Minerals Status of Growing Friesian Calves Fed Different Levels of Poultry Litter

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Abstract: Eighteen male Friesian calves six months of age and averaging 175 kg body weight were used to study the effect of feeding rations containing different levels of poultry litter and corn silage on mineral balance and concentration in hair, blood and seminal plasma and body tissues. The experiment period lasted 6 months and metabolism trial conducted at the fifth month of experiment. Calves were divided into three similar groups assigned randomly to fed on three experimental rations as follows (on DM basis): R1: 12.5% poultry litter + 12.5% ground corn grain + 75.0% corn silage. R2: 25.0% poultry litter + 25.0% ground corn grain + 50.0% corn silage. R3**:** 37.5% poultry litter + 37.5% ground corn grain + 25.0% corn silage. The results showed that the contents of calcium (Ca), phosphorus (P), magnesium (Mg), sodium (Na), potassium (K), copper (Cu), zinc (Zn), manganese (Mn), iron (Fe) and cobalt (Co) in poultry litter were higher compared with corn grain and corn silage. The contents of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co in the experimental rations increased with the increasing level of poultry litter and decreasing the level of corn silage. The intake, excretion in feces and urine, apparent absorption and retention of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co (g or mg/ day) increased significantly ($P<0.05$) with the increasing level of poultry litter and decreasing the level of corn silage. The concentrations of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co in hair, blood and seminal plasma of Friesian calves increased significantly ($P<0.05$) with the increasing level of poultry litter and decreasing the level of corn silage in the rations. Also, the contents of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co in liver, kidneys, testis and muscle of Friesian calves increased significantly ($P<0.05$) with the increasing level of poultry litter and decreasing the level of corn silage in the rations.
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1. Introduction

Broiler litter, which includes bedding, excreta, wasted feed and feathers, has been used successfully as a feed for ruminants (Bhattacharya and Taylor, 1975). Feeding corn silage alone does not support optimum growth rates of beef cattle, because it is not a balanced diet of growing animals. Poultry manure is a good source of macro and trace elements and could ensure against minerals deficiencies (Ben-Ghedalia *et al*., 1996). They also indicated that poultry litter (PL) is among the least expensive ingredients; therefore, it is used occasionally as a component at up to 10% of the total mixed ration dry matter (TMR DM). Poultry litter is rich in minerals but, no information exists on mineral absorption from TMR supplemented with PL by lactating cows, and very little relevant information exists on conventional TMR. If the diet consists of at least 20% poultry manure, no additional mineral supplementation is needed (Gerken, 1990).

Analyses of soils and pasture are not reliable for assessing minerals status of grazing cattle. Analyses of tissues and blood appear to provide better indices (Khalili *et al*., 1993). Evaluation of trace elements status can be difficult because much disease status will alter blood analyses used to evaluate nutrient adequacy. Proper dietary and animal evaluation is response to supplementation before diagnosing a minerals deficiency (Graham, 1991). The chemical composition of body tissues particularly the liver is a better reflection of the dietary status of domestic and wild animals (Webb *et al*., 2001).

Animal responses are useful means for evaluating and assessing nutritional status. Blood minerals concentrations are related for nutritional responses. The strategy for use mineral status assessment is to minimize non-nutritional variation by grouping animals for testing based on physiological factors that affect or are likely to affect the concentration of minerals or minerals being tested (Herdt *et al*., 2000). Trace elements are essential based on growth and other effects with animals, under improved procedures for purification of diets use of metal free isolator systems for raising animals (McDowell, 1992).

1.1 Objective of the study

The objective of this study was to investigate the effect of feeding rations containing different levels of poultry litter and corn silage on minerals status in growing Friesian calves.

2. Materials and methods

The current work was carried out at Karada

Animal Production Research Station, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture.

2.1. Experimental animals and rations:

Eighteen male Friesian calves with an average body weight of 175 kg and 6 months of age were assigned randomly for three similar groups (6 each) according to live body weight and age. The experiment period lasted 6 months. Calves were fed individually on the experimental rations containing different levels of poultry litter and whole plant corn silage to cover the recommended requirements of growing calves according to NRC (1996). Formulation and average daily feed intake are shown in Table (1). Poultry litter and corn grain mixture was offered two times daily at 8 am and 4 pm. While, corn silage were offered once daily at 11 am. Calves were watered three times daily at 7, 12 am and 7 pm. Feed intake was adjusted biweekly in corresponding the changes of body weight.

2.2. Corn silage:

Whole corn plant of hybrid single cross 10 was harvested at dough stage of maturity, chopped into 1-1.5 cm of length and ensiled in horizontal built walls silo with dimension of 40 x 5 x 2 m length, width and height, respectively. Chopped corn crop stock was compressed by tractor, then covered with plastic sheet, hard pressed with 20-30 cm of soil layer and ensiled for two months.

2.3. Metabolism trial:

Metabolism trial was conducted with three Friesian calves chosen randomly from each group to determine mineral balance at the fifth month of experiment. The trial consisted of 14 days as a preliminary period followed by 7 days as a collection period. Samples of feedstuffs were taken at the beginning, middle and end of collection period. Feces were collected using plastic bags, weighed daily and representative sample of 10% by weight was taken. Also, urine was collected daily from each calf during collection period by rubber funnel adjoining with plastic hose in plastic bucket containing 100 ml sulfuric acid (10%), urine volume was measured and sample of 10% of the volume was taken in glass bottle.

2.4. Hair samples:

Hair samples were collected every three months from the upper right or lift shoulder for each calf, cutting (full hand) by a clean shaving tackle close to the skin surface of the animal in clean nylon bag. Each sample was thoroughly washed by tap water, and then rinsed by distilled and boiled distilled water until both the filter and filtrate appeared clear.

2.5. Blood plasma samples:

Blood samples were taken at the same time of hair samples from the jugular vein of each animal by clean sterile needle in a clean dry plastic tubes using heparin as an anticoagulant after 3 hours from the morning feeding. Then centrifuged at 4000 rpm for 15 minutes to obtain plasma and stored at -20 ^{o}C till analysis.

2.6. Seminal plasma samples:

Two successive ejaculates semen were collected weekly from each calf with interval of 30 minutes using artificial vagina. Semen was centrifuged at 3000 rpm for 15 minutes to obtain seminal plasma and stored at -20 ^{o}C till analysis.

2.7. Body tissues samples:

At the end of the experiment (average body weight of each group was 450 kg), three calves from each group were chosen randomly, weighed after fasted for 16 hours and slaughtered. Upon completion of bleeding, animals were skinned, dressed out and samples of liver, kidneys, testis and muscles were taken for minerals determination.

2.8. Preparation of samples and minerals determination:

The samples of feedstuffs, feces, urine, blood and seminal plasma and body tissues were prepared for minerals determination according to the methods of AOAC (1990). Calcium, magnesium, copper, zinc, manganese, and iron were determined by Atomic Absorption Spectrophotometer (Perkin Elmer 2380). Phosphorus was determined using Spectrophotometer (Milton Roy Company Spectronic 20 D). Sodium and potassium were determined by Flame Photometer (Jenway PFP 7).

2.9. Statistical analysis:

The obtained data were statistically analyzed using general linear models procedure adapted by SPSS (2008) for user's guide. Duncan test within program SPSS was done to determine the degree of significance between means.

Table 1: Formulation and average daily DM intake (kg) of experimental rations by growing Friesian calves (on DM basis).

Items	R2		R3		R4	
	%	Kg	%	Kg	%	Kg
Corn silage*	75.0	6.36	50.0	4.52	25.0	2.34
Corn grain	12.5	1.06	25.0	2.26	37.5	3.51
Poultry litter	12.5	1.06	25.0	2.26	37.5	3.51
Total DM	100.0	8.48	100.0	9.04	100.0	9.36

* Quality of corn silage was pH 4.05, lactic acid 6.38% of DM, TVFA's 1.96% of DM and ammonia nitrogen 4.42% of total-N.

3. Results and discussion

3.1. Minerals contents of tested feedstuffs and experimental rations:

The contents of calcium (Ca), phosphorus (P), magnesium (Mg), sodium (Na), potassium (K), copper (Cu), zinc (Zn), manganese (Mn), iron (Fe) and cobalt (Co) in poultry litter were higher compared with corn grain and corn silage (Table 2). The contents of Ca, P, Na, Zn and Mn in corn silage were below the recommended requirements of growing calves according to NRC (1996) being 0.42, 0.21, 0.10%, 30 and 30 ppm, respectively. Therefore, the contents of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co in the experimental rations increased with the increasing level of poultry litter and decreasing the level of corn silage. The contents of minerals in R2 and R3 (contained 25.0 and 37.5% poultry litter, respectively) were higher than the recommended requirements of growing calves according to NRC (1996). Poultry litter was a good source of trace elements for growing calves, which the supplementation of poultry litter by 12.5% of the ration containing corn grain and corn silage could ensure against minerals deficiency of corn grain and corn silage. Poultry litter is a good source of mineral (Owen *et al*., 2008). Gaafar (2009) detected the deficiency of Ca, P, Na, Zn and Mn in corn silage.

3.2. Minerals balance:

Results in Table (3) showed that the intake, excretion in feces and urine, apparent absorption and retention of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co increased significantly ($P<0.05$) with the increasing level of poultry litter and decreasing the level of corn silage. The R3 (37.5% poultry litter) showed the highest ($P<0.05$) intake, apparent absorption and retention of Ca, P, Mg, Na, Cu, Zn, Mn, Fe and Co, while R1 (12.5% poultry litter) had the lowest ($P<0.05$) values of all minerals. The intake, apparent absorption and retention of minerals revealed similar trend to their contents in the rations (Table 2). The efficiency of mineral absorption and retention decreased as the dietary mineral intake increased. These results agree with those obtained by El-Amary (1995) and Khattab *et al.* (1997) they reported that minerals intake by lambs and calves increased with the increasing level of poultry litter in the rations. Ben-Ghedalia *et al.* (1996) showed that the intake and apparent absorption of macro and micro-minerals were higher with poultry litter ration compared with control ration. Gaafar (2003) found that minerals balance increased with increasing minerals intake. The evaluation of feeds and feed supplements as sources of minerals depends not only on what the feed contains (the total content or concentration as determined physico-chemically) but also on how much of the total minerals can be absorbed from the gut and used by animal's cells and tissues (Durand *et al*., 1982 and Georgievskii *et al*., 1982). Abdel-Raouf *et al*. (1994) indicated that the proportion of dietary mineral absorb and retention will decrease as dietary minerals increase above requirement of the tissues for absorbed minerals.

3.3. Minerals concentrations in hair:

Minerals concentrations in hair of growing calves fed rations containing different levels of poultry litter and corn silage are presented in Table (4). The concentrations of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co in hair increased significantly ($P<0.05$) with the increasing level of poultry litter and decreasing the level of corn silage in the rations. These results may be attributed to increasing minerals intake, absorption and retention with the increasing level of poultry litter and decreasing the level of corn silage in the rations (Table 3). These results are in agreement with those obtained by Abdel-Raouf *et al*. (1994) and Gaafar (1994) who found that minerals concentrations in hair of cattle increased with increasing dietary minerals intake. Gaafar (2009) reported that mineral contents in hair increased with the increasing level of concentrate feed mixture and decreasing the level of corn silage in the rations.

The concentrations of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co in hair of Friesian calves fed R2 (25% poultry litter) and R3 (37.5% poultry litter) were higher than the normal level indicated by Anke, 1966, 1967, Anke *et al*., 1981 and Combs, 1987. These results might be due to the higher minerals content in poultry litter than the recommended requirements of growing calves according to NRC (1996). Significant positive correlations exist between the intake, absorption, retention and the concentration of all minerals in hair.

3.4. Minerals concentrations in blood plasma:

The effect of the levels of poultry litter and corn silage in the rations of growing calves on mineral concentrations in blood plasma are shown in Table (4). The concentrations of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co in blood plasma of Friesian calves increased significantly (P<0.05) with the increasing level of poultry litter and decreasing the level of corn silage in the rations. These results are in accordance with those obtained by El-Amary (1995) and Khattab *et al.* (1997) they found that minerals concentrations in blood serum of lambs and calves increased as the level of poultry litter in the ration increased. Gaafar (2009) reported that mineral concentrations in blood plasma increased with the increasing level of concentrate feed mixture and decreasing the level of corn silage in the rations. Moreover, the concentrations of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co in blood plasma of calves fed R2 (25% poultry litter) and R3 (37.5% poultry litter) were higher than the normal level as reported by Georgievskii *et al*. (1982).

3.5. Minerals concentrations in seminal plasma:

The concentrations of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co in seminal plasma of Friesian calves increased significantly (P<0.05) with the increasing level of poultry litter and decreasing the level of corn silage in the rations (Table 4). These results may be attributed to increasing minerals intake, absorption and retention with the increasing level of poultry litter and decreasing the level of corn silage in the rations (Table 3). These results are in accordance with those obtained by Abdel-Raouf (1980) and Abdel-Rahman *et al*. (2000) they found that mineral concentration in semen increased with the increasing level of poultry litter in rations.

3.6. Minerals concentrations in body tissues:

Results obtained in Table (5) showed that the contents of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co in liver, kidneys, testis and muscle of Friesian calves increased significantly (P<0.05) with the increasing level of poultry litter and decreasing the level of corn silage in the rations. These results may be attributed to increasing mineral retention with the increasing level of poultry litter and decreasing the level of corn silage in the rations (Table 3). Similar results were obtained by Khattab *et al*. (1997) and Webb *et al*. (2001) they found that the contents of minerals in body tissues increased with the increasing level of poultry litter in the rations of Friesian calves. Gaafar (2009) reported that mineral contents in body tissues increased with the increasing level of concentrate feed mixture and decreasing the level of corn silage in the rations. Moreover, the contents of Ca, P, Mg, Na, K, Cu, Zn, Mn, Fe and Co in body tissues of calves fed R2 (25% poultry litter) and R3 (37.5% poultry litter) were higher than the normal levels. Liver and kidneys revealed higher contents of elements compared with testis and muscle. Underwood (1981) and Georgievskii *et al*. (1982) reported that chemical composition of body tissues reflect the dietary status of the animals. Chemical estimations on tissues can therefore be used to assist in the detection and definition of range of mineral disabilities in livestock.

Table 2: Mineral content of tested feedstuffs and experimental rations used in feeding Friesian calves.

Item	Macro-mineral (%)					Micro-mineral (ppm)				
	Ca	P	Mg	Na	K	Cu	Zn	Mn	Fe	Co
Feedstuffs										
Corn silage	0.35	0.26	0.25	0.12	1.28	9.86	21.63	19.52	165.45	0.20
Corn grain	0.14	0.29	0.15	0.10	0.78	4.31	14.27	6.80	65.32	0.10
Poultry litter	3.15	1.76	0.74	0.94	2.55	45.40	198.60	284.20	320.45	0.32
Experimental rations										
R1	0.67	0.45	0.30	0.22	1.38	13.61	42.82	51.00	172.31	0.20
R2	1.00	0.64	0.35	0.32	1.47	17.36	64.03	82.51	179.17	0.21
R3	1.32	0.83	0.40	0.42	1.57	21.11	85.24	114.02	186.03	0.21

Table 3: Mineral intake, absorption and retention by Friesian calves fed experimental rations.

Item	Macro-mineral					Micro-mineral				
	Ca	P	Mg	Na	K	Cu	Zn	Mn	Fe	Co
Intake			*(g/day)*						*(mg/day)*	
R1	57.13^{c}	38.27^{c}	25.33^{c}	18.66^{c}	116.71^{c}	115.71^{c}	363.21^{c}	432.67^{c}	1461.18^{c}	1.72^{c}
R2	90.17^{b}	58.08^{b}	31.41^{b}	28.93^{b}	133.11^{b}	156.91^{b}	578.85^{b}	745.94^{b}	1619.67^{b}	1.85^{b}
R3	123.67^{a}	78.04^{a}	37.09^{a}	39.31^{a}	146.84^{a}	197.55^{a}	797.79^{a}	1067.11^{a}	1741.21^{a}	1.94^{a}
Excretion in feces			*(g/day)*						*(mg/day)*	
R1	32.85^{c}	20.70^{c}	14.00^{c}	2.61^{c}	15.17^{c}	68.86^{c}	219.57^{c}	263.77^{c}	948.95^{c}	1.03^{b}
R2	57.63^{b}	35.56^{b}	18.56^{b}	4.34^{b}	18.64^{b}	98.68^{b}	392.08^{b}	530.05^{b}	1075.74^{b}	1.13^{ab}
R3	82.75^{a}	50.53^{a}	22.82^{a}	6.29^{a}	22.03^{a}	130.16^{a}	567.23^{a}	803.04^{a}	1172.97^{a}	1.19^{a}
Excretion in urine			*(g/day)*						*(mg/day)*	
R1	9.71^{c}	6.68^{c}	4.42^{c}	9.40^{c}	75.54^{c}	17.80^{c}	57.45^{c}	70.94^{c}	220.26^{c}	0.26^{b}
R2	13.01^{b}	8.56^{b}	5.01^{b}	16.79^{b}	86.5^{b}	22.75^{b}	74.71^{b}	90.67^{b}	233.89^{b}	0.27^{ab}
R3	16.37^{a}	10.4^{a}	5.56^{a}	24.06^{a}	95.19^{a}	25.61^{a}	92.23^{a}	110.91^{a}	244.34^{a}	0.29^{a}
Apparent absorption			*(g/day)*						*(mg/day)*	
R1	24.28^{c}	17.57^{c}	11.33^{c}	16.05^{c}	101.54^{c}	46.85^{c}	143.64^{c}	168.90^{c}	512.23^{c}	0.69^{b}
R2	32.54^{b}	22.52^{b}	12.85^{b}	24.59^{b}	114.47^{b}	58.23^{b}	186.77^{b}	215.89^{b}	543.93^{b}	0.72^{ab}
R3	40.92^{a}	27.51^{a}	14.27^{a}	33.02^{a}	124.81^{a}	67.39^{a}	230.56^{a}	264.07^{a}	568.24^{a}	0.75^{a}
Apparent retention			*(g/day)*						*(mg/day)*	
R1	14.57^{c}	10.89^{c}	6.91^{c}	6.65^{c}	26.00^{c}	29.05^{c}	86.19^{c}	97.96^{c}	291.97^{c}	0.43^{b}
R2	19.53^{b}	13.96^{b}	7.84^{b}	7.80^{b}	27.97^{b}	35.48^{b}	112.06^{b}	125.22^{b}	310.04^{b}	0.45^{ab}
R3	24.55^{a}	17.06^{a}	8.71^{a}	8.96^{a}	29.62^{a}	41.78^{a}	138.33^{a}	153.16^{a}	323.90^{a}	0.46^{a}

a, b, c: Means in the same column for each item with different superscripts differ significantly ($P<0.05$).

Table 4: Mineral concentration in hair, blood and seminal plasma of Friesian calves fed experimental rations.

Item	Macro-mineral					Micro-mineral				
	Ca	P	Mg	Na	K	Cu	Zn	Mn	Fe	Co
Hair						*(ppm on DM basis)*				
R1	2137.10^{c}	228.91^{c}	1383.94^{c}	1664.95^{c}	5000.47^{c}	9.08^{c}	215.46^{c}	14.80^{c}	32.47^{c}	0.76^{c}
R2	2285.78^{b}	259.63^{b}	1448.84^{b}	1779.99^{b}	5197.37^{b}	11.09^{b}	280.16^{b}	17.52^{b}	35.99^{b}	0.82^{b}
R3	2436.51^{a}	290.56^{a}	1509.43^{a}	1896.28^{a}	5362.02^{a}	13.06^{a}	345.84^{a}	20.32^{a}	38.69^{a}	0.86^{a}
Blood plasma			*mg/100 ml*						*ug/100 ml*	
R1	9.71^{c}	6.05^{c}	2.77^{c}	359.48^{c}	21.67^{c}	113.09^{c}	116.19^{c}	3.92^{c}	146.12^{c}	0.67^{c}
R2	13.02^{b}	7.76^{b}	3.14^{b}	394.00^{b}	23.31^{b}	125.96^{b}	142.06^{b}	5.01^{b}	161.97^{b}	0.72^{b}
R3	16.37^{a}	9.48^{a}	3.48^{a}	428.89^{a}	24.68^{a}	138.56^{a}	168.33^{a}	6.13^{a}	174.12^{a}	0.76^{a}
Seminal plasma			*mg/100 ml*						*ug/100 ml*	
R1	12.67^{c}	43.56^{c}	7.60^{c}	172.99^{c}	247.04^{c}	101.67^{c}	120.66^{c}	9.80^{c}	24.35^{c}	0.72^{c}
R2	16.98^{b}	55.85^{b}	8.62^{b}	196.00^{b}	265.75^{b}	124.18^{b}	156.89^{b}	12.52^{b}	26.99^{b}	0.77^{b}
R3	21.35^{a}	68.22^{a}	9.58^{a}	219.26^{a}	281.39^{a}	146.23^{a}	193.67^{a}	15.32^{a}	29.02^{a}	0.81^{a}

a, b, c: Means in the same column for each item with different superscripts differ significantly ($P<0.05$).

Table 5: Mineral content in body tissues of Friesian calves fed experimental rations.

Item	Macro-mineral					Micro-mineral				
	Ca	P	Mg	Na	K	Cu	Zn	Mn	Fe	Co
Liver	(ppm on DM basis)									
R1	415.70[c]	6435.65[c]	695.67[c]	3464.95[c]	10300.47[c]	33.98[c]	129.28[c]	10.31[c]	194.82[c]	0.149[c]
R2	465.26[b]	6558.51[b]	742.03[b]	3579.99[b]	10497.37[b]	41.51[b]	168.09[b]	13.18[b]	215.96[b]	0.161[b]
R3	515.50[a]	6682.24[a]	785.30[a]	3696.29[a]	10662.02[a]	48.88[a]	207.50[a]	16.12[a]	232.16[a]	0.169[a]
Kidneys	(ppm on DM basis)									
R1	332.56[c]	5148.52[c]	834.81[c]	11261.08[c]	10094.46[c]	6.18[c]	64.64[c]	7.22[c]	233.79[c]	0.134[c]
R2	372.21[b]	5246.81[b]	890.44[b]	11634.98[b]	10287.42[b]	7.55[b]	84.05[b]	9.23[b]	259.15[b]	0.145[b]
R3	412.40[a]	5345.79[a]	942.36[a]	12012.96[a]	10448.78[a]	8.89[a]	103.75[a]	11.28[a]	278.59[a]	0.152[a]
Testis	(ppm on DM basis)									
R1	665.12[c]	5663.37[c]	556.54[c]	7276.39[c]	9476.43[c]	6.80[c]	43.09[c]	2.06[c]	108.23[c]	0.083[c]
R2	744.42[b]	5771.49[b]	593.63[b]	7517.99[b]	9657.58[b]	8.30[b]	56.03[b]	2.64[b]	119.97[b]	0.089[b]
R3	824.81[a]	5880.37[a]	628.24[a]	7762.22[a]	9809.06[a]	9.78[a]	69.17[a]	3.22[a]	128.99[a]	0.094[a]
Muscle	(ppm on DM basis)									
R1	230.94[c]	6757.43[c]	1113.07[c]	3291.70[c]	15450.71[c]	9.71[c]	38.02[c]	1.87[c]	64.94[c]	0.019[b]
R2	258.48[b]	6886.43[b]	1187.25[b]	3400.99[b]	15746.05[b]	11.86[b]	49.44[b]	2.40[b]	71.98[b]	0.020[ab]
R3	286.39[a]	7016.35[a]	1256.48[a]	3511.48[a]	15993.03[a]	13.97[a]	61.03[a]	2.93[a]	77.39[a]	0.021[a]

a, b, c: Means in the same column for each item with different superscripts differ significantly ($P<0.05$).

4. Conclusion

From these results it could be concluded that poultry litter is a good source of macro and micro minerals for growing calves and introduce it at 12.5% of the ration, could ensure against mineral deficiencies of corn silage.

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