Efficacy of feeding selenium-enriched yeast to finishing beef cattle

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ABSTRACT

An experiment was conducted to evaluate supplementation with Se yeast of a finishing diet containing adequate Se from feedstuffs. Forty calves (307 ± 3.2 kg) were blocked by sex and randomly allotted to 8 pens. After completing acclimation to the diet, pens were randomly assigned within sex to the basal finishing diet (CON) or the basal finishing diet plus 0.34 mg of supplemental Se per kilogram of dietary DM from Se yeast (SUP) for a 130-d finishing period. Body weight and blood samples were obtained at 28-d intervals and before shipping. At slaughter, hot carcass weights were recorded and liver samples collected. After a 48-h chill, standard carcass data and LM samples were obtained. No differences (P > 0.10) in BW, ADG, DMI, feed efficiency, or any carcass measures were detected. Serum Se had a treatment-by-time interaction (P < 0.01) where initial serum Se concentrations were similar, but subsequently SUP calves had greater (P < 0.01) serum Se concentrations than did CON calves. Muscle and liver Se concentrations were lower (P < 0.01) for CON than for SUP calves. There was a treatment-by-sex interaction (P < 0.01), with heifers on SUP having higher liver Se concentrations than those of SUP steers. Results of this experiment indicate that supplementing 0.34 mg/kg Se (DM) from Se yeast to a basal feedlot diet with adequate Se does not increase performance but does result in increased tissue Se concentrations that do not exceed a range determined as normal.

Key words: beef, carcass, cattle, ruminant, selenium

INTRODUCTION

Selenium is an essential nutrient for humans and livestock. Beef cattle have a general requirement of 0.1 mg/kg Se in their diet (NRC, 2000). Many regions of the United States have soils that are low in Se. Because forage and feedstuffs Se concentrations vary with soil Se concentrations, the Se status of beef cattle herds is highly variable (Dargatz and Ross, 1996). Since 1974, sodium selenite and selenate have been approved for use as livestock supplements. Despite different absorption mechanisms (Wolffram et al., 1986), the 2 forms appear to have similar relative biopotencies in rats (Mason and Weaver, 1986) and ruminants (Podoll et al., 1992). In sheep, Lopez et al. (1969) reported that supplementing sodium selenite results in most of the Se being excreted in the feces. This is of concern when supplementing beef cattle diets, because Se supplementation has been restricted to supplying a maximum of 0.3 mg/kg of Se as sodium selenite or selenate by the US Food and Drug Administration, Department of Health and Human Services (1994).

With supplement limitations, it is desirable to have more available sources (Pehrson et al., 1999; Finley, 2000; Gunter et al., 2003) of Se such as Se yeast to use in beef cattle diets. However, with increased availability of Se sources, it is unknown if tissue Se concentrations will remain in the range considered normal by the US Food and Drug Administration (NARA, 2007) at currently allowable supplement levels. Therefore, the objective of this experiment was to determine the effect of feeding a basal diet containing adequate Se from feedstuffs with or without 0.34 mg/kg (DM; 0.30 mg/kg as-fed) Se from Se yeast to finishing calves on corresponding calf performance and serum Se concentrations and to determine whether edible animal products exceed normal Se concentrations.
MATERIALS AND METHODS

Animals

Animal care and sampling procedures were approved by the University of Tennessee Animal Care and Use Committee. Thirty-five heifers and 32 steers were purchased through local markets, vaccinated for infectious bovine rhinotracheitis, bovine viral diarrhea virus, bovine respiratory parainfluenza-3, and bovine respiratory syncytial virus with Triangle 4 plus type II bovine viral diarrhea virus (Fort Dodge, Overland Park, KS) and with Clostridial 7-Way plus Sommunune (AgriLabs, St. Joseph, MO). Calves were then delivered to The University of Tennessee Agricultural Experiment Station in Knoxville, Tennessee. Upon arrival, calves were ear-tagged and tattooed in both ears, treated for internal and external parasites (Eprinex, Merial, Duluth, GA), and treated with Nuflor (Schering-Plough Animal Health, Union, NJ). Calves were maintained on a cool-season pasture and, following a minimum interval of 28 d, all calves were weighed and heifers verified open by ultrasonography. Twenty steers and 20 heifers (307 ± 3.2 kg) were selected within sex to provide the smallest range in BW, blocked by sex, and randomly allotted to 1 of 4 groups of 5 calves within a block. This provided 4 replicates per treatment (2 replicates per sex). Groups were randomly assigned to pens. Pens were in a partially covered barn with a concrete floor and free-choice access to automatic water fountains. After calves were assigned to pens, they were fed a common diet that, on a DM basis, initially consisted of 36.9% cracked corn, 45.0% alfalfa pellets, 10.0% corn gluten feed pellets, 5.0% molasses, 0.3% salt, 1.8% fish meal, and 1.0% vitamin-mineral premix (CO-OP All Purpose Cattle Mineral, Tennessee Farmers Co-op, La Vergne, TN). The vitamin-mineral supplement provided 0.20 mg/kg supplemental Se from sodium selenite in the acclimation diets. Grain acclimation was accomplished over a 20-d period by decreasing the levels of alfalfa pellets from 45% to 35%, 25%, and 15%, with the difference being made up by cracked corn. Fish meal was included in the acclimation diets to allow calves to become accustomed to its consumption. High Se concentrations in fish meal allowed it to be an alternate feedstuff to be included in the final diet to increase the basal diet Se concentration to the desired concentration if other feed ingredients varied between lots. Fish meal would have replaced a portion of corn and urea but was not needed. After the acclimation period, pens of calves were randomly assigned, within sex, to 1 of 2 finishing diet treatments. Finishing diet treatments consisted of a control basal diet (CON; Table 1) balanced to contain 0.20 mg/kg Se (DM) without supplemental Se and the basal diet plus 0.34 mg/kg Se (DM) from Se yeast [SUP; Sel-Plex (1,000 mg/kg), Alltech, Nicholasville, KY].

Experimental Finishing Period

The finishing period of this experiment was conducted as a double-blinded experiment in which only the principal investigator knew the composition of the Se premixes. Feeding personnel only knew the color code of Se premix to be included in each diet. Similarly, sample codes for laboratory analyses were labeled with an additional coding system so personnel conducting the Se assays did not know which samples corresponded to which dietary treatment code. Treatment-initiation BW were the average of BW recorded on 2 consecutive mornings before feeding. Feeding of experimental diets was initiated after the second morning weighing was completed. Final weights were the average of weights taken the final 2 mornings before feeding.

Diets

Calves were fed their respective diets free choice, with daily replenishment. Prior to daily feeding, any feed present from the previous day’s feeding was removed from the feed bunk, weighed, recorded, a subsample

<table>
<thead>
<tr>
<th>Table 1. Composition of finishing diets (% of dietary ingredients, DM basis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingredient</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Cracked corn</td>
</tr>
<tr>
<td>Alfalfa pellets</td>
</tr>
<tr>
<td>Corn gluten feed pellets</td>
</tr>
<tr>
<td>Molasses</td>
</tr>
<tr>
<td>Urea</td>
</tr>
<tr>
<td>Vitamin and mineral supplement</td>
</tr>
<tr>
<td>Fine-ground corn</td>
</tr>
<tr>
<td>Treatment premix¹</td>
</tr>
<tr>
<td>Vitamin and mineral supplement²</td>
</tr>
<tr>
<td>Limestone</td>
</tr>
<tr>
<td>Salt</td>
</tr>
<tr>
<td>Mineral supplement²</td>
</tr>
<tr>
<td>Vitamin supplement³</td>
</tr>
</tbody>
</table>

¹Premix: 80.75% fine-ground corn, 19.25% Sel-Plex (DM; Alltech, Nicholasville, KY). Supplements provided 0 or 0.34 mg/kg Se (DM) to yield a total dietary concentration of 0.20 or 0.54 mg/kg Se (DM).
²Supplement: 45.76% corn, 4.00% molasses, 17.70% magnesium oxide, 16.55% zinc sulfate, 9.00% iron oxide, 2.60% manganous oxide, 3.95% copper sulfate, and 0.44% potassium iodide (DM basis).
³Co-op Vitamin ADE Micro Mix (Tennessee Farmers Co-op, La Vergne, TN): vitamin A, 11,000 IU/kg; vitamin D, 880 IU/kg; and vitamin E, 5.5 IU/kg.
retained, and the remainder discarded. To verify Se concentrations of the finishing diets, a 0.45-kg sample was collected from each batch of complete finishing diet. These samples were composited into weekly samples, and a 0.91-kg subsample of each diet was retained for Se analysis. In addition, a 0.45-kg sample of all major feed ingredients was collected upon delivery to the animal facility, and Se concentration was determined to verify a consistent concentration in the basal diet.

The SUP treatment premix consisted of ground corn with 200 mg/kg Se from Se yeast, whereas the CON treatment only included fine-ground corn. The SUP premix was prepared in a tumble drum mixer. The mixing procedure was validated by taking 10 samples from random spots within the mixer at 3 different mixing times. These samples were analyzed for Se concentration by the procedures below. The CV of the time point used for mixing treatment premixes was 6.3%. Two batches of treatment premix were manufactured. Samples from those batches were analyzed for Se concentration before feeding to ensure proper inclusion level. Fine-ground corn or SUP treatment premix was blended in the treatment diets to provide 0 or 0.34 mg/kg Se (DM) to yield a total dietary concentration of 0.20 or 0.54 mg/kg Se (DM). Both finishing diets used a common vitamin and mineral supplement that did not contain supplemental Se. Final feeds were manufactured daily by mixing the major feed ingredients, vitamin and mineral supplement, and fine-ground corn or treatment premix in a horizontal paddle mixer (Marion Mixers Inc., Marion, IA) and then slowly adding liquid molasses. The mixing procedure was verified by taking 10 samples as the complete SUP diet exited the mixer to ensure consistent distribution of SUP treatment premix in the diet. The CV for Se in the complete SUP diet was 2.5%.

**Serum Collection**

Blood was collected from all calves on d 1, 28, 56, 84, 112, and 129. Whole blood (10 mL) was obtained via jugular venipuncture and collected into red top Vacutainers (Becton Dickinson and Co., Franklin Lakes, NJ). Samples were immediately placed on ice, taken to the Animal Science Laboratory the same morning, allowed to coagulate, and centrifuged for 20 min (2,600 × g) at room temperature. Serum was harvested and frozen (−4°C) for subsequent Se analysis.

**Slaughter Measurements**

On d 130, animals were loaded for overnight transport to a commercial slaughter facility. Animals were slaughtered on d 131. At slaughter, carcasses were identified, hot carcass weights recorded, and liver samples collected from each liver lobe (approximately 100 g from each lobe for a total of 300 g). Samples were placed in labeled plastic bags and packed in dry ice for transport to the laboratory, where they were stored frozen (−4°C) until analysis. After a 48-h chill, standard USDA quality grade data were recorded as determined by a USDA meat grader. Adjusted fat thickness was determined by measuring fat depth 3/4 the distance around the LM at the 12th rib. This fat measurement was then subjectively adjusted according to USDA guidelines to reflect the overall carcass fatness. Longissimus muscle area was measured using a standard USDA grid. Each 12th-rib LM area was measured twice and the average recorded. The percentage of KPH was determined to the nearest 0.5%. After completing the carcass evaluations, LM samples (500 g) were collected at the 12th rib, placed in plastic bags, identified, and packed in dry ice for transport to the laboratory, where they were stored frozen (−4°C) until analysis.

**Selenium Determination**

Upon retrieval from the freezer and thawing, a scalpel was used to remove similar slices (by weight) from each of the 3 liver lobe sections of each animal to be combined for a single analytical observation. This procedure was repeated twice to produce triplicate samples. Each LM sample was divided into 4 approximately equal quadrants, and a core sample was obtained from each quadrant using a #10 cork borer (150 mm in diameter) so that a sample from each quadrant was represented in each sample for Se analysis. This procedure was repeated twice to produce triplicate samples. Sample size from this process was approximately 6 g. This was larger than could be digested in available test tubes, so LM samples were predigested and subsampled for Se determination. Feed samples were ground to pass a 1-mm screen in a Wiley Mill (Arthur H. Thomas Company, Philadelphia, PA) before analysis. Selenium concentration of feed, serum, meat, and liver samples was determined using methodology based on the fluorometric procedure by Koh and Benson (1983) as published by the AOAC (1990). Samples were analyzed for Se in triplicate, and a CV was determined. If triplicates of a sample had a CV higher than 10%, samples were rerun. In addition, a standard from the National Institute of Standards and Technology (#1577b bovine liver; Gaithersburg, MD) of known Se concentration was assayed with each run of samples. If the bovine liver standard for a run was not within 10% of the certified value, the run was reanalyzed. All feed and tissue Se concentrations in this experiment are reported on a DM basis. Serum Se concentrations are reported on an as-is basis.

**Statistical Analysis**

Feed consumption, growth performance, and tissue Se concentrations were analyzed as a randomized complete block design using the MIXED procedure of SAS (SAS Inst. Inc.,
Cary, NC). The model included sex, dietary treatment, and the interaction. Pen was the experimental unit. Differences in means were separated using the LSD procedure of SAS. Serum Se concentrations, collected at fixed times throughout the experiment, were analyzed using the repeated measure methodology of SAS. For all response variables measured, results were considered significant at $P < 0.01$.

### RESULTS AND DISCUSSION

#### Diet Selenium

Feedstuffs were purchased from a local feed distributor as mill run ingredients without prior screening for Se concentration. Five lots of alfalfa pellets had an average Se concentration of 0.68 mg/kg and ranged from 0.50 to 1.00 mg/kg. Twelve lots of corn were all below the average NRC (2000) published value of 0.14 mg/kg (SD = 0.12 mg/kg) and averaged 0.09 mg/kg Se, with values ranging from 0.06 to 0.13 mg/kg Se. Four lots of dry corn gluten feed pellets had an average Se concentration of 0.41 mg/kg, ranging from 0.39 to 0.43 mg/kg Se. One lot of fish meal contained 3.03 mg/kg Se. Grain acclimation diets were all supplemented with 0.20 mg/kg Se from a commercial vitamin-mineral premix (CO-OP All Purpose Cattle Mineral) and received an additional 0.06 mg/kg from fish meal; however, the dietary Se concentrations varied due to changing alfalfa-pellet-to-corn ratios. Analysis of feedstuffs used in the finishing treatment occurred after delivery to our research facility and before incorporation into treatment diets. The CON and SUP weekly dietary Se analysis averaged 0.20 mg/kg Se with a SD of 0.08 mg/kg and 0.56 mg/kg Se with a SD of 0.06 mg/kg, respectively.

Lack of change in ADG, DMI, or G:F in this experiment was expected due to both diets exceeding the Se requirements of the calves. The general recommendation for beef cattle dietary Se is 0.1 mg/kg of diet (NRC, 2000), and the computer model, adjusted for the conditions of this experiment, predicts a Se requirement of 1.48 mg/d. The average daily consumption of Se throughout the experiment was 2.85 times greater for the SUP treatment, with CON animals consuming an average of 1.71 mg/d and SUP animals consuming an average of 4.88 mg/d of Se. No calves from either treatment showed signs of or were treated for illness while consuming experimental diets, suggesting that the addition of 0.34 mg/kg Se from Se yeast did not result in any observed negative health effects over the 130-d feeding period.

These results are in agreement with research in which feeding organic forms of Se over a wide range of concentrations above the NRC requirement was not detrimental. Hintze et al. (2002) fed steers a 55% concentrate diet containing 0.62 or 11.90 mg/kg (1.55 or 27.6 mg/d) Se from feedstuffs and reported no difference in performance.

#### Performance and Carcass Measures

Body weights at the initiation of finishing diet treatments were not different and averaged 360.4 ± 3.6 kg (Table 2). Treatment had no effect on final BW. There was a tendency ($P = 0.02$) for a sex effect, with heifers being lighter than their counterpart steers at the 3 weigh points. There was no treatment-by-sex interaction for any of the BW measurements. Treatment, sex, and their interaction had no effect on ADG, DMI, or G:F.

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### Table 2. Effect of Se yeast supplementation on finishing calf performance, carcass characteristics, and tissue DM

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>Supplement</th>
<th>SEM</th>
<th>Sex</th>
<th>Treatment</th>
<th>Treatment × sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW, kg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allotment</td>
<td>304.0</td>
<td>309.9</td>
<td>3.2</td>
<td>0.02</td>
<td>0.26</td>
<td>0.97</td>
</tr>
<tr>
<td>Treatment initiation</td>
<td>358.5</td>
<td>362.2</td>
<td>3.6</td>
<td>0.02</td>
<td>0.51</td>
<td>0.95</td>
</tr>
<tr>
<td>Final</td>
<td>524.9</td>
<td>523.0</td>
<td>8.2</td>
<td>0.02</td>
<td>0.88</td>
<td>0.81</td>
</tr>
<tr>
<td>ADG, kg</td>
<td>1.29</td>
<td>1.24</td>
<td>0.07</td>
<td>0.12</td>
<td>0.63</td>
<td>0.75</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>8.59</td>
<td>8.68</td>
<td>0.30</td>
<td>0.16</td>
<td>0.83</td>
<td>0.94</td>
</tr>
<tr>
<td>G:F</td>
<td>0.150</td>
<td>0.142</td>
<td>0.010</td>
<td>0.14</td>
<td>0.25</td>
<td>0.46</td>
</tr>
<tr>
<td>Hot carcass weight, kg</td>
<td>322.8</td>
<td>318.8</td>
<td>7.0</td>
<td>0.13</td>
<td>0.71</td>
<td>0.92</td>
</tr>
<tr>
<td>Fat thickness, cm</td>
<td>1.46</td>
<td>1.33</td>
<td>0.06</td>
<td>0.02</td>
<td>0.18</td>
<td>0.03</td>
</tr>
<tr>
<td>KPH, %</td>
<td>2.68</td>
<td>2.65</td>
<td>0.06</td>
<td>0.05</td>
<td>0.78</td>
<td>0.10</td>
</tr>
<tr>
<td>LM, cm²</td>
<td>85.0</td>
<td>81.5</td>
<td>3.6</td>
<td>0.56</td>
<td>0.53</td>
<td>0.51</td>
</tr>
<tr>
<td>QG¹</td>
<td>19.9</td>
<td>20.1</td>
<td>0.3</td>
<td>0.28</td>
<td>0.60</td>
<td>0.28</td>
</tr>
<tr>
<td>LM DM, % as-is</td>
<td>731.07</td>
<td>30.93</td>
<td>0.50</td>
<td>0.66</td>
<td>0.85</td>
<td>0.32</td>
</tr>
<tr>
<td>Liver DM, % as-is</td>
<td>28.75</td>
<td>28.76</td>
<td>0.25</td>
<td>0.18</td>
<td>0.98</td>
<td>0.43</td>
</tr>
</tbody>
</table>

¹QG:19 = Choice−, 20 = Choice0, and 21 = Choice+.
diets, inclusion of high-Se hay, high-Se wheat, or sodium selenite to increase a basal diet from 0.38 to an average of 2.83 mg/kg for 126 d did not result in changes in performance (Lawler et al., 2004). Clyburn et al. (2000) compared sources of inorganic and organic Se supplementation at 0.30 mg/kg to a control feedlot diet and found no difference in ADG, DMI, or G:F over a 103-d finishing period. Results from supplementation with inorganic Se in deficient diets have been variable. When growing heifers deemed to be receiving a Se-deficient diet (Maas, 1998) were dosed with boluses releasing 3 mg Se from sodium selenite each day, no performance differences were detected. In contrast, Nunn et al. (1996) determined that additional Se from Se boluses increased feed efficiency of steers offered a diet of Se-deficient hay.

No treatment, sex, or treatment-by-sex-interaction differences were detected in hot carcass weight, 12th-rib fat, percent KPH, ribeye area, or USDA quality grade. The lack of changes in carcass measures is in agreement with the lack of differences in performance. These results are consistent with other reports comparing a Se-adequate basal diet to the basal diet with inclusion of Se yeast (Clyburn et al., 2000) or high-Se feedstuffs (Lawler et al., 2004).

### Serum Selenium

Concentrations of serum Se were affected by treatment, time, and a treatment-by-time interaction (Figure 1). Serum Se was not affected by sex, a sex-by-time interaction, or a treatment-by-time-by-sex interaction. On d 1, there was no difference in serum Se concentration between the treatments. There was a difference between CON and SUP at all subsequent measurements. Within CON, serum Se dropped from d 1 to 56 (0.091 to 0.078 μg/mL) and then reached a plateau on d 56 (0.080 μg/mL) with no time point mean differing from the previous time point mean for the remainder of the experiment. This drop is associated with changes in dietary concentrations. Grain acclimation diets contained 0.20 mg/kg supplemental Se from sodium selenite and 0.06 mg/kg Se from fish meal in addition to varying concentrations from remaining feedstuffs, whereas the CON treatment had a total concentration of 0.20 mg/kg Se. In SUP, serum Se increased between d 1 and 28 and then reached a plateau from d 28 to 130 at an average concentration of 0.111 μg/mL. Although this was 1.39 times the concentration in CON, the design of this experiment did not allow differentiation between effects caused by increasing dietary Se concentrations in general or specific effects from Se yeast.

Changes in serum Se concentrations in this experiment are similar to results reported from experiments with animals having a wide range of initial concentrations and subsequently subjected to various dietary Se concentrations. Hintze et al. (2002) conducted an experiment with growing beef cattle diets to determine if cattle from areas with naturally high Se feedstuffs could be viable sources of Se for human diets. They obtained steer calves from areas with moderate and high Se soil concentrations and fed diets containing 0.62 or 11.90 mg/kg Se. Steers from the high-Se area had an initial plasma Se concentration of 0.56 μg/mL, and steers from the moderate area had concentrations of 0.12 μg/mL. The plasma concentrations from the moderate area are comparable to serum concentrations from calves at initiation of the present experiment, but concentrations from the high-Se areas are greater than any concentrations measured in the current experiment. Neither steers from the high-Se area fed the 11.90-mg/kg diet nor steers from the moderate area fed the 0.62-mg/kg diet showed a change in plasma Se concentrations. Steers from the moderate area fed the 11.90-mg/kg diet increased plasma Se concentrations within 2 mo to concentrations similar to steers previously exposed to high Se. Steers previously exposed to high Se concentrations and fed the 0.62-mg/kg diet had plasma Se concentrations drop to concentrations that, at the end of the 105-d feeding period, were not different from calves originating from the moderate area and receiving the same diet. The lowest concentration of Se fed by Hintze et al. (2002) was slightly higher than the concentrations of our SUP treatment and higher than our CON treatment. Calves fed the 0.62-mg/kg diet in the experiment of Hintze et al. (2002) had similar plasma Se concentrations to serum concentrations in our SUP calves (0.13 μg/mL vs. 0.11 μg/mL, respectively). Both values are in a range described as normal (~0.10 μg/mL; Maas, 1998). Awadeh

![Figure 1. Effect of Se yeast supplementation on serum selenium concentration. Treatment, P < 0.01; treatment × time, P < 0.01; SEM = 0.001.]
et al. (1998) found similar results when growing calves were fed diets containing 0.41 mg/kg or 0.73 mg/kg Se, and serum Se concentrations were 0.12 μg/mL versus 0.29 μg/mL, respectively.

**Longissimus Dorsi Selenium**

Average LM Se concentration was 0.40 mg/kg higher for SUP than for CON (Figure 2) and was not affected by sex or a treatment-by-sex interaction. The Se concentration of the LM, as collected in this experiment, has been determined to be representative of several of the edible muscle tissues including cuts from the round, sirloin, shoulder cod, and LM (Hintze et al., 2002). Percent DM of the meat samples was not different and averaged 31.00%. All meat values below are presented on a DM basis. The DM concentration from this experiment has been used to adjust other as-is meat data to a DM basis when corresponding DM values were not reported.

Although there was a 1.9-fold increase in the muscle Se concentration in the SUP compared with the CON treatment, both values are still lower than values obtained from calves in moderate- or high-Se areas of the United States and those fed diets consisting of feedstuffs raised in high-Se regions. They were also lower than those in sheep fed a corn-based diet with the addition of 0.30 mg/kg inorganic Se (Podoll et al., 1992). In the experiment by Hintze et al. (2002), steers purchased from high-Se regions had muscle biopsy Se concentrations of 6.76 mg/kg, whereas calves from moderate regions averaged 1.39 mg/kg. When these calves were fed diets containing 11.90 or 0.62 mg/kg Se, steers from the high-Se region fed the 11.90-mg/kg diet had LM Se concentrations of 6.65 mg/kg, and those from the moderate-Se area fed the 0.62-mg/kg diet contained 1.13 mg/kg. In the experiment of Lawler et al. (2004), calves fed the control diet or a diet supplemented with sodium selenite had similar muscle Se concentrations (1.33 and 1.55 mg/kg, respectively), but those fed high-Se wheat or high-Se hay (intermediate) had 4.41 and 3.32 mg/kg, respectively. While analyzing ground beef from animals raised in various regions of the United States, Finley et al. (1996) found that Se concentrations varied from 1.08 mg/kg in ground beef purchased in North Dakota to 0.19 mg/kg for samples from cattle raised in southwestern Missouri. In a subsequent evaluation (Finley, 2000), meat samples collected from cull cows from different regions of North Dakota had Se concentrations ranging from 0.90 to 2.16 mg/kg Se. These data show that there is currently great variability in the Se concentration of beef reaching the retail market.

**Liver Selenium**

Liver Se concentrations were affected by treatment, sex, and a
treatment-by-sex interaction (Figure 3). Average SUP liver Se concentrations were 2.0-fold higher than those of the CON treatment. The percent DM of the liver samples was not different and averaged 28.76%. All liver values below are presented on a DM basis. The DM concentration from this experiment has been used to adjust other as-is liver data to a DM basis when corresponding DM values were not reported. Liver concentrations of Se are generally related to dietary Se concentration but not as highly correlated as in other tissues (Hintze et al., 2001). Podoll et al. (1992) reported that sheep fed a high-corn diet with 0.3 mg/kg Se from selenate or selenite had similar liver concentrations (6.22 and 7.30 mg/kg, respectively). Steers in the experiment of Hintze et al. (2002) had liver Se concentrations ranging from 3.09 to 20.65 mg/kg. In the experiment of Lawler et al. (2004), liver Se concentrations followed the same pattern as the meat samples, with the liver Se concentrations of steers fed the control diet having the lowest (2.33 mg/kg) concentrations, the high-selenium-wheat calves had the highest (10.79 mg/kg) concentrations, and high-selenium-hay feeding was intermediate (6.56 mg/kg, DM). These experiments consisted of diets meeting the 0.3-mg/kg supplemental Se restriction but resulted in liver concentrations greater than the range of 0.35 to 4.17 mg/kg (0.10 to 1.20 mg/kg, as-is) determined as normal by the US Food and Drug Administration (NARA, 2007) or those observed in this experiment.

Heifers within each treatment had higher liver Se concentrations than did steers (P < 0.01). Whereas differences between sexes on the CON diet were small, livers of heifers on SUP treatments contained 0.68 mg/kg more Se than did those of steers on SUP treatments. Serum Se concentrations were not different at the initiation of the experiment, but they are noted to be more representative of Se status over a shorter period than are liver tissues (Podoll et al., 1992). Differences in responses of liver tissues to supplementation may be due to an adaptation to prolonged high dietary Se concentrations. Calves for this experiment were purchased through local market channels and most likely represent many sources and varied backgrounds. Despite 56 d of common pasture grazing and adaptation diets, liver differences that occurred could be a carryover effect from prior management. Hintze et al. (2002) determined that steers from a moderate-Se background and fed a high-Se diet had higher liver Se concentrations than those of steers from a high-Se background and fed high-Se diets. They proposed that this resulted from differences in the upregulation of Se methylation by S-adenosylmethionine, which is necessary for Se excretion. Differences in Se requirements or toxicity based on sex have been suggested in rats (Burk, 1983) and chicks (Pilch et al., 1980). Blood distribution of Se in humans has also been shown to differ by sex (Oster and Prellwitz, 1988). Similarly, Finley and Kincaid (1991) reported male rats had greater plasma Se but not erythrocyte Se. Finley and Kincaid (1991) also determined that liver cytosol glutathione peroxidase activity and Se concentrations were approximately 2-fold greater in female than in male rats. Liver glutathione peroxidase activity could explain the discrepancy in tissue responses between muscle and liver. In rat liver, 83% of Se is associated with glutathione peroxidase compared with relatively low concentrations of that form in muscle (Behne and Wolters, 1983).

**IMPLICATIONS**

Results of this experiment indicate that supplementing at a maximum limit of 0.3 mg/kg Se from Se yeast in a feedlot diet adequate in Se does not affect animal performance but does increase serum, LM, and hepatic Se concentrations. However, the range of normal liver concentrations provided by the US Food and Drug Administration is 0.10 to 1.20 mg/kg (as-is) of Se (NARA, 2007). Selenium in meat is noted to be one-third to one-fourth the concentrations in the liver. This results in normal meat Se concentrations ranging from 0.03 to 0.40 mg/kg (as-is). Calves fed Se yeast at 0.3 mg/kg had average liver and meat Se concentrations within these normal ranges. Therefore, Se residues in edible tissue from feedlot beef cattle supplemented with 0.3 mg/kg Se from Se yeast do not exceed allowable concentrations or other published concentrations.

**LITERATURE CITED**


