DOI: 10.5433/1679-0359.2018v39n3p1351

# Performance and carcass traits of Nellore cattle fattening on pasture receiving different zinc contents in the mineral supplementation

# Desempenho produtivo e características de carcaça de bovinos Nelore em regime de engorda a pasto recebendo diferentes teores de zinco na suplementação mineral

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## Abstract

The objective of this work was to study the effect of different zinc content ($ZnSO_4$) in the mineral supplementation for Nellore steers grazing *Brachiaria brizantha* (cv) MG-4, on productive performance and carcass traits. Twenty-eight castrated animals with average body weight of 355 kg, were used. The animals were randomly divided into four groups and housed in paddocks of 6.25 ha each one, equipped with covered feeders and waterers, and grazed alternately each 28 days. The experimental design was completely randomized, with four zinc (Zn) content and seven repetitions. Different zinc content were: Zn-0, without Zn; Zn-2, with 2,000 mg Zn $kg^{-1}$; Zn-4, with 4,000 mg Zn $kg^{-1}$; and Zn-6, with 6,000 mg Zn $kg^{-1}$; in the inorganic form (Zinc Sulphate) in mineral supplement. Mineral supplements were given *ad libitum* in covered troughs and previously weighed, with leftovers control for determining intake. The experimental period was 370 days. Organs, viscera, carcass and non-carcass components were weighed from each slaughtered animal. Loin eye area (LEA) and subcutaneous fat thickness (SFAT), as well as, color, pH and lipid oxidation, were evaluated. The increasing inclusion of zinc content in the diet of steers do not affected ($P>0.05$) final body weight (FBW) and average daily weight gain (ADWG). Difference ($P < 0.05$) was observed in the Zn intake (ZnI) ($\hat{Y} = -2.09386 + 146.9616x$; $R^2 = 0.99$) and hot carcass weight ($\hat{Y}= 299.92662 + 3.33362x$; $R^2= 0.24$), as well as, in meat lipid oxidation ($\hat{Y} = 0.15170 + 0.02539x$; $R^2= 0.31$). There was an increasing linear effect for meat color, evaluated by values of L* (luminosity) ($\hat{Y} = 32.23309 + 0.41445x$, $R^2 = 0.14$), a* (red-green intensity) ($\hat{Y} = 0.88592 + 18.16225x$, $R^2 = 0.25$) and b* (yellow-blue intensity) ($\hat{Y} = 9.35295 + 0.45030x$, $R^2 = 0.20$), but remained within normal values for meat. It can be concluded that beef cattle grazing *Brachiaria brizantha* MG-4, and supplemented with different zinc contents in mineral supplements, supplied *ad libitum*, do not show changes in weight gain, carcass yield, physical carcass composition, as well as,

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Received: Dec. 15, 2017 - Approved: Mar. 14, 2018

in non-carcass components, but the Zn content has a positive linear influence on hot carcass weight, without causing changes in absolute and relative weights of organs and viscera.
**Key words:** Intake. Non-carcass component. Organs and viscera. Ruminants. Weight gain.

## Resumo

Objetivou-se estudar o efeito de diferentes teores de Zinco na suplementação mineral de novilhos Nelore em pastagem de *Brachiaria brizantha* cultivar (cv) MG-4, sobre o desempenho produtivo e características de carcaça. Foram utilizados 28 animais, castrados, com peso vivo médio inicial de 355 kg. Os animais foram divididos ao acaso em quatro grupos e alojados em piquetes de 6,25 hectares cada, equipados com comedouro coberto e bebedouros, sendo pastejados alternadamente a cada pesagem (28 dias). O delineamento experimental foi inteiramente casualizado, com quatro dosagens de zinco (Zn) no suplemento mineral e sete repetições. As doses de zinco avaliadas foram: Zn-0, sem adição de Zinco; Zn-2, com 2.000 mg de Zn $kg^{-1}$; Zn-4, com 4.000 mg de Zn $kg^{-1}$; e Zn-6, com 6.000 mg de Zn $kg^{-1}$; sob forma inorgânica (Sulfato de Zinco) no suplemento mineral. Os suplementos minerais foram pesados e fornecidos *ad libitum,* em cochos cobertos, com controle das sobras para determinação do consumo. O período experimental foi de 370 dias. De cada animal abatido pesaram-se órgãos, vísceras, carcaça e componentes não carcaça. Avaliaram-se a área de olho de lombo (AOL) e espessura da gordura subcutânea (EGSC), bem como a cor, pH e oxidação lipídica. A crescente inclusão do zinco na dieta dos bovinos, não influenciou ($P > 0,05$) o peso vivo final (PVF) e o ganho de peso médio diário (GPMD). Observou-se diferença ($P<0,05$) no consumo de Zn (CZn) ($\hat{Y} = -2,09386 + 146,9616x$; $R^2=0,99$) e peso de carcaça quente ($\hat{Y}= 299,92662 + 3,33362x$, $R^2= 0,24$), bem como na oxidação lipídica da carne ($\hat{Y}= 0,15170 + 0,02539x$; $R^2=0,31$). Houve efeitos lineares crescentes sobre a cor da carne, avaliados pelos valores de "L*" (luminosidade) ($\hat{Y}= 32,23309 + 0,41445x$; $R^2= 0,14$), "a*" (intensidade de vermelho-verde) ($\hat{Y}= 0,88592 + 18,16225x$, $R^2 = 0.25$) e "b*" (intensidade de amarelo-azul) ($\hat{Y}= 9,35295 + 0,45030x$; $R^2=0,20$), porém mantiveram-se dentro dos valores normais para carne bovina. Pode-se concluir que bovinos mantidos em pastagens e recebendo diferentes doses de zinco em suplementos minerais, fornecidos *ad libitum*, não sofrem influência no ganho de peso, rendimento de carcaça, composição físicas das carcaças, assim como nos componentes não carcaça, mas o Zn exerce influencia linear positiva sobre o peso de carcaça quente, sem causar alterações nos pesos relativos e absolutos de órgão e vísceras.
**Palavras-chave**: Componente não carcaça. Consumo. Ganho de peso. *Órgãos* e vísceras. Ruminantes.

## Introduction

The beef cattle industry is developed in all Brazilian states and is an important economic activity with major role in the trade balance of the country (EUCLIDES FILHO; EUCLIDES, 2010).

In a general way, on tropical regions, the cattle get the most part of nutrients (energy, protein, minerals and vitamins) required from forage. According to Silva and Baruselli (2001), studies in the University of Florida using 2,615 samples of forage from Latin America, showed that 43% of the samples were deficient in cobalt, 47% in copper, 35% in magnesium, 73% in phosphorus, 60% in sodium and 75% in zinc (Zn), for livestock feeding.

The *ad libitum* intake of minerals is the most common way to deliver minerals to cattle grazing. The complete mineral mix usually includes common salt and the phosphorus source, in addition to calcium, cobalt, copper, iodine, iron and zinc. However, in tropical regions of acidic soil, the manganese and iron can be eliminated from the mixture (CARVALHO et al., 2005).

On regions with tropical weather where there is predominance of vegetation of the type Brazilian

cerrado and soils with low fertility, the Zn has received special attention, due to his low content found on the mineral profile of different forage used in livestock production. The requirements for zinc in beef cattle are around 30 mg Zn $kg^{-1}$ of dry matter for all categories of animals (MORAES, 2001).

One of the first symptoms which arise in zinc deficiency is the reduction of appetite, up to 60% of cases. Associated to this fact occurs the progressive weight loss, because the growth factor levels (Insulin-like growth factor 1 - IGF1) are reduced, and the incorporation of nitrogen to tissue becomes lowered due to increased excretion of this component by urine (ORTOLANI; SUCUPIRA, 2010).

The insertion of available technologies in the beef production chain could result in substantial impact on beef cattle production and on competitiveness of the various segments of the chain of meat production (EUCLIDES FILHO; EUCLIDES, 2010).

Zinc as an essential trace element to the animal production system and has been extensively studied in other countries, but the research in Brazil are still insufficient. The enzymes that require Zn are involved in the nucleic acids, proteins and carbohydrates metabolism and, consequently, cell metabolism, emphasizing their importance for normal functioning of the immune system. In addition, the amino acid requirement in protein synthesis is injured by Zn deficiency, which justifies its great importance on animal performance (CRUZ; SOARES, 2011).

Zinc deficiency among other factors, results in the reduction of GH (growth hormone) receptor and the consequent decrease in IGF-1 (insulin-like growth factor 1) reducing the release of the neuropeptide, and appetite loss (SALGUEIRO et al., 1999). Numerous enzymes that are involved in DNA and RNA synthesis process are zinc metalloenzymes dependent, which may influence the hormonal regulation of cell division, especially pathway GH and IGF-1 besides to interfere with mitogenic hormones acting on cell proliferation (SENA; PEDROSA, 2005). Zinc is component of superoxide dismutase enzyme (Cu-ZnSOD) having as an active center a zinc ion present in the cytoplasm of all cells. The Cu-ZnSOD action is to catalyze the conversion of superoxide ($O_2^-$) in hydrogen peroxide and oxygen (LEHNINGER et al., 2006), while glutathione peroxidase (GSH-Px) removes hydrogen peroxide by transforming them in water, neutralizing the oxidizing action of peroxides (VÁZQUEZ-AÑÓN et al., 2008).

The objective of this study was to evaluate the effect of different zinc content in mineral supplementation on productive performance and carcass traits of beef cattle on pasture.

## Material and Methods

The experiment was conducted at the farm of the Matsuda Group, located in the municipality of "Mirante do Paranapanema" (SP) around 230 km far from Londrina (PR). The geographic coordinates are 22º16'03.33 "S and 51º46'46.69" W; 440 meter height from sea level; annual average temperature of 22.8ºC and pluviometric index of 1,298 mm $year^{-1}$.

The experiment lasted 370 days. Twenty-eight steers, male, castrated, Nelore breed, aged 30 months and initial mean live weight of 355 kg were used. The animals were previously weighed (after 16 hours solids fasting), identified with numbers in the right leg, vaccinated against foot and mouth disease and submitted to the endo and ectoparasites control. Then, they were randomly distributed in four groups and housed in paddocks of 6.25 hectares each, with *Brachiaria brizantha* cv. MG-4, all equipped with covered feeders and drinkers, where they were grazed alternately in each weighing (28 days). The annual average stocking rate was 1.14 AU $ha^{-1}$.

Samples of *Brachiaria brizantha* cv. MG-4 were harvested from the pasture, every 28 days,

for chemical analysis and determination of mineral contents. For the sampling of *Brachiaria brizantha* cv. MG-4, the grazing by the animals was simulated, taking care to avoid feces and bed grounds of the animals.

The chemical and mineral analysis of the forage (Table 1) were carried out in the animal nutrition laboratory of the company Comércio e Indústria Matsuda Importadora e Exportadora Ltda, in Álvares Machado - SP.

**Table 1.** Average chemical and mineral composition of *Brachiaria brizantha* cv. MG-4, according to the season of the year.

| | | Year Season | | | | Average |
|---|---|---|---|---|---|---|
| | | Spring | Summer | Fall | Winter | |
| Dry Matter | (g $kg^{-1}$) | 274.1 | 258.1 | 308.2 | 335.1 | 293.9 |
| Mineral Mater | (g $kg^{-1}$) | 89.3 | 95.8 | 73.0 | 68.4 | 81.6 |
| Crude Fiber | (g $kg^{-1}$) | 363.1 | 371.6 | 377.3 | 380.5 | 373.1 |
| Ether Extract | (g $kg^{-1}$) | 16.9 | 16.7 | 15.5 | 13.7 | 15.7 |
| Crude Protein | (g $kg^{-1}$) | 83.7 | 102.3 | 74.5 | 65.3 | 81.5 |
| NNE[1] | (g $kg^{-1}$) | 44.70 | 41.36 | 45.97 | 47.21 | 44.81 |
| TDN Estimated[2] | (g $kg^{-1}$) | 535.3 | 530.6 | 528.8 | 524.7 | 530.5 |
| NDF | (g $kg^{-1}$) | 762.0 | 751.0 | 777.8 | 768.5 | 764.8 |
| ADF | (g $kg^{-1}$) | 413.5 | 384.8 | 425.8 | 406.7 | 407.7 |
| Phosphorus, P | (g $kg^{-1}$) | 2.75 | 2.9 | 2.25 | 2.8 | 2.68 |
| Potassium, K | (g $kg^{-1}$) | 26.6 | 22 | 18.05 | 21.35 | 22.00 |
| Calcium, Ca | (g $kg^{-1}$) | 6.45 | 6.3 | 7.15 | 6.2 | 6.53 |
| Magnesium, Mg | (g $kg^{-1}$) | 4.45 | 3.95 | 5.65 | 5.15 | 4.80 |
| Sulfur, S | (g $kg^{-1}$) | 1.0 | 0.97 | 1.05 | 0.94 | 0.99 |
| Boron, B | (mg $kg^{-1}$) | 19.0 | 21.0 | 18.5 | 18.0 | 19.13 |
| Copper, Cu | (mg $kg^{-1}$) | 13.0 | 12.0 | 11.5 | 11.0 | 11.88 |
| Iron, Fe | (mg $kg^{-1}$) | 85.0 | 114.5 | 116 | 96.5 | 103.0 |
| Manganese, Mn | (mg $kg^{-1}$) | 47.5 | 95.5 | 78.5 | 103.5 | 81.25 |
| Zinc, Zn | (mg $kg^{-1}$) | 31.5 | 29.5 | 32 | 32.5 | 31.38 |

NDF= Neutral detergent fiber; ADF= Acid detergent fiber; NNE= non-nitrogenous extract.
[1] Calculated by formula: NNE = 100 - CP - CF - EE - MM, described by Mizubuti et al. (2009).
[2] Calculated by McDowell et al. (1974).

To determine the chemical composition of the forage, the methods described by Mizubuti et al. (2009) were used. Total digestible nutrient values (TDN) were estimated according to McDowell et al. (1974), using the following equation: $TDN = -72.943 + 4.75*(CF) - 1.28*(EE) + 1.611*(NNE) + 0.497*(CP) - 0.044*(CF)^2 - 0.76*(EE)^2 - 0.039*(CF)*(NNE) + 0.087*(EE)*(NNE) - 0.152*(EE)*(CP) + 0.074*(EE)^2*(CP)$.

For determination of the mineral content of the forage, the methodology of metals analysis using spectrophotometry of atomic absorption was used, according to the recommendation of AOAC (1990).

The experimental design was completely randomized, comprising mineral supplements with four different zinc contents (Zn) and seven replicates. The zinc contents evaluated were: Zn-0, without Zinc addition; Zn-2, with 2,000 mg Zn $kg^{-1}$; Zn-4, with 4,000 mg Zn $kg^{-1}$ and Zn-6, with 6,000 mg Zn $kg^{-1}$, on inorganic form of Zinc Sulfate ($ZnSO_4$), supplied to the animals in mineral supplement of ready utilization. The period of adaptation of the animals to the mineral supplements and the conditions of handling was 30 days.

The mineral supplement, formulated according to recommendations of NRC (2000) (Table 2) was weighed and supplied *ad libitum* to the animals in covered troughs and the consumption by the animals was monitored by control of leftovers and replacement of the same in the troughs.

The animals were weighed every 28 days, after fasting for solid food for 16 hours. Then, the animals were rotated to receive supplements with different zinc contents in the paddocks, called Paddocks A, B, C and D, always changing in a clockwise direction, thus allowing all the animals receiving different zinc contents to graze in all of the paddocks in the course of the experiment. At each rotation, the salt troughs were cleaned for paddocks exchange and mineral supplements, thus avoiding contamination between the supplements.

**Table 2.** Composition of the mineral supplements with different levels of zinc used during the experimental period.

| Components | Mineral Supplement[1] (Guarantee levels per quilogram of product) | | | |
|---|---|---|---|---|
| | Zn-0 | Zn-2 | Zn-4 | Zn-6 |
| Calcium (Max.) (g $kg^{-1}$) | 120 | 120 | 120 | 120 |
| Calcium (Min.) (g $kg^{-1}$) | 105 | 105 | 105 | 105 |
| Phosphorus (Min.) (g $kg^{-1}$) | 43 | 43 | 43 | 43 |
| Sodium (Min.) (g $kg^{-1}$) | 107 | 107 | 107 | 107 |
| Sulfer (Min.) (g $kg^{-1}$) | 12 | 12 | 12 | 12 |
| Magnesium (Min.) (mg $kg^{-1}$) | 5,000 | 5,000 | 5,000 | 5,000 |
| Cobalt (Min.) (mg $kg^{-1}$) | 150 | 150 | 150 | 150 |
| Copper (Min.) (mg $kg^{-1}$) | 1,500 | 1,500 | 1,500 | 1,500 |
| Iodine (Min.) (mg $kg^{-1}$) | 100 | 100 | 100 | 100 |
| Manganese (Min.) (mg $kg^{-1}$) | 780 | 780 | 780 | 780 |
| Selenium (Min.) (mg $kg^{-1}$) | 18 | 18 | 18 | 18 |
| Zinc (Min.) (mg $kg^{-1}$) | 0,000 | 2,000 | 4,000 | 6,000 |
| Iron (Min.) (mg $kg^{-1}$) | 800 | 800 | 800 | 800 |
| Fluorine (Max.) (mg $kg^{-1}$) | 430 | 430 | 430 | 430 |
| Crude Protein (Min.) (g $kg^{-1}$) | 180 | 180 | 180 | 180 |
| NPN - Eq. Protein (Max.) (g $kg^{-1}$) | 140 | 140 | 140 | 140 |
| TDN (Mín.) (g $kg^{-1}$) | 200 | 200 | 200 | 200 |

Zn-0, no addition of Zn; Zn-2, with 2,000 mg of Zn $kg^{-1}$; Zn-4, with 4,000 mg of Zn $kg^{-1}$; and Zn-6, with 6,000 mg of of Zn $kg^{-1}$.
[1]Basic composition of the products: calcium carbonate, dicalcium phosphate, sodium chloride, ventilated sulfur, magnesium oxide, cobalt sulfate, copper sulfate, potassium iodide, manganese sulphate, sodium selenite, zinc sulphate, iron sulphate, livestock urea, soybean meal, corn, corn gluten.
NPN= non-protein nitrogen; TDN= total digestive nutrients.

The animals were slaughtered at an average live weight of 570 kg after fasting for solid food for 16 hours, and weighed to allow subsequent determination of carcass yield.

All the animals were slaughtered at Frigorífico C. J. Comércio Ltda, located in the Presidente Prudente city, State of São Paulo. The stunning of the animals was performed with captive bolt gun for subsequent bleeding through the jugular vein section.

From each slaughtered animal were weighed: carcass, head, blood, liver, heart, kidneys, lung, tongue, leather, tail, esophagus, trachea and penis to evaluate the influence of different levels of Zn on absolute and relative weights of organs, viscera, carcasses and non-carcass components.

After slaughter, the carcasses were washed, identified and kept in a cold room for 24 hours at a temperature of 0 to -2 °C. The carcass yield (CY) was calculated using the equation: CY = (hot carcass weight/live weight) x 100.

The carcass length was measured from each half-carcass left, measured by the distance between the anterior border of the pubis and the medial anterior border of the first rib, and the width of the carcass measured by the distance from the lower border of the sternum to the lower edge of the carcass medulla between the fifth and the sixth dorsal vertebra, both with the aid of a tape measure.

Also, the leg length was measured by the distance between the midpoint of the tarsus-metatarsal joint and the anterior border of the ischium-pubic synthesis. The leg circumference was measured by wrapping it with a tape measure half its length.

The thickness of the thigh was obtained with the aid of a compass, obtaining the distance between the lateral and medial surfaces of the thigh.

After 24 hours of carcass chilling, the subcutaneous fat thickness (fat covering the *Longissimus dorsi* muscle) and loin eye area (LEA) were measured. With the aid of a pachymeter, the subcutaneous fat thickness was evaluated and by tracing the contour of *Longissimus dorsi*, on vellum, the loin eye area was determined. Both measurements were made between the $12^{th}$ and $13^{th}$ rib, according to the methodology described by USDA (1989).

From left half carcass, the cross section of the *Longissimus dorsi* including $9^{th}$, $10^{th}$ and $11^{th}$ ribs (section H-H) was obtained. To determine the proportions of muscle, fat and bones, the proposed equations by Hankins and Howe (1946) were used: proportion of muscle: $y = 16.08 + 0.80x$; proportion of adipose tissue: $y = 3.54 + 0.80x$; proportion of bones: $y = 5.52 + 0.57x$, where x is the percentage of the component in section H-H.

For determination of lipid oxidation, samples of *Longissimus dorsi* were collected, identified, packed in polyethylene film and frozen at -20 ° C. The TBARS (lipid oxidation) analysis of meat was performed by the indicative of thiobarbituric acid reactive substances (TBARS), according to Crackel et al. (1988).

The pH of the meat was determined using a Hanna portable potentiometer equipped with a metal penetration electrode at 2 cm inside the *Longissimus dorsi* muscle after 24 hours of carcass cooling.

The meat color was determined in samples after 30 minutes of exposure to oxygen, for reaction of myoglobin with atmospheric oxygen, using the portable Minolta color colorimeter CR10, for evaluation of the components L* (luminosity), a* (red intensity -green) and b* (yellow-blue intensity) by the CIELAB system (MINOLTA, 1998). The measurements were performed in three different regions, taking the mean as determined value.

Data were analyzed through analysis of variance and regression, using the procedure PROC GLM and PROC REG of the statistical analyzes system - SAS (2003).

## Results and Discussion

Productive performance and mineral supplement intake

The increasing inclusion of zinc in mineral supplementation of cattle did not affect (P> 0.05) final body weight (FBW) and average daily weight gain (ADWG) (Table 3).

Brown et al. (2004) studied different sources and zinc contents in cattle, no significant differences on average daily weight gain (ADWG) were observed, although they noted that animals of control group (60 ppm $ZnSO_4$) gained weight more rapidly, followed by animals of group receiving 90 ppm $ZnSO_4$ and lastly, those receiving 90 ppm ZnMet.

**Table 3.** Productive performance; mineral supplement intake containing different levels of zinc and inorganic zinc intake by the animals kept in pasture of *Brachiaria brizantha* cv. MG-4.

| Variables | Mineral Supplement[1] | | | | CV(%) | Pr > F | Regression |
|---|---|---|---|---|---|---|---|
| | Zn-0 | Zn-2 | Zn-4 | Zn-6 | | | |
| IBW, kg | 361.6 | 351.6 | 359.1 | 358.1 | 2.764 | 0.298 | Y= 357.62 |
| FBW, kg | 569.9 | 556.5 | 570.8 | 583.3 | 3.752 | 0.166 | Y= 570.14 |
| ADWG, kg | 0.562 | 0.553 | 0.572 | 0.608 | 8.859 | 0.224 | Y= 0.574 |
| MSI, g $day^{-1}$ | 146 | 143 | 149 | 146 | 3.762 | 0.271 | Y= 146 |
| ZnI, mg $day^{-1}$ | 0 | 286 | 596 | 976 | 4.208 | 0.0001 | $\hat{Y}$= -2.09386 + 146.9616x; $R^2$= 0.99 |

[1]Zn-0, no addition of Zn; Zn-2, with 2,000 mg of Zn $kg^{-1}$; Zn-4, with 4,000 mg of Zn $kg^{-1}$e Zn-6, with 6,000 mg of Zn $kg^{-1}$; IBW=Initial body weight; FBW= Final body weight; ADWG= average daily weight gain; MSI= average mineral supplement intake per animal per day; ZnI= average zinc intake per animal per day.

The final body weight and average daily weight gain obtained in this experiment were found to be similar to those reported by Malcom-Callis et al. (2000), when using levels of 20, 100 or 200 mg Zn $kg^{-1}$ DM in the feed of steers under confinement, as well as the results reported by Mullis et al. (2003).

It has also been observed in the literature that some researchers such as, Spears and Kegley (2002) and Mullis et al. (2003), evaluated the supply of different sources of zinc, organic and inorganic ($ZnSO_4$ and ZnProt, ZnO) to growing and finishing cattle, reporting no effect on dry matter intake, daily average weight gain, feed conversion and weight to slaughter.

There was no difference (P> 0.05) in mineral supplement intake, confirming that zinc sulfate does not interfere with the acceptability of the mineral mixture, therefore, all animals ingested the same amount of the other minerals present in the formulations. On the other hand, there was difference (P <0.05) in zinc intake by the animals that received different levels of zinc supplementation.

It was found that the variables ADWG and FBW in animals receiving different levels of zinc in the supplementation (Zn-0, Zn of 2,000, 4,000 and 6,000 mg Zn $kg^{-1}$), did not show any differences between them, indicating that the supplementation of these levels of Zn does not influence the performance of beef cattle.

## Carcass traits

The increase of zinc inclusions in the diet of cattle on pasture showed a positive linear effect (P<0.05) on the weight of hot carcasses, with averages of 310.53 kg. Comparing the hot carcass weights of the animals receiving supplements Zn-0 and Zn-6, there was an increase of 6.86 kg. Likely,

increasing Zn levels in the mineral supplementation of animals improved growth hormone (GH) levels by modulating their secretion along the pituitary gland, which in turn stimulates the synthesis and secretion of insulin-like growth factor-1 (IGF1) through association with hepatic GH receptors, thus increasing the uptake of glucose and amino acids by the muscle fibers, thus promoting the muscular growth of the organism (GOMES; TIRAPEGUI, 1998).

The hot carcass yield (HCY) was not influenced (P> 0.05) by the different levels of zinc in the supplementation (Table 4), because it was obtained from hot carcass weight relative to the live weight of the animals, which did not change with respect to the different supplements. According to Brondani et al. (2006), carcasses with lower amount of fat and greater amount of muscle are ideal, as it increases the carcass yield.

**Table 4.** Performance and carcass composition of cattle maintained on *Brachiaria brizantha* cv. MG-4, receiving mineral supplementation with different contents of zinc.

| Variables | Mineral Supplement[1] | | | | CV (%) | Pr > F | Regression |
|---|---|---|---|---|---|---|---|
| | Zn-0 | Zn-2 | Zn-4 | Zn-6 | | | |
| HCW, kg | 305.14 | 301.28 | 314.71 | 312.00 | 4.22 | 0.038 | $\hat{Y}$= 299.92662 + 3.33362x; $R^2$= 0.24 |
| HCY, % | 53.54 | 54.15 | 55.16 | 55.02 | 2.68 | 0.154 | $\hat{Y}$= 54.47 |
| Muscle, % | 62.37 | 63.49 | 63.47 | 64.11 | 4.59 | 0.73 | $\hat{Y}$= 63.36 |
| Muscle, kg | 190.31 | 191.41 | 199.75 | 206.14 | 7.42 | 0.17 | $\hat{Y}$= 196.90 |
| Bone, % | 13.84 | 13.73 | 13.17 | 13.40 | 6.13 | 0.43 | $\hat{Y}$= 13.53 |
| Bone, kg | 42.18 | 41.37 | 41.46 | 42.99 | 7.22 | 0.73 | $\hat{Y}$= 42.00 |
| Fat, % | 23.80 | 22.77 | 23.36 | 22.50 | 12.74 | 0.84 | $\hat{Y}$= 23.10 |
| Fat, kg | 72.65 | 68.51 | 73.50 | 71.87 | 12.39 | 0.74 | $\hat{Y}$= 71.63 |
| RMB | 4.51 | 4.64 | 4.84 | 4.81 | 7.87 | 0.33 | $\hat{Y}$= 4.70 |
| RMF | 2.64 | 2.83 | 2.76 | 3.00 | 20.90 | 0.71 | $\hat{Y}$= 2.81 |
| LEA, $cm^2$ | 70.87 | 70.50 | 67.93 | 73.50 | 11.54 | 0.655 | $\hat{Y}$= 70.70 |
| SCFT, mm | 6.00 | 5.71 | 8.57 | 7.00 | 38.45 | 0.195 | $\hat{Y}$= 6.82 |

[1]Zn-0, no addition of Zn; Zn-2, with 2,000 mg of Zn $kg^{-1}$; Zn-4, with 4,000 mg of Zn $kg^{-1}$ e Zn-6, with 6,000 mg of Zn $kg^{-1}$; HCW= Hot carcass weight; HCY= Hot carcass yield; RMB= Relationship Muscle:Bone; RMF= Relationship Muscle:Fat; LEA= Loin eye area; SCFT= Subcutaneous fat thickness.

The physical composition of the carcasses (Table 4), obtained through the cut between the 9th and 11th ribs, showed no differences between animals in different supplements. The amount (kg) and percentage of muscle, bone and fat in the carcass were also not influenced by the increasing inclusion of zinc in mineral supplementation.

The mean (kg and %) of muscle, bone and fat in the carcass were 196.9 kg and 63.36% (muscle), 42 kg and 13.53% (bone) and 71.63 kg and 23.10% (fat), respectively, and the relationships between muscle and bone was 4.70; and between muscle and fat, was 2.81 in carcass with a mean weight of 310.53 kg.

These values are compatible with the percentages of muscle, bone and fat of Nellore breed, and resemble the results obtained by Vittori et al. (2006), who found values in the range of 61% for muscle yield, 15% for bone tissue yield and 24% for adipose tissue yield. Considering that the bone tissue is of early maturity, the small variation among terminating animals is justified.

The loin eye area (LEA) and subcutaneous fat thickness (SCFT) measurements (Table 4) did not differ (P>0.05) among animals receiving supplements with different zinc contents. Berg and Butterfield (1976) have stated in their evaluations that in contemporary animals of the same breed no differences in LEA are expected.

The SCFT mean values reached 6.82 mm, considered as uniform coverage. Only values of SCFT of the animals receiving supplementation with 2,000 mg Zn $kg^{-1}$ (Zn-2) presented values of 5.71 mm, classified as median coverage, according to criteria adopted by Normative Instruction No. 9, of the Ministry of Livestock Agriculture and Supply (BRASIL, 2004).

There was no difference (P>0.05) for carcass traits of steers raised on pasture supplemented with different contents of zinc in this study (Table 5).

**Table 5.** Carcass traits of steers maintained on *Brachiaria brizantha* cv. MG-4, receiving mineral supplementation with different contents of zinc.

| Variables | Mineral Supplement[1] | | | | CV(%) | Pr > F | General average |
|---|---|---|---|---|---|---|---|
| | Zn-0 | Zn-2 | Zn-4 | Zn-6 | | | |
| Fore, kg | 128.35 | 128.85 | 132.90 | 136.67 | 5.31 | 0.118 | 131.69 |
| Fore, % | 22.54 | 23.16 | 23.31 | 23.40 | 4.95 | 0.504 | 23.10 |
| Rear, kg | 177.93 | 173.92 | 182.14 | 184.71 | 5.11 | 0.162 | 179.67 |
| Rear, % | 31.19 | 31.25 | 31.90 | 31.68 | 3.08 | 0.468 | 31.50 |
| Carcass length, cm | 137.71 | 136.14 | 137.57 | 138.43 | 3.81 | 0.872 | 137.46 |
| Carcass width, cm | 49.00 | 48.43 | 48.85 | 49.43 | 4.14 | 0.832 | 48.93 |
| Leg length, cm | 95.07 | 93.64 | 95.85 | 93.50 | 2.72 | 0.273 | 94.51 |
| Thigh Thickness, cm | 31.14 | 30.57 | 29.35 | 31.35 | 6.95 | 0.316 | 30.60 |
| Thigh circumference, cm | 115.28 | 115.43 | 115.00 | 116.57 | 3.28 | 0.873 | 115.57 |

[1]Zn-0, no addition of Zn; Zn-2, with 2,000 mg of Zn $kg^{-1}$; Zn-4, with 4,000 mg of Zn $kg^{-1}$ e Zn-6, with 6,000 mg of Zn $kg^{-1}$.

Kabeya et al. (2002), studied the supply of different supplements for steers kept in pastures of *Brachiaria brizantha* cv. Marandu, and did not observe difference in carcass traits.

According to Rotta et al. (2009), the carcass traits such as weight and length of fore and rear, are little modified through nutritional management, being more influenced by different genetic groups.

The increasing inclusion of zinc in the mineral supplementation of pastured cattle, negatively influenced (P<0.05) the lipid oxidation values (Table 6), increasing the concentrations of malonaldehyde (mg TBARS $kg^{-1}$ of sample) in the meat. These results contradict those of Garmyn et al. (2011) who observed a significant relationship, however low, between concentration of minerals, zinc on sulphate form and lipid oxidation, reporting that all of the minerals, except calcium and manganese were positively correlated (P<0.05) in samples of *Longissimus dorsi* of Angus cattle.

**Table 6.** Lipid oxidation, color and pH in the meat of Nellore steers maintained in *Brachiaria brizantha* cv. MG-4 pasture, receiving mineral supplementation with different zinc contents.

| Variables | Mineral Supplement[1] | | | | CV (%) | Pr > F | Regression |
|---|---|---|---|---|---|---|---|
| | **Zn-0** | **Zn-2** | **Zn-4** | **Zn-6** | | | |
| LO, mg | 0.155 | 0.190 | 0.269 | 0.289 | 34.59 | 0.01 | $\hat{Y} = 0.15170 + 0.02539x$; $R^2$=0.31 |
| *L* | 31.89 | 32.16 | 35.14 | 33.88 | 6.13 | 0.02 | $\hat{Y} = 32.23309 + 0.41445x$; $R^2$= 0.14 |
| *a* | 18.63 | 18.22 | 24.11 | 22.28 | 13.69 | 0.001 | $\hat{Y} = 18.16225 + 0.88592x$; $R^2$= 0.25 |
| *b* | 9.36 | 9.14 | 12.79 | 11.30 | 14.23 | 0.003 | $\hat{Y} = 9.35295 + 0.45030x$; $R^2$=0.20 |
| pH | 5.68 | 5.65 | 5.56 | 5.60 | 1.59 | 0.112 | $\hat{Y}$= 5.62 |

[1]Zn-0, no addition of Zn; Zn-2, with 2,000 mg of Zn $kg^{-1}$; Zn-4, with 4,000 mg of Zn $kg^{-1}$ e Zn-6, with 6,000 mg of Zn $kg^{-1}$.
L= luminosity; "a"= red-green intensity; "b"= yellow-blue intensity; LO= Lipid Oxidation express as mg of TBARS $kg^{-1}$ of meat.

The increase in the concentrations of malonaldehyde probably occurred due to the fact that zinc is a structural component of the Cu-ZnSOD enzyme, whose function is to catalyze the conversion of superoxides to hydrogen peroxide (potent pro-oxidant enzyme) promoting the disruption of the electrochemical barrier between the oxygen and molecules of unsaturated fatty acids, thus promoting lipid oxidation.

Esterbauer (1993) stated that zinc is the structural component of the enzyme superoxide dismutase, which in turn catalyzes the conversion of superoxide into potent pro-oxidant hydrogen peroxide. Although some minerals act as cofactors of antioxidant enzymes, certain microminerals such as zinc can also act as catalysts in lipid oxidation (AL-QUDAH et al., 2009).

The color variable, which gives the initial acceptability to the product, is perhaps the only tool for quality assessment that consumers use. L* values are especially important for fresh beef, with higher values indicating paler meat (L* = 0 black, L* = 100 white). To measure the validity of fresh meat on the shelf, the value of a* becomes more important, and when they are higher, indicate more red meat.

The difference of color values in the meat from animals that received mineral supplements with different zinc contents was significant, but there are no studies that correlate zinc with the action of myoglobin, which may be related to the action of anabolic hormones such as GH and IGF-1, in addition to the interference of mitogenic hormones, which act on cell proliferation (SENA; PEDROSA, 2005).

Muchenje et al. (2009) reported that in cattle the average luminosity (L*) varied between 33.2 and 41.0; the averages of red-green intensity color (a*) vary between 11.1 to 23.6 and the averages of yellow-blue intensity color (b*), vary between 6.1 and 11.3. In this work, the averages of L*, a* and b* remained within the values described by the authors, these limits being considered normal for beef.

There was no difference among the groups of animals that received different levels of zinc on pH values of the meat, and the average pH value found in this work was 5.62, characterizing a meat with good quality. Some factors such as nutritional status, temperament, transport and pre-slaughter management may influence the final pH. Steers under stress in pre-slaughter management, promote reduction of muscle glycogen reserves *ante-mortem*. There is a reduction in lactate levels and an increase in *post-mortem* pH, modifying the organoleptic characteristics of the meat, favoring the development of pathogenic microorganisms and bad smell. This reduces the shelf life of the meat (FERREIRA, 2006).

There was no difference (P> 0.05) in the relative and absolute weight of the variables: heart, tongue, kidneys, lung, trachea, liver, penis, head, leather and tail (Table 7). These results may be related to the similarity of the average final live weight and the carcasses yield that did not present differences in the animals receiving levels of zinc.

According to Peron et al. (1993), regardless of the level of feeding, the weights of some organs such as heart and lung are not affected, indicating that these organs maintain their integrity, as well as the weight of the head and tail, which are usually constant and their alteration is insignificant in relation to animals of the same weight and breed. This can be confirmed with the data obtained in this experiment, where the organ and visceral weights did not present statistical difference among the animals receiving supplements with different zinc contents.

**Table 7.** Absolute and relative weights of non-carcass components (kg and % of final live weight) of Nellore cattle maintained on *Brachiaria brizantha* cv. MG-4, receiving mineral supplementation with different zinc contents.

| Variables | Mineral Supplement[1] | | | | CV(%) | Pr > F | General average |
|---|---|---|---|---|---|---|---|
| | Zn-0 | Zn-2 | Zn-4 | Zn-6 | | | |
| Heart, kg | 1.64 | 1.69 | 1.72 | 1.70 | 10.59 | 0.852 | 1.68 |
| Heart, % | 0.28 | 0.30 | 0.30 | 0.29 | 9.74 | 0.621 | 0.29 |
| Tongue, kg | 3.89 | 3.70 | 3.93 | 3.70 | 7.35 | 0.296 | 3.81 |
| Tongue, % | 0.68 | 0.66 | 0.68 | 0.63 | 7.28 | 0.181 | 0.66 |
| Kidney, kg | 0.68 | 0.91 | 0.92 | 0.85 | 23.58 | 0.183 | 0.85 |
| Kidney, % | 0.12 | 0.16 | 0.16 | 0.14 | 22.18 | 0.124 | 0.14 |
| Lung, kg | 3.41 | 3.45 | 2.92 | 3.08 | 15.22 | 0.147 | 3.21 |
| Lung, % | 0.60 | 0.62 | 0.51 | 0.52 | 14.65 | 0.555 | 0.56 |
| Trachea, kg | 0.82 | 0.72 | 0.96 | 1.09 | 27.06 | 0.053 | 0.90 |
| Trachea, % | 0.14 | 0.13 | 0.17 | 0.18 | 26.29 | 0.084 | 0.15 |
| Liver, kg | 5.52 | 6.01 | 6.05 | 6.17 | 10.67 | 0.258 | 5.93 |
| Liver, % | 0.97 | 1.08 | 1.06 | 1.05 | 11.01 | 0.305 | 1.04 |
| Penis, kg | 0.62 | 0.75 | 0.67 | 0.72 | 15.74 | 0.175 | 0.70 |
| Penis, % | 0.11 | 0.13 | 0.11 | 0.12 | 16.31 | 0.110 | 0.12 |
| Head, kg | 9.60 | 9.45 | 10.42 | 9.71 | 7.32 | 0.080 | 9.80 |
| Head, % | 1.68 | 1.70 | 1.82 | 1.66 | 6.76 | 0.071 | 1.71 |
| Leather, kg | 51.91 | 47.57 | 51.20 | 48.82 | 12.59 | 0.544 | 49.87 |
| Leather, % | 9.09 | 8.55 | 8.97 | 8.37 | 11.91 | 0.534 | 8.75 |
| Tail, kg | 1.55 | 1.43 | 1.60 | 1.43 | 11.41 | 0.190 | 1.50 |
| Tail, % | 0.27 | 0.25 | 0.28 | 0.24 | 10.16 | 0.118 | 0.26 |

[1]Zn-0, no addition of Zn; Zn-2, with 2.000 mg of Zn $kg^{-1}$; Zn-4, with 4.000 mg of Zn $kg^{-1}$ e Zn-6, with 6.000 mg of Zn $kg^{-1}$.

## Conclusion

Nellore steers, finishing on *Brachiaria brizantha* cv. MG-4 and supplemented with increasing zinc contents, presented linear increases in hot carcass weight, without causing an increase in organ and viscera weight.

Increasing levels of zinc in the mineral supplement did not affect carcass yield, weight gain and carcass physical composition of steers finished in pasture.

Supplementation with increasing zinc levels, increases the malonaldehyde (TBARS) concentrations, indicating a higher oxidative action in meats of Nellore steers finished on pasture.

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