Effects of Feeding 60% Dried Corn Distillers Grains Plus Solubles or the Equivalent Sulfur as $CaSO_4$ to Yearling Angus Bulls on Glucose, Urea Nitrogen, and Trace Mineral Concentrations in Serum and Seminal Plasma

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The objectives of this study were to investigate the effects feeding 60% dried corn distillers grains plus solubles (DDGS) or the equivalent sulfur (S) as $CaSO_4$ *on glucose, urea-nitrogen (N), and trace mineral concentrations in serum and seminal plasma. Thirty-six half-sibling Angus bulls were fed in a Calan gate system to target an average daily gain of 1.6 kilograms per day (kg/d) for 112 days. The results from this study indicate that sulfur may not be the only factor within DDGS influencing semen characteristics.*

Summary

Thirty-six half-sibling Angus bulls from the Central Grasslands Research Center near Streeter, N.D., were fed one of three treatments: 1) 60% corn-based concentrate diet (CON; S = 0.18%; n = 12); 2) diet containing 60% DDGS as a replacement for corn (60DDGS; S = 0.55% DM; n = 12); 3) CON diet + equivalent S of the 60DDGS diet added as $CaSO_4$ (SULF; S = 0.54%; n = 12). Bulls were fed indoors in a Calan gate system and targeted to gain 1.6 kg/d for 112 days. Blood and semen samples were collected on days 0, 56 and 112, then evaluated for concentrations of glucose, urea N, and trace mineral concentrations in serum and seminal plasma.

In serum, at days 112 and 56, bulls had greater ($P < 0.01$) concentrations of glucose, compared with day 0. In seminal plasma, glucose concentrations were greater ($P < 0.02$) at day 112 (231.6 milligrams per deciliter [mg/dL]), compared with days 0 (109.2 mg/dL) and 56 (171.5 mg/dL).

At day 0, serum urea-N concentrations were not different ($P > 0.77$) among treatments; however, at days 56 and 112, 60DDGS had greater ($P < 0.01$) concentrations of urea-N, compared with SULF and CON. For seminal plasma urea-N, 60DDGS had a greater ($P < 0.01$) concentration when compared with CON and SULF.

For trace mineral concentrations in serum, treatment × day interactions were observed for cobalt (Co), copper (Cu), zinc (Zn), selenium (Se) and molybdenum (Mo) ($P < 0.03$). At day 0, no differences ($P > 0.3$) were observed for Co, but on day 56, CON was greater ($P < 0.01$) than 60DDGS and SULF, with no divergence observed among treatments at day 112 ($P \geq 0.09$).
For Cu, no differences ($P > 0.15$) were observed at days 0 or 56, but at day 112, DDGS was reduced ($P < 0.01$), compared with SULF and CON. At day 0, Zn was greater ($P < 0.01$) in SULF, compared with CON, whereas 60DDGS was intermediate and at day 112, SULF was reduced ($P = 0.03$), compared with CON.

In serum, at day 0, no differences ($P > 0.09$) were observed for Se; however, at days 56 and 112, Se was greater ($P < 0.01$) in 60DDGS, compared with CON and SULF. For Mo, at day 0, 60DDGS was greater ($P = 0.03$) than CON, whereas SULF was intermediate. At days 56 and 112, CON was greater ($P < 0.01$) than SULF and 60DDGS for Mo.

In seminal plasma, treatment × day interactions were observed for Cu and Mo ($P < 0.02$). For Cu, no differences ($P \geq 0.09$) were observed on days 0 or 56, but on day 112, CON and 60DDGS were

greater ($P < 0.01$), compared with SULF. For Mo, at day 0, 60DDGS was greater ($P = 0.03$), compared with SULF, whereas CON was intermediate, but at days 56 and 112, CON was greater ($P < 0.01$) than DDGS and SULF.

In addition, seminal plasma Se was greater ($P = 0.02$) for DDGS, compared with SULF, whereas CON was intermediate. Feeding 60% DDGS in the diets of young beef bulls altered urea-N and trace mineral concentrations, however, this response may not be due solely to sulfur.

Introduction

Attainment of puberty and semen quality in young bulls can be influenced by nutrition. Research has indicated that bulls on a high plane of nutrition early in life reach puberty at a younger age and have increased testes weight, resulting in greater daily sperm production (Thundathil et al., 2016).

One ingredient that has been increasingly utilized in beef cattle diets to supply the animal with more protein and energy is dried corn distillers grains plus solubles (DDGS). However, DDGS contains an elevated concentration of sulfur, which is in the form of sulfuric acid and S-containing amino acids.

Therefore, when DDGS are fed at greater percentages of the diet, it may be influencing growth and reproductive performance in beef cattle (Drewnoski et al., 2014). This study was conducted to investigate the effects of feeding 60% DDGS or the equivalent sulfur as $CaSO_4$ on glucose, urea-N, and trace mineral concentrations in serum and seminal plasma of yearling Angus bulls.

Procedures

All procedures were approved by the North Dakota State University Institutional Animal Care and Use Committee.

Animals and Diets

Thirty-six half-sibling Angus bulls [256 ± 8 days; mean initial body weight (BW) = 320 ± 2 kg] were assigned to one of three treatments: 1) corn-based diet containing 60% concentrate [CON; S = 0.18% dry matter (DM); n = 12]; 2) diet containing 60% dried corn distillers grains plus solubles (DDGS) as a replacement for corn (60DDGS; S = 0.55% DM; n = 12); 3) CON diet + equivalent sulfur of the 60DDGS diet added as $CaSO_4$ (SULF; S = 0.54% DM; n = 12). All bulls were housed indoors in the Animal Nutrition and Physiology Center in Fargo, N.D. Bulls were fed individually in a Calan gate system, and individual intakes were adjusted to target a 1.6 kg/d average daily gain (ADG) for 112 days.

Blood and Seminal Plasma Collection

Body weights were recorded every 14 days during the 112-day study, with a two-day weight at the beginning and end of the study. Blood samples were collected in tubes containing heparin for plasma before the morning feeding on days 0, 56 and 112 via jugular venipuncture.

Semen was collected on days 0, 28, 56, 84 and 112 via electroejaculation (Pulsator IV; Lane Manufacturing Inc.; Denver, Colo.) into disposable plastic semen collection bags. All blood and semen samples were centrifuged at 1,500 × g for 20 minutes at 4 C (Sorvall ST 16R; Thermo Scientific Inc.; Waltham, Mass.). The supernatant from the plasma blood tubes and semen tubes were pipetted into 2-milliliter (mL) screw cap tubes and stored at minus 20 C.

Laboratory Analyses

Glucose was analyzed on a microplate spectrophotometer using the Infinity glucose kit from Thermo Scientific containing the hexokinase/glucose- 6- phosphate dehydrogenase method (Pittsburgh, Pa.). Serum urea-N was analyzed based on the procedures of Jung et al. (1975). A QuantiChrom Urea Assay Kit (BioAssay Systems; Hayward, Calif.) containing *o*-phthaldialdehyde and primaquine diphosphate was analyzed on the microplate spectrophotometer.

A trace mineral panel was evaluated on all serum and seminal plasma samples. This panel consisted of Co, Cu, manganese (Mn), Mo, Se, iron (Fe) and Zn. All samples were analyzed at the Veterinary Diagnostic Lab at Michigan State University

(Lansing, Mich.). Results were considered significant when *P*-values were ≤ 0.05.

Results

In serum, at days 56 and 112, bulls had greater (*P* < 0.01) concentrations of glucose, compared with day 0. In seminal plasma, glucose concentrations were greater (*P* < 0.02) at day 112, compared with days 0 and 56.

At day 0, serum urea-N concentrations were not different (*P* > 0.77) among treatments; however, at days 56 and 112, 60DDGS had greater (*P* < 0.01) concentrations of urea-N, compared with SULF and CON. For seminal plasma urea-N concentrations, 60DDGS was greater (*P* < 0.01) when compared with CON and SULF.

For trace mineral concentrations in serum, treatment × day interactions were observed for Co, Cu, Zn, Se and Mo (*P* ≤ 0.02; Figure 1A-E). At day 0, no differences (*P* ≥ 0.38) were observed for Co, but at day 56, CON was greater (*P* < 0.01) when compared with 60DDGS and SULF; however, no differences (*P* ≥ 0.09) were observed among treatments for Co at day 112.

For Cu, no differences (*P* ≥ 0.15) were observed at days 0 or 56, but at day 112, DDGS was reduced (*P* < 0.01) when compared with SULF and CON. For Se at day 0, no differences (*P* ≥ 0.09) were observed; however, at days 56 and 112, 60DDGS was greater (*P* ≤ 0.01) when compared with CON and SULF.

For Mo at day 0, 60DDGS was greater (*P* = 0.03) than CON, whereas SULF was intermediate. At days 56 and 112, CON was greater (*P* < 0.01) than SULF and 60DDGS for Mo.

For seminal plasma trace mineral concentrations, treatment × day interactions were observed for Cu and Mo (*P* = 0.02, 0.01, respectively; Figures 2A-B). For Cu, no differences (*P* ≥ 0.09) were observed at days 0 or 56, but at day 112, CON and DDGS were greater (*P* < 0.01), compared with SULF.

For Mo at day 0, 60DDGS was greater (*P* = 0.03), compared with SULF, whereas CON was intermediate. At days 56 and 112, CON was greater (*P* < 0.01), compared with 60DDGS and SULF for Mo. Furthermore, a treatment effect was observed for Se in which 60DDGS was greater (*P* = 0.02), compared with SULF, whereas CON was intermediate (Figure 3).

Discussion

Increased urea-N concentrations for 60DDGS may have been observed because of the percentage of crude protein (CP) in the diet. The 60DDGS diet had 22% CP, whereas the CON and SULF treatments had 13% CP. The nitrogen from this protein will be converted to microbial protein in the rumen, then absorbed as amino acids by the small intestine, excreted or transported to the liver, where other amino acids will be synthesized.

Many interactions among trace minerals have been reported, but the relationship among Cu, Mo and S may explain some of the differences observed. In brief, Mo and S can influence the absorption of Cu, which can affect the synthesis of enzymes and hormones, and influence the regulation of cell replication (Baker et al., 2006).

Diets containing greater concentrations of sulfur can cause Cu and Mo concentrations to decrease in serum through the production of thiomolybdates (Suttle, 1974). In this study, we observed that the diets containing greater amounts of sulfur had reduced Mo; however, for Cu, a different trend was observed.

The different sources of sulfur may be an explanation for the conflicting responses observed for Cu and Mo. Calcium sulfate from the SULF treatment may have been more readily converted to ruminal hydrogen sulfide (H_2S), which is less likely to enter circulation and affect Cu concentrations in serum.

Selenium is another trace mineral that can be influenced by increasing concentrations of dietary sulfur because both elements have similar chemical and physical properties (Ivancic and Weiss, 2001).

Additionally, Se is a major component of glutathione peroxidase, which aids in the protection of sperm from oxidative damage (Baker, 2006).

In this study, Se concentrations in seminal plasma paralleled well with seminal plasma glutathione peroxidase concentrations that were reported previously. However, additional research is necessary to evaluate the DNA and RNA structure and integrity of these bulls to further elucidate how DDGS influenced these populations of sperm.

In summary, concentrations of glucose increased in serum and seminal plasma as bulls were maturing, demonstrating that components of seminal plasma change as bulls approach puberty. Additionally, differences in trace mineral concentrations in serum and seminal plasma may have been observed in response to the increase of dietary sulfur, and therefore, the necessary enzymes were synthesized to maintain proper sperm function. Furthermore, factors other than sulfur may be influencing semen characteristics when DDGS are fed to beef bulls.

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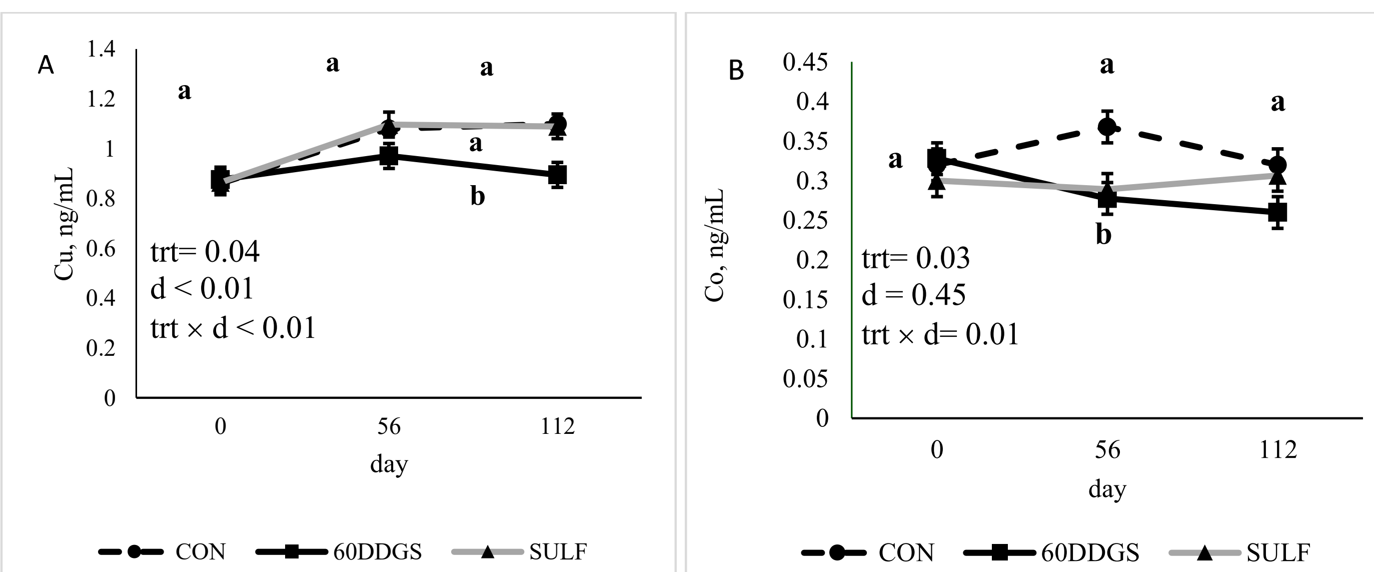

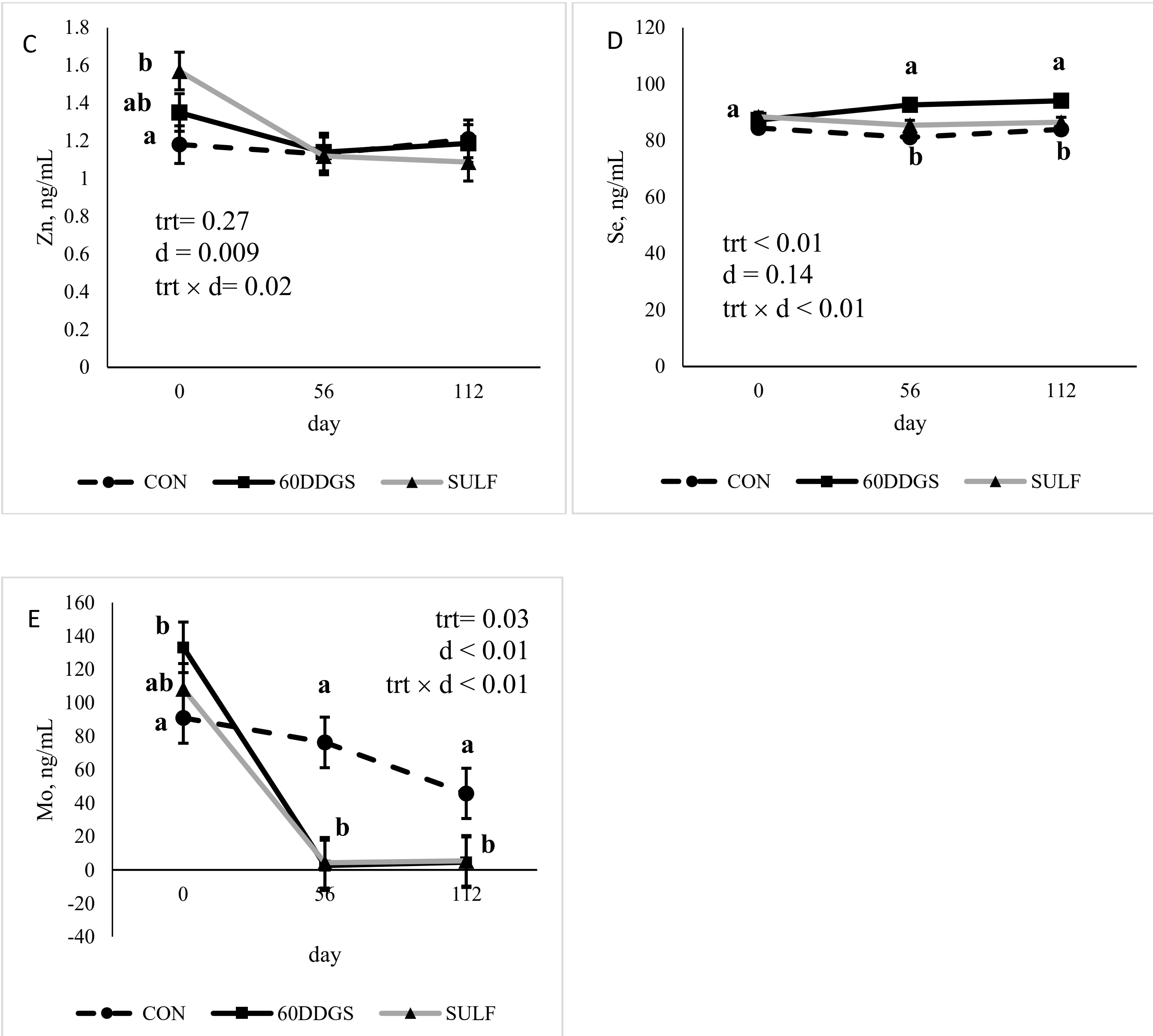

Figure 1. Treatment × day interactions for trace mineral concentrations in serum.
Dietary treatments were: 1) corn-based diet containing 60% concentrate (CON; n = 12); 2) diet containing 60% DDGS as a replacement for corn (60DDGS; n = 12); 3) equivalent sulfur of 60DDGS added to the CON diet as calcium sulfate (SULF; n = 12) and were fed to bulls from 291 ± 8.5 days of age (9 months) to day 112, when they were 403 ± 8.5 days of age (13 months). [ab] Differences indicated when the *P*– values were ≤ 0.05.

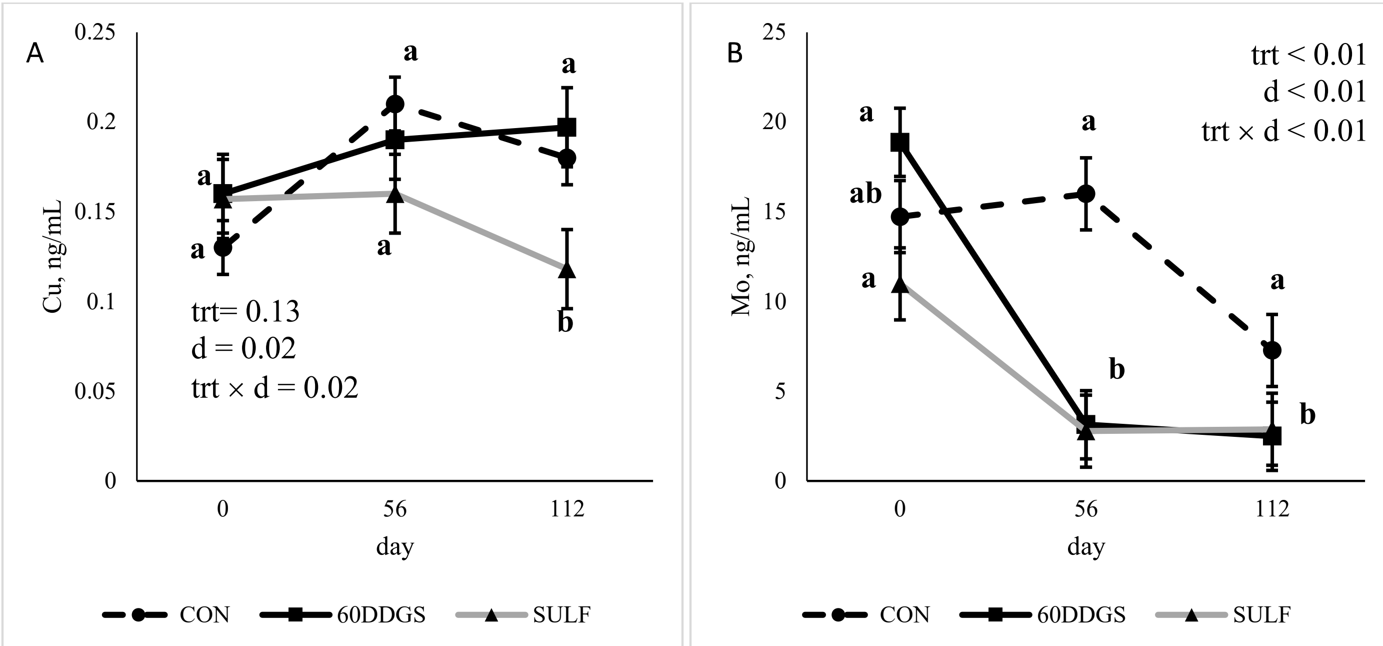

Figure 2. Treatment × day interactions for trace minerals in seminal plasma.
Dietary treatments were: 1) corn-based diet containing 60% concentrate (CON; n = 12); 2) diet containing 60% DDGS as a replacement for corn (60DDGS; n = 12); 3) equivalent sulfur of 60DDGS added to the CON diet as calcium sulfate (SULF; n = 12) and were fed to bulls from 291 ± 8.5 days of age (9 months) to day 112, when they were 403 ± 8.5 days of age (13 months). [ab] Differences indicated when the *P*– values were ≤ 0.05.

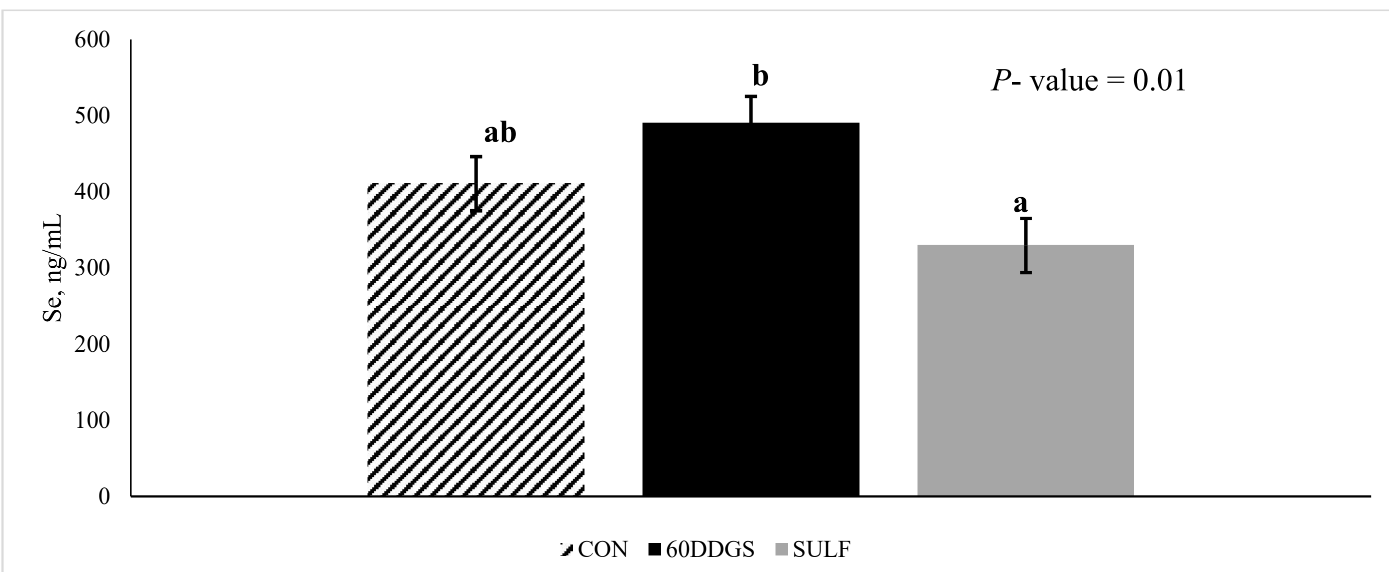

Figure 3. Effects of treatment for Se concentrations in seminal plasma.
Dietary treatments were: 1) corn-based diet containing 60% concentrate (CON; n = 12); 2) diet containing 60% DDGS as a replacement for corn (60DDGS; n = 12); 3) equivalent sulfur of 60DDGS added to the CON diet as calcium sulfate (SULF; n = 12) and were fed to bulls from 291 ± 8.5 days of age (9 months) to day 112, when they were 403 ± 8.5 days of age (13 months). [ab] Differences indicated when the *P*– values were ≤ 0.05.