of 0.036N sulfuric acid (0.036N H_2SO_4) was collected in a 200 mL capacity vessel.

SAMPLE ANALYSES AND CALCULATIONS

Feed, leftovers and fecal samples were subjected to the following analysis: DM (oven drying at 105°C; method 930.15; AOAC 2000); ash (method 942.05; AOAC 2000), Kjeldahl N (method 984.13; AOAC 2000); neutral detergent fiber and acid detergent fiber de [NDF and ADF; Van Soest et al. 1991; corrected for NDF-ash, incorporating heat-stable a-amylase (Ankom Technology, Macedon, NY, USA) at 1 mL per 100 mL of NDF solution (Midland Scientific, Omaha, NE, USA)]. Organic matter (OM) content was estimated as DM minus ash content. The NFC of feed was obtained by the equation (Detmann et al., 2012):

NFC = 100 - (% CP +% NDFap +% EE +% ash)

The total digestible nutrients (TDN) was obtained for each animal, within its treatment and period, by the equation:

TDN = CPD + (EED x 2.25) + NFDD + NFCD

Wherein:
CPD = crude protein digestible;
EED = ether extract digestible;
NFDD = neutral fiber digestible detergent;
NFCD = non-fibrous carbohydrates digestible.

Nitrogen (N) intake was calculated using analyzed dietary N content of each feedstuff and multiplied by total DMI. Fecal N and urine N were calculated using the total weight feces and urine collected and their N composition. Individual steer N retention was calculated using the NRC (1996) net protein and net energy equations. N balance was determined by the difference between N intake and N retention.

Apparent nutrient digestibilities were calculated from concentrations of nutrients in diets, orts, and feces using the following equation, according to Silva e Leão (1979):

Apparent digestibility (%) = ((consumed - excreted in the faeces) x 100) / consumed.

STATISTICAL ANALYSES

The effects of the aluminosilicates level on characteristics of digestion and fermentation were analyzed as a 5×5 Latin square design in SISVAR (Ferreira, 2011). The fixed effects consisted of treatment and period, and steer as a random effect. The statistical model for the trial was as follows:

$$Y_{ijk} = m+S_i +P_j +T_k + E_{ijk}$$

Where: Y_{ijk} is the response variable, m is the common experimental effect, S_i is the steer effect (n = 5), P_j is the period effect, T_k is the treatment effect (doses levels of 0,0; 0,5; 1,0; 1,5 and 2,0%), and E_{ijk} is the residual error.

RESULTS

INTAKE, APPARENT DIGESTIBILITY OF NUTRIENTS AND METABOLISM OF NITROGENOUS COMPOUNDS

The effects of inclusion of aluminosilicates on the intake, digestibility and metabolism of nitrogen compounds are presented in Tables 3, 4 and 5.

Aluminosilicates supplementation did not affect (P>0.05) daily nutrient intake ($kg.day^{-1}$), coefficient of apparent digestibility (%) and metabolism of nitrogenous compounds.

DISCUSSION

INTAKE, DIGESTIBILITY OF NUTRIENTS AND METABOLISM OF NITROGEN COMPOUNDS

According to the Ionstatic Theory, mineral additives can increase osmolarity and the release of norepinephrine, a Central Nervous System (CNS) mediator, which would increase water intake and salivation. This fact can cause an increase in passage rate and DMI (Gonçalves, Borges and Ferreira, 2009). However, Sherwood et al. (2006) and Cole et al. (2007), in agreement with the present study, included 1.2 and 2.0% of zeolite in DM of diet and found no statistical differences in nutrient intake. Dschaak et al. (2010) provided 1.4% clinoptilolite, on a DM basis, for dairy cows and, similarly, did not find differences in nutrient intake.

A possible explanation for these results is that physiological, physical, psychogenic, environmental factors and aspects inherent to the animal control DMI. The dominance of one intake control mechanism over another may be related to the quality of the diet, energy content and digestibility since these mechanisms work in an integrated way to generate positive or negative stimuli. (Detmann et al. 2014).

Because diets in this study were isoproteic and there was no difference in DMI, there was no change in CP intake. However, Câmara et al. (2012), who worked with 3.0% zeolite in beef cattle diet, found a positive linear effect for CP intake. The authors add urea in substitution to cornmeal in the diets with zeolite supplementation, slightly changing the concentration of CP supplied between treatments.

The effects of aluminosilicates addition of on digestibility are inconsistent in the literature. Ghaemnia et al. (2010) reported the increase in mineral content (ash) with the zeolite addition would decrease the nutrient digestibility since it would cause the dilution effect. The dilution effect indicates that the concentration of the nutrients per kg of treatment with the mineral additive reduces concerning the control treatment. Johnson et al. (1988) indicated that the zeolite supplementation decreased the DM digestibility and justified this result by the influence of the dilution effect since these authors used inclusions of 9% of zeolite in the dietary DM.

Digestibility can be improved by decreasing the passage rate, increasing the substrate time exposure to the fermentation process (Krehbiel, 2014). The silicates have adsorbent properties that would increase the ruminal viscosity, which could compensate for the dilution effect, reducing the passage rate and, consequently, increasing the digestibility coefficient (Spotti et al., 2005). Sweeney et al. (1984) observed a higher digestibility coefficient of OM (an increment of 3.5%) by the zeolite supplementation of 50g.kg^{-1} DM in the beef cattle diet.

The works of Cole et al. (2007) and Câmara et al. (2012) corroborate the digestibility data of this study. They did not find differences between nutrient digestibilities with zeolite supplementation in beef cattle diets. According to Toprac et al. (2016), the silicates in powder form do not chemically react with nutrients or body fluids, since they are inert in the digestive system; therefore, they may not influence digestibility.

The responses regarding the metabolism of nitrogenous compounds and the use of aluminosilicates have not been consistent among the studies.

Beef cattle fed with high energy diets (<60% rumen undegradable protein (RUP) and <20% NDF), zeolite supplementation (2.5%) did not affect the metabolism of nitrogen compounds (Cole et al., 2007). However, in lambs fed a growth diet (> 70% RUP and 32% NDF), zeolite supplementation (6%) increased the nitrogen balance by 3.5% (Ghaemnia et al., 2010).

These differences in the literature are related to the different inclusion levels, different minerals types (clinoptilolite, synthetic zeolite, ammonia zeolite, etc) and RUP and NDF levels. In the present study, the highest inclusion of aluminosilicates was 2% of the DM, the estimated mean RUP was 44% and the NDF was 27%.

CONCLUSION

It was concluded that the aluminosilicates supplementation does not change the nutrients intake and digestibility.

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Ingredients	Aluminosilicate levels* (%)				
	0	0.5	1.0	1.5	2.0
	Percentual composition (%)				
Corn silage	39.2	39.0	38.8	38.6	38.4
Cornmeal	44.1	43.9	43.7	43.4	43.2
Soybean meal	14.7	14.6	14.5	14.5	14.4
Aluminosilicate	0	0.5	1.0	1.5	2.0
Mineral Salt[1]	2.0	2.0	2.0	2.0	2.0
Total	100.0	100.0	100.0	100.0	100.0

Table 1 - Proportion of the ingredients (%) used in the experimental diets for beef cattle

*DM basis; Mineral salt composition: 150-190g Calcium; 85g Phosphorus; 129.5g Sodium; 18g Magnesium; 18g Sulfur; 60 mg Cobalt; 1500 mg Copper; 90 mg Iodine; 1500 mg manganese; 20 mg Selenium; 5250 mg Zinc; 1500 mg iron; 1000 mg Fluorine.

Item	Corn silage	Cornmeal	Soybean meal	Aluminosilicate
DM	32.20	88.60	90.0	99.43
Ash	4.50	2.50	6.5	97.70
CP	7.60	08.05	50.15	-
EE	3.40	4.60	4.20	-
NDFap	51.40	10.70	17.90	-
ADF	27.90	3.18	6.70	-
NFC	33.10	74.20	21.30	-
TDN*	63.72	86.63	78.67	-
Ca	0.21	40	0.34	-
P	0.15	0.31	0.51	-
K	-	-	-	-

Table 2 - Chemical composition (%) of the ingredients used in the experimental diets for beef cattle, based on dry matter (DM)

DM = dry matter; CP= crude protein; EE = ether extract; NDFap = neutral detergent fiber corrected for ash and protein; ADF = acid detergent fiber; NFC = non-fibrous carbohydrates; TDN = total digestible nutrients; Ca = calcium; P = phosphorus; k = potassium.

*NDT values calculated from BR-Corte 3 (Valadares Filho et al., 2016).

Variable	Aluminosilicate levels* (%)					SE[2]	P	
	0.0	0.5	1.0	1.5	2.0		L	Q
	Intake kg.day^{-1}							
DM	9.06	8.32	7.63	7.40	8.81	0.61	0.45	0.06
Ash	8.59	7.88	07.09	6.79	8.12	0.58	0.31	0.06
CP	1.24	1.15	0.98	0.97	1.16	0.11	0.38	0.11

EE	0.42	0.39	0.41	0.38	0.42	0.04	0.82	0.70
NDFap	2.77	2.37	2.23	02.09	2.47	0.23	0.25	0.10
ADF	1.39	1.19	1.13	1.60	1.30	0.11	0.50	0.11
NFC	3.99	3.84	3.40	3.22	3.90	0.28	0.28	0.09
TDN	6.30	5.93	5.48	5.76	6.27	0.18	0.73	0.06
AS³	0.00	0.04	0.07	0.11	0.18	-	-	-

Table 3. Effect of aluminosilicate supplementation in beef cattle diets on means and standard error of nutrient intake estimation

*DM basis; DM = dry matter; CP= crude protein; EE = ether extract; NDFap = neutral detergent fiber corrected for ash and protein; ADF = acid detergent fiber; NFC = non-fibrous carbohydrates; TDN = total digestible nutrients. ²SE = standard error; ³Aluminosilicate.

	Aluminosilicate levels* (%)					SE²	P	
	0.0	0.5	1.0	1.5	2.0		L	Q
Variable	Coefficients of apparent digestibility (%)							
DM	67.99	67.08	68.63	62.39	68.85	5.18	0.86	0.73
OM	70.55	70.91	72.15	64.68	72.17	05.07	0.86	0.76
CP	62.84	63.79	64.75	65.69	66.64	9.23	0.75	0.48
NDFap	48.28	49.00	49.77	50.56	51.30	6.99	0.73	0.99
ADF	35.50	27.42	39.96	44.79	41.05	6.99	0.78	0.79
NFC	84.70	83.04	86.88	81.24	86.56	5.11	0.90	0.81

Table 4. Effect of aluminosilicate supplementation in beef cattle diets on means and standard error of nutrients digestibility estimation

*DM basis; DM = dry matter; CP= crude protein; EE = ether extract; NDFap = neutral detergent fiber corrected for ash and protein; ADF = acid detergent fiber; NFC = non-fibrous carbohydrates; ²SE = standard error.

	Aluminosilicate levels* (%)					SE²	P	
	0.0	0.5	1.0	1.5	2.0		L	Q
Variable	Metabolism of nitrogenous compounds (g.day⁻¹)							
N intake	182.5	171.55	151.8	178.02	178.77	17.55	0.98	0.51
N feces	80.36	73.05	56.47	58.99	56.11	16.97	0.26	0.67
N urinary	58.38	74.08	74.32	86.38	84.04	17.06	0.26	0.71
N bal	43.77	24.41	21.08	32.67	38.62	12.28	0.38	0.93
%Nret/Nin	22.44	11.24	16.00	16.58	21.82	6.90	0.90	0.49

Table 5. Effect of aluminosilicate supplementation in beef cattle diets on means and standard error of metabolism of nitrogenous compounds estimation

*DM basis; Nret/Nin: utilization rate of nitrogen, calculated by the formula = (nitrogen retained/Nitrogen ingested)*100; ²SE: standard error.