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Effects of sodium selenite and chromium sulphate as metabolic modifiers on stress alleviation, performance and liver mineral contents of feedlot Bonsmara cross steers

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The objective of the study was to investigate the effects of supplemental selenium and chromium on blood cortisol and glucose levels on stress alleviation and the carry-over effects on performance and liver mineral contents of local beef cattle under feedlot conditions. Seventy-two Bonsmara cross weaned calves weighing on average 185 ± 20.729 kg were allocated to 12 pens of six animals each, three replicates per treatment and fed for 120 days either a standard diet (CON) or supplemented with 0.3 mg.kg $^{-1}$ DM sodium selenite (SEL) 0.3 mg.kg $^{-1}$ DM chromium sulphate (CHR) and a combination of Se and Cr (SEL/CHR). Blood cortisol and glucose levels as stress parameters, feed intake and growth performance parameters were assessed. There was no statistical difference in blood cortisol levels on d0. On d14, cortisol concentrations were lower than on d0 (P<0.05) except for treatment SEL/CHR. On d42, the values were higher than on d0 and d14 except for SEL/CHR that had very low cortisol values (P<0.05). Blood glucose concentrations followed similar trend. There was no carry-over effect of stress alleviation on growth performance though SEL/CHR tended to have better ADG (P=0,148) and predicted FCR (P=0,197). Liver tissue mineral levels were within normal ranges. However, SEL increased significantly (P<0.05) liver Ca, Mg, Co and Mn while CHR decreased Ca and Mg concentrations. Selenium was positively correlated with Cu (r=0.30, P= 0.01) and phosphorus (r=0.44, P=0.0001) while Cr was negatively correlated with Ca (r=-0.50, P=0.01) and Mg (r=-0.30, P=0.01). Liver tissue minerals did not affect performance parameters. SEL/CHR might act better on stress alleviation and growth improvement. The effects on carcass characteristics and meat quality and the use of different forms of supplemental Se and Cr warrant further research.

Key words: Selenium, chromium, stress, cortisol, glucose, feedlot, Bonsmara.

INTRODUCTION

Beef production in South Africa faces many constraints compared with other bigger producers such as the USA, Canada and Brazil. Grain to beef ratio in South Africa is estimated at 13:1 as compared to Australia with 22:1 and USA 24:1 (Ford, 1998). This situation opens the door to all types of manipulations aiming at compensating the low use of grain in feedlot animal diets. Many metabolic modifiers are still used but consumers are becoming aware of health risks related to some of these products; many of them have been banned in some regions like the European Union (EU). It is suggested that minerals and, more particularly, trace minerals constitute a natural and

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safe way of supplementing animal feed in order to improve animal performance.

Feedlot cattle are subjected to many stressors that is, transport, high energy diet etc. Transportation stress alters rumen function, serum biochemical constituents and serum cortisol concentration more than those fasting alone (Cole et al., 1988). In feedlot practice, stress is assessed by the degree of shrink or weight loss which is due primarily to losses of body and digestive tract water (Hutcheson, 1992). This loss is accompanied by depletion of body minerals and vitamins. Cortisol is a useful indicator of short-term stresses such as transport and handling. It is a time-dependent measure that takes 10 to 20 min to reach peak values (Grandin, 1997). That is why other indicators such as blood glucose level and tissue mineral status need to be investigated. During stress, glucose metabolism increases simultaneously with increased secretion of cortisol, as well as an elevation of blood glucose and increased urine chromium secretion (Burton, 1995). It is suggested that during stress, cortisol acts antagonistically to insulin, preventing entry of glucose into muscle and adipose tissue and sparing it for tissues of high demand (e.g. liver and brain) (Burton, 1995).

Studies on the use of both Cr and Se in animal nutrition are scarce (Dominguez –Vara et al., 2009). As far as it can be ascertained, the use of the inorganic sulphate form has not been reported in animal feeding. Chromium sulphate ($Cr_2(SO_4)_3$) is obtained by preparation of anhydrate salt by dehydration of hydrated forms. It is used in insolubilisation of gelatine and also, like the previous form, in catalyst preparation; as mordant in textile industry and in tanning (Merck and Co, 1996).

Chromium is a nutritional substance and not a therapeutic product. As such, it will act during the period of deficiency such as during stress. Because stress in a feedlot is constant, that is, more physical during the adaptation period but dietary later, it is assumed Cr would be beneficial to feedlot animals for the whole feeding period. Chromium supplementation is thought to prevent other mineral losses during stressful conditions (Moonsie-Shageer and Mowat, 1993).

The dietary supplements of Se and Cr have been described separately in animal production. This study was therefore aimed at assessing the effect of a combination of selenium and chromium on stress alleviation during the adaptation period in the feedlot; to determine the magnitude of the response to supplementation on animal performance and to determine the status and interaction of major minerals and trace elements in animal tissues.

MATERIALS AND METHODS

Experimental animals

The animals were taken care of according to the Ethics Committee of the Medical University of Southern-Africa (Medunsa, South Africa). Seventy-two Bonsmara X Brahman X Nguni cross male weaned calves aged seven to nine months old and weighing between 150 and 180 kg were sorted into twelve groups of six animals and thereafter different groups were allocated at random to four treatments in three replicates. They were processed after two days of adaptation into a feedlot setting to the standard diet (control) and hay; this included castration, dehorning, tagging and sorting randomly into the four treatment groups. They were treated for tick control with Ectoline ND (Bayer, (Pty) Ltd) and dewormed with ValbazenND (Pfizer, (Pty) Ltd). The dietary composition is presented in Table 1.

The diet did not include any other metabolic modifiers (e.g. monensin, antibiotics) and was kept constant for the entire period of 120 days. The animals were weighed full stomachs on d1 and fortnightly subsequently. On d120, they were weighed and transported to the Johannesburg City Deep Abattoir (approximately 90 km from Medunsa) for slaughtering the next day. The liver samples were collected and kept in 10% formalin solution for further processing and mineral analyses. The liver is the most labile body tissue for most of the minerals (Boyazoglu, 1997). Carcass characteristics and meat colour data have been published elsewhere.

The diet contained in average, that is Dry matter %: 90.41; Ash %: 6.40; Crude protein %: 14.56; Crude fat %: 2.99; crude fibre %: 13.25; Ca %: 0.55; P%: 0.47; Mg%: 0.21; Co (mg/kg): 2.7; Cu (mg/kg): 12.9; Fe (mg/kg): 562.5; Mn (mg/kg): 112.9; Se (mg/kg): 1.48; Zn (mg/kg): 52; Cr (mg/kg): 3.4.

Laboratory procedures

Blood samples were collected into evacuated glass tubes containing sodium fluoride-potassium oxalate for glucose, and plain silicone coated tubes for cortisol determinations by jugular vena puncture on d0, d14 and d42. Plasma glucose determination was made using the SYNCHRON SYNCHRO System SYNCHRO MULTI Calibrator (Beckman Instruments, 1993). Quantitative determination of cortisol levels in serum was made using the Clinical Assays GammaCoat Cortisol Radioimmunoassay Kit (Incstar Corporation - Stillwater, Minnesota, USA).

Feed samples were analysed by proximate procedures for nitrogen (N) content, as an indication of crude protein (CP) of the feed samples using the FP 428 Nitrogen Determinator (LECO Corp.); dry matter (DM), ash and crude fibre (total) as per laboratory methods by ALASA (1998); crude fat as per modified Soxhlet Method with hexane as an extracting solvent.

Mineral determinations in feed and liver were done using specialised laboratory procedures. The Ca, Mg, Cu, Fe, Mn, Co, Cr, Zn content of feed and liver samples were determined on a Flame Atomic Absorption Spectrophotometer (FAAS) (Perkin Elmer, Model 5100 PC). Phosphorus was determined by spectrometry (Sequoia - Turner Corp.). The anhydride generator for atomic absorption was used for Se determination (FIAAS 100, Perkin Elmer).

Statistical analysis

Data from two animals, which died, were removed from the analysis of growth but they were included in the stress assessment because they were still alive during this initial period. One animal died when attempt was done to repair a fistula and the second died towards the end of the trial due to acidosis (bloat). The data was analysed by Analysis of Variance (ANOVA) using the General Linear Models (GLM) procedure of SAS version 8.3 (SAS Institute Inc., 1999). It should be noted that unless stated otherwise, tabulated data are least square means. Discrepancies may arise if it is attempted to calculate one value from another through simple arithmetic.

Table 1. Diet composition in a ton of feed for feedlot cattle.

Ingredients	Inclusion (kg)	Inclusion (%)
Yellow maize meal	450	45
Wheaten bran	100	10
Yeast	50	5
Malt dust	50	5
Eragrostis meal	260	26
Molasses	50	5
Urea	10	1
Limestone powder	10	1
Monocalcium phosphate	5	5
Salt	10	1
Premix*	5	5

*Contains appropriate amounts of trace elements including Se and Cr according to treatment.

Table 2. Blood cortisol (nmol/L) and glucose (mmol/L) concentrations (±sem) of feedlot cattle fed a supplement of se and cr (±SEM).

Treatment	do		d14		d42	
	Cortisol	Glucose	Cortisol	Glucose	Cortisol	Glucose
CON	63.39± 5.8	4.88±0.2	54.05±6.6^{b}	4.82±0.1^{b}	88.72±7.3^{b}	5.31±0.1^{b}
SEL	82.28±6.0	4.91±0.2	70.39±6.8^{b}	5.44±0.1^{a}	82.13±7.5^{b}	5.00±0.1^{a}
CHR	70.86±6.0	5.13±0.2	60.83±6.8^{b}	4.94±0.1^{b}	82.94±7.5^{b}	5.19±0.1^{b}
SEL/CHR	71.94±5.8	5.04±0.2	79.17±6.6^{a}	4.87±0.1^{b}	61.28±7.3^{a}	4.98±0.1^{a}

Values with superscripts within a column differ significantly from others ($P \leq 0.05$).

Student's t test was used for comparisons of two means. The 5% probability ($P \leq 0.05$) was used as the significance level.

RESULTS AND DISCUSSION

Stress alleviation

The data related to cortisol and glucose concentrations are presented in Table 2. For data analysis, the model used includes cortisol and glucose levels as dependent variables on d0, d14, and d42. Treatments are used as independent variables. For overtime changes, the differences between two consecutive measurements e.g. cortisol d14-d0, d42-14 are considered as dependent variables.

The least-square means of the blood cortisol measurements (nmol/L of blood) across the different treatments in this trial were 73.31, 65.79 and 78.60 respectively on d1, d14 and d42. These values are higher than those reported by Moonsie-Shageer and Mowat (1993). Values higher than 70 nmol/L have been suggested by Grandin (1997) as sign of stressful handling and at a level of 90 nmol/L, it was assumed that there was an extreme stress upon that animal. But in the study by Moonsie-Shageer and Mowat (1993) the cortisol values were below that mark line of 70 nmol/L for three out four treatments. It was assumed, nevertheless, that the higher the value of cortisol for a specific treatment, the higher was its stress level. The same approach was taken in the present study.

It seems that the animals were more stressed on d0 and d42 because of the higher cortisol values. Obviously on d0, all the stressors as indicated earlier are related to transportation, handling and other management procedures (Cole et al., 1988) while on d42 it could be due to dietary stress (Anderson et al., 1997). But values may also differ according to breeds. Similarly to animals used in this study, Brahman-cross cattle have been reported to have a high cortisol level during handling. It is therefore possible that values reported here are relatively higher than those of Moonsie-Shageer and Mowat (1993) who used Charolais-crosses in their research.

Paired-T test was used to compare the different treatments. There was no statistical difference between treatments on d0. On d14, all the treatments resulted in lowered cortisol levels except for treatment SEL/CHR for which a peak in the cortisol concentration ($P \leq 0.05$) was noted. On d42, all the values were high again except for treatment SEL/CHR that had very low ($P \leq 0.05$) concentration.

The combination of Se and Cr may have been effective in lowering blood cortisol. It is also probable that the animals became used to handling (Cole et al., 1988). But after this settlement in the new environment for two weeks (d14), the increased cortisol level on d42 might have been a sign of the dietary stress (Anderson et al., 1997). With low levels recorded for treatment SEL/CHR, it can be speculated that there was a direct positive effect of this treatment on stress alleviation when the dietary stress is prominent. This can also be confirmed by lowered glucose concentration ($P \leq 0.05$). Moreover, this treatment had stable cortisol concentrations during the 42-day assessment period. It appears that the effect of combined Se and Cr is probably more effective than Se and Cr alone during this growing phase.

Blood glucose levels across treatments in this study were 4.99, 4.99 and 5.12 respectively for d0, d14 and d42. These values were within the normal range in cattle (Kaneko, 1997) and were not different at the beginning of the trial (P=0.08). However on d14, concentrations were highly significantly lowered ($P \leq 0.01$) except for treatment SEL. On d42, blood glucose values were again higher and tended to differ between treatments (P=0.07) with treatments SEL and SEL/CHR having the lowest values.

The differences in glucose concentrations from d0 to d14 differed very significantly between treatments ($P \leq 0.05$). From d14 to d42, the differences were even higher ($P \leq 0.01$) with biggest differences with treatment SEL/CHR. There was a positive correlation between cortisol and glucose on d14 (r = 0.56, p = 0.016) and a tendency on d42 (r = 0.39, p = 0.105) for SEL/CHR. This suggests that Se - Cr combination has acted on blood glucose concentration through simultaneous effects of both elements on blood cortisol and glucose.

It was also proposed that by lowering the cortisol levels in the animals, the dietary supplements of Se and Cr could improve the animal performance. The Pearson's correlation coefficient was used to analyse the relationships between the independent variables (cortisol and glucose concentrations) and the dependent variables (performance parameters). There were no correlations between most of the independent and dependent variables on d0, d14 and d42 except for treatment SEL/CHR.

Selenium and chromium provided alone have proven to be ineffective in alleviating stress and subsequently improving animal performance in much research. Lawlet et al. (2004) fed supranutritional and organically bound selenium to finishing beef steers and found no effect on production and carcass quality. Kegley and Spears (1995) fed 0.4 mg/kg of $CrCl_3$, high-Cr yeast and Cr nicotinic but there was no positive response. Others (Mowat et al., 1993) who investigated the finishing-growing phase reported similar results. In contrast, Moonsie-Shageer and Mowat (1993) reported the carryover effect of the decreased cortisol concentrations on the performance during the adaptation period. Although it is accepted that the content of total diet Cr in a diet bear a little relationship to its effectiveness as biologically active Cr (NRC, 1997), it was reported that the highest dosage (1 mg of Cr per kg DM of feed) was more effective than the adequate levels.

Growth performance

The data related to growth rate of the steers are presented in Table 3. Repeated measures analysis of variance showed that the effect of supplemental Se and Cr were affected by days on feed ($P \leq 0.01$) and by the interaction days x treatment ($P \leq 0.05$). It was clear that all the animals were in a sustained phase of growth, which started to flatten around d112 (Figure 1). The contrast between LWT120 and LWT112 was not significantly different (P=0.10). The decision to stop the trial on d120 was thus justifiable because there was need to analysis all the growth parameters at a similar maturity.

The animals attained in average 345.461 kg live weight. The mean final ADG across treatments was 1.300 kg per day. These values are lower than the standards in the South African feedlot industry estimated to be around 420 kg for the live weight and an ADG of 1.700 to 1.800 kg (or even 2.000 kg) per day (Henning et al. 1999).

Although it was not statistically significant, the treatment SEL/CHR tended (P=0.197) to have high ADG (1.393 kg) as compared to treatments CON and CHR that gained 1.321 kg per day (5.37% less) and treatment SEL with 1.311 kg per day (6.26% less).

According to Slabbert and Swart (1989) the mature size and genetic potential of the animal establish the patterns of daily lean (protein) accretion whilst the nutritional level with other factors such as sex and the use of metabolic modifiers determine the extent to which these potentials are achieved. The steers used in the present trial were Bonsmara x Brahman x Nguni crosses. The Brahman is a medium frame and early maturing type of cattle. The Nguni cattle are of small frame and early maturing type while the Bonsmara is of medium frame and medium maturity type. The Brahman cattle were used in the breeding process for their harshness and resistance to tropical diseases. The Nguni and Bonsmara cattle are very close breeds; the heterosis effect is therefore small on growth since only the Bonsmara contributes to the improvement of growth rate. The weak growth potential of animals used in some trials such by Ammerman et al (1980) and Kincaid et al. (1999) have been also indicated as the cause of the lack of improvement in growth rate in different studies using Se in young animals. Moreover, because the genotypes that have excellent adaptability

Table 3. Mean values for performance of feedlot steers fed a supplement of Se and Cr (± SD).

Treatment	LWTD0	LWTD120	ADG	P-FCR
CON	185.297±19.813	343.888±33.631	1.321±0.203	6.66±0.84
SEL	187.352±21.295	344.706±27.184	1.311±0.125	6.68±0.49
CHR	185.352±21.578	343.529±23.436	1.321±0.141	6.65±0.56
SEL/CHR	182.5±21.777	349.722±37.079	1.393±0.185	6.37±0.70
AVERAGE	185±20.729	345.50±30.373	1.337±0.167	6.59±0.66
P-value	0.981	0.264	0.197	0.148

SD = standard deviation; LWTD1 = live weight on d1; LWTD120 = live weight on d120; ADMI = average daily gain; FCR = feed conversion ratio.

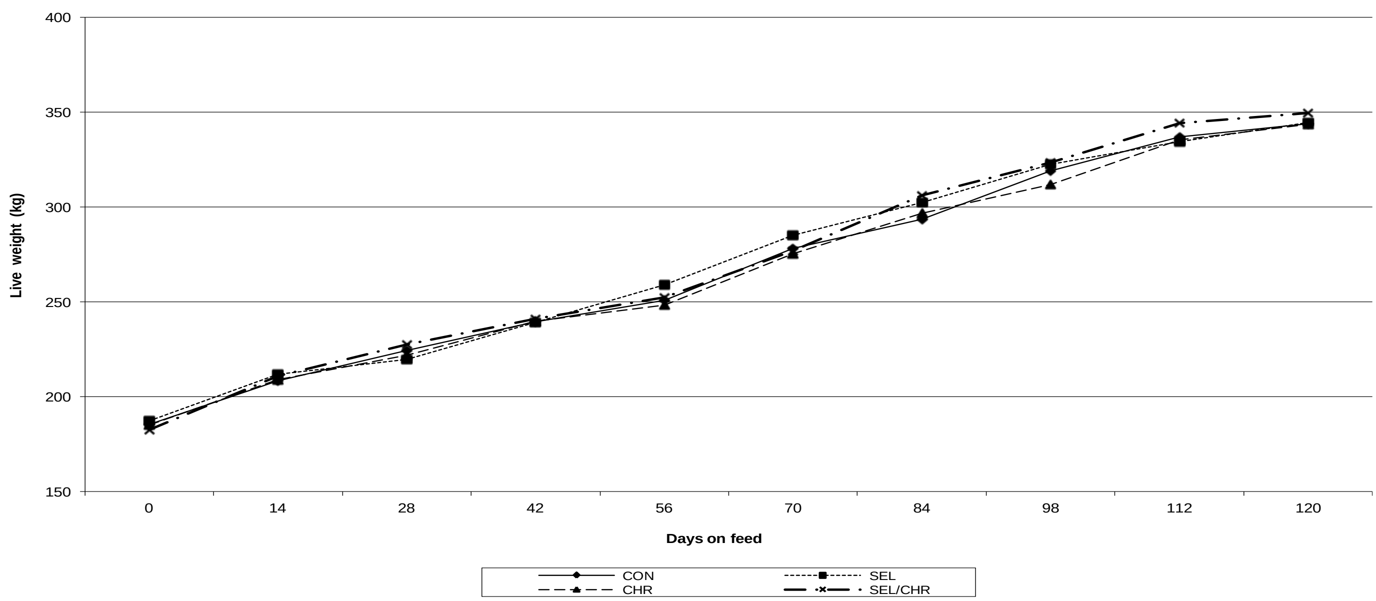

Figure 1. Growth performance of feedlot steers fed a supplement of Se and Cr.

traits for the tropical and sub tropical climates do not perform well under feedlot conditions (Bosman, 1998) it can be assumed that these animals achieved adequate growth potential for the given feeding period.

A functional selenium deficiency has been suggested as the major factor affecting the response to supplementation and the major challenge to Se activity is the level of oxidant stress presented by the diet or metabolism (Van Ryssen et al., 1992a). But as shown earlier, animals in this trial had a high Se diet therefore eliminating any possibility of Se deficiency. It has been also shown that the feed intake and subsequent growth rate of the animals can be depressed by a high intake of Se in pigs (Meyer et al., 1981) and in sheep (Echevarria et al., 1989). It has been agreed with Smolders et al. (1993) that the management and animal husbandry have generally a greater effect on growth rate and development than the mineral supply.

The difference in species and breeds in the absorption of Se was reported by Van Niekerk et al. (1990). Gerloff (1992) demonstrated that variations in genetic ability to absorb or retain Se may be present in cattle and variations of genetic lines on different farms may result in differences in response to Se supplementation. And more importantly, growth rate as an indicator of Se supplementation is an inaccurate measure because it is easily masked by such factors as sex and breeds (Van Ryssen et al., 1992b). Direct improvement of animal growth can be easily attained by improving the digestibility of the nutrients. However the dietary supplement of Se does not affect the digestibility of the nutrients (Nicholson et al., 1991a).

Treating steers with Cr (CHR) alone did not affect the performance as well in the present study. According to Pollard and Richardson (1999) research pertaining to chromium in the diets of beef cattle has been less consistent in its effect on performance and growth parameters. The high-Cr yeast and $CrCl_3$ dietary supplements did not alter the ADG and feed efficiency of weaned stressed calves. Feeding weaned stressed calves with a supplement of chelated Cr was ineffective in experiments by Wright et al. (1994) and Mathison and Engstrom (1995). Bunting et al. (1994) suggested that the lack of physiological stress during growing phase can explain the absence of dietary chromium effect. However, this is not in accordance with the present study which was conducted during the South African winter which is harsh and stressful weather and feedlot diet is also suspected to bring about a physiological stress.

Many other factors can also be considered when interpreting the results but the age of the animal is a very important factor. Kegley et al. (1996) used calves of less than 7 days. Arthington et al. (1997) used calves aged 3 to 4 weeks. Pollard and Richardson (1999) used suckling calves. Kegley and Spears (1995) used young calves on milk replacer supplemented with Cr-Nicotinic acid complex (Cr-NAC) or Cr-Cl_3 that failed to improve the performance. Here, the authors argued that the lack of stress, the stage of the digestive system development and the use of the inorganic form (Cr-Cl_3) known to be less absorbable (Merck and Co, 1996) could be considered. The growth pattern of any animal as seen in the well-known growth curve is minimal at this stage. The exponential growth pattern is seen in the feedlot after seven to nine weeks on feed when the cattle are brought in after weaning.

In another research, Kegley et al. (1996) pointed out that the cattle may have not been stressed because they were only shipped from 100 km as compared to studies showing Cr effects where cattle were shipped much greater distances and were severely stressed before the initiation of the study. In the present study, cattle were shipped over much longer distance (approximately 200 km). The performance was not improved nevertheless.

The main action of Cr is thought to be its involvement in glucose metabolism (Burton, 1995; NRC, 1997). However, it seems that adult ruminants derive a major portion of their glucose requirement from hepatic gluconeogenesis (Samsell and Spears, 1989). Therefore, there is no high expectation of Cr effect on the digestibility of the nutrients and subsequent improvement of feed intake.

Feed intake and feed conversion rate

The data related to feed intake was recorded on a pen basis. However, in order to obtain meaningful statistics, predicted feed conversion rate (Meissner, 1998) was instead used. The animals consumed in average 8.85 kg of concentrate feed DM per day, which represents approximately 2.6% of body mass. Muir et al. (1992) reported similar value. Given the mean ADG of 1.300 kg, the feed to gain ratio was 6.6:1. This figure is high compared with the average feed conversion ratio of 5:1 reported by Henning et al. (1999). It should be noted again here that the diet used was not a typical feedlot diet used in South Africa since known metabolic modifiers, e.g. monensin, where not used and the effect of breed as noted early could be prominent.

Because Se is also known to be ineffective in the improvement of the digestibility of the nutrients (Nicholson et al., 1991a) it is thus accepted that it would not improve the intake. Likewise, others (Nicholson et al., 1991b) did not find a positive effect of dietary Se supplement on feed intake and feed conversion. According to Perry et al. (1976) higher levels of Se than 0.1 mg/kg DM can lead to depression in rate of gain in cattle. Diets in this study had Se levels on average of 1.48 mg/kg DM.

Mineral composition of liver samples

The univariate procedures of the GLM (SAS, 1999) were used for each mineral under investigation in order to test the distribution. Data was analysed with or without the outliers defined here as the 5 highest and the 5 lowest values. The results were the same and therefore all variables were included in the interpretations of the results. Pearson’s correlation coefficients were used to study the interactions between different elements.

Table 4 presents the liver mineral and trace elements concentrations. With the exception of Se and Co that had high concentration and Cr with low concentrations, all the values recorded in this experiment were within the normal range for cattle (Puls, 1994). The average Se concentrations recorded for the feed samples were higher than the normal ranges of 0.1 to 0.3 ppm (NRC, 1980) and 0.3 to 1.0 ppm (Puls, 1994) except for the control diet that was Se adequate. This was however a certain overall higher Se status for all the treatments.

Although Se feed content was in average 5 to 8-fold higher than the normal range, the liver content was only 3-fold higher than the normal liver concentration. This confirms findings from Van Ryssen (1996), that is, it seems that a proportion of Se consumed by the ruminant is reduced in the rumen to unavailable forms depending on the rumen degradability of the protein sources. Net Se absorption was reported to be about 35% in sheep (NRC, 1980). There is, therefore, a limit to the body Se absorption making Se intoxication rare in cattle. Probably that is why Se deficiency or toxicity symptoms are rarely reported in South Africa (Van Ryssen, 1996) though losses as a result of marginal deficiency could occur unnoticed.

An inverse relationship between Se uptake and the levels of dietary Se and the Se status was also reported by Jelinek et al. (1985). In contrast Zachara et al. (1993) showed that Se concentration in the liver increased linearly with Se level in the diet of goat. Others reported that higher dietary Se resulted in increased Se

Table 4. Liver mineral concentration (ppm) of feedlot cattle fed a supplement of Se and Cr (± S.E.).

Mineral	Treatment				Average	Significant p-value
	CON	SEL	CHR	SEL/CHR		
Ca	85.05 ± 5.48[a]	153.00 ± 5.66 [b]	49.08 ± 5.66[c]	43.21 ± 5.48[c]	82.15	0.001
P	3580.56±03.34	3036.96±210.01	3091.00±210.01	2921.06±3.34	3159.44	
Mg	149.54 ± 8.46[a]	220.92 ± 8.74[b]	111.62 ± 8.74[a]	100.28 ± 8.46[a]	144.4	0.001
Co	1.79 ± 0.48 [a]	8.38 ± 0.49[b]	1.69 ± 0.49 [a]	0.93 ± 0.48[a]	3.161	0.0001
Cu	88.91 ± 7.21[a]	67.07 ± 7.44[b]	80.03 ± 7.44[ab]	95.50 ± 7.21 [a]	82.87	0.0475
Fe	81.85 ± 5.43	77.96 ± 5.61	87.29 ± 5.61	81.64 ± 5.43	81.9	
Mn	4.33 ± 0.26 [a]	5.66 ± 0.26 [b]	4.38 ± 0.26 [a]	5.35 ± 0.26[b]	4.934	0.001
Zn	50.12 ± 3.40	48.68 ± 3.51	41.85 ± 3.51	44.94 ± 3.40	46.33	
Se	1.74 ± 0.16	1.48 ± 0.17	1.44 ± 0.17	1.70 ± 0.16	1.597	
Cr	1.70 ± 0.14[a]	1.31 ± 0.15[a]	2.79 ± 0.15[b]	1.73 ± 0.14[a]	1.87	0.0001

Values with different superscripts differ (P≤0.05) within a row.

concentrations in all pig tissues (Lowry et al., 1985) and cows (Ammerman et al., 1980). Due to the liability of tissue Se, its losses from the body are rapid initially and then slower latter (Mahan, 1985). It is therefore possible that in 120 days on feed in this trial, the Se losses that could have been enhanced by stress were recovered and its status stabilised.

As compared to CHR and SEL/CHR, treatment SEL increased significantly (P≤0.05) the liver Ca, Co and Mn contents. These results would suggest that dietary supplement of Se is more effective than supplemental Cr in the improvement of the general status of minerals and trace elements in feedlot cattle. The low liver concentrations of Ca and Mg might be due to a negative correlation between liver Cr and some minerals. Others also (Chang and Mowat, 1992) demonstrated that the dietary Cr did not augment the tissue concentrations of Zn, Fe, Mg, Ca and P. This was further assessed by correlations between Se and Cr and other minerals.

The correlation coefficients and statistical significance of the minerals are described subsequently. Mineral interrelationships are complex as described by Puls (1994). The interrelating and antagonistic effects of the elements have to be considered if more than one element is added to the diet (AFRC, 1988). In the present study, liver Se was positively correlated with Cu (r=0.30, P=0.01) and phosphorus (r=0.44, P=0.0001). Cu had positive relationship with Fe (r=0.31, P=0.009) and Mn (r=0.263, P=0.027). Phosphorus had also positive correlations with Fe (r=0.30, P=0.01) and Zn (r=0.30, 0.01). Cr was negatively correlated with Ca (r=-0.54, P=0001) and Mg (r=-0.29, P=0.012). Calcium was strongly and negatively correlated with Mg (r=-0.75, P=0.001).

These results are not in consonance with those of Cloete et al. (1994) who did not find a positive relationship between Se and Cu. They supplemented sodium selenite to sheep and suggested that there was no interaction between Se and Cu because the combination Se-Cu did not affect performance whilst Cu or Se supplemented alone affected the animal performance. In contrast Se and P were decreased in Se deficient cows (Salewski and Seegers, 1994; Klawoun and Landfried, 1996) showing that a positive correlation was present as demonstrated in the present study.

The regressions between Se and Cr, and different minerals are presented as follows:

1. y^P =2302.194 + 537.22a, where y^P is phosphorus regression given 'a' concentration of Se;
2. y^{Cu} = 62.395 + 12.832a, where y^{Cu} is copper regression given 'a' concentration of Se, and
3. y^{Ca} = 146.730 –34.525b, where y^{Ca} is calcium regression given 'b' concentration of Cr

The correlation procedures and stepwise and non-stepwise regression were used to study the relationships between the liver minerals in one hand, and the growth parameters in finishing steers on the other hand. It was assumed that a significant positive correlation between gain and mineral concentration in liver indicated a beneficial effect of a trace element. A significant negative correlation was an evidence of a detrimental or non-beneficial effect of the supplementation of a mineral. No direct and significant effect of minerals was noticed. Particularly for Se, Juniper et al. (2008) did not find neither any effects on the performance of ruminant animals fed high doses of the trace element (10 times the European Union or near 20 times the US Food and Drug Administration requirements).

Conclusion

Feedlot cattle are subjected to stress during transportation, handling and feeding of high energy diets. Local cattle breeds are thought to adapt less in feedlot environment. Blood cortisol and glucose measurements were lowered in Bonsmara-cross steers fed a combination of Se and Cr (SEL/CHR) during the period of high dietary stress. There were no correlations between blood cortisol and glucose levels and growth performance parameters on d0, d14 except a tendency for treatment SEL/CHR on d42. The overall live weight and average daily gain were lower than the standards in the South African feedlot industry but treatment SEL/CHR tended to have high ADG as compared to other treatments. Treatment SEL increased significantly liver Ca, Co and Mn and liver Se was positively correlated to Cu and phosphorus. Cr was negatively correlated to Ca and Mg. In the light of these results it could be suggested that further work with different sources of Se and or Cr and their combination and interactions with other minerals on stress alleviation and carry-over on performance and carcass characteristics should be undertaken.

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