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Effect of dietary selenium on boar sperm quality

K.W. Lovercamp*, K.R. Stewart, X. Lin, W.L. Flowers

Department of Animal Science, North Carolina State University, Raleigh, NC 27695-7621, USA

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ABSTRACT

The primary objective of this research was to evaluate the effect of long-term dietary selenium supplementation of commercial swine diets on semen production and sperm quality. The dietary treatments were a non-supplemented basal diet or the basal diet supplemented with 0.3 ppm selenium in either an organic or inorganic form. A secondary objective was to determine if there were any beneficial effects of dietary selenium supplementation on changes in sperm quality during storage of semen post collection. Boars were fed dietary treatments from weaning at 20.97 ± 0.18 d of age until the study was terminated when they were 382.97 ± 0.18 d of age. Boars (n = 6 per treatment) were maintained on a 1 time per week collection frequency for 5 months. Immediately after this, boars were collected six times over a 4 day period. Ejaculates were extended in a commercially available, 5-day semen extender and evaluated on day 1 and 6 of storage post-collection. Boars fed the organic selenium had higher ($P < 0.01$) plasma levels of selenium compared to control boars and similar levels to those supplemented with the inorganic form ($P = 0.18$). Dietary treatment did not affect ($P > 0.2$) volume, concentration, total sperm in the ejaculate, sperm motility, progressive motility, morphology, lipid peroxidation, or glutathione peroxidase activity. These results indicate that supplementing a basal diet with organic or inorganic selenium did not affect semen quantity or sperm quality in fresh ejaculates nor did it appear to have any beneficial latent effects in extended semen stored post collection.

1. Introduction

Previous reports have demonstrated that males consuming diets low in selenium produce sperm with low motility and increased abnormalities (Hansen and Deguchi, 1996; Maiorino et al., 1999). The underlying cause of this reduced sperm quality is not known, but may be the result of abnormal development during spermatogenesis (Behne et al., 1996). One possible mechanism through which this could occur is *via* the activity of glutathione peroxidase. Selenium is an important component of glutathione peroxidase, which, in turn, is important for preserving the structural integrity of the sperm plasma membrane (Wu et al., 1979). It is capable of neutralizing reactive oxygen species and thereby provides an important protective mechanism against lipid peroxidation for developing and mature spermatozoa (Drevet, 2006; Storey, 2008).

Previous studies evaluating the effect of dietary selenium have shown beneficial effects on boar sperm quality. Marin-Guzman et al. (1997) found that boars supplemented with 0.5 ppm of selenium produced sperm with better motility and morphology and had improved fertility compared to boars fed a diet deliberately formulated to be deficient in selenium. Jacyno and Kawecka (2002) found that boars supplemented with an organic source of selenium had higher sperm concentration and total sperm numbers as well as a lower percentage of abnormal sperm compared to boars supplemented with an inorganic form. In the previously mentioned study, however, selenium supplementation was confounded with dietary

* Corresponding author at: University of Central Missouri, Agriculture program in the School of Environmental, Physical and Applied Sciences, 245-B Grinstead, Warrensburg, MO 64093, USA. Tel.: +1 660 543 8094; fax: +1 660 543 8142.
E-mail address: klovercamp@ucmo.edu (K.W. Lovercamp).

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Table 1
Calculated analysis of experimental diets.

Dietary phase							
	Nursery 1	Nursery 2	Grower 1	Grower 2	Finisher 1	Finisher 2	Maintenance
Age (days)	21–35	36–56	57–84	85–112	113–140	141–168	169–382
Calculated analysis[a,b,c,d]							
Metabolizable energy, kcal/kg	3450.00	3472.00	3509.00	3465.00	3469.00	3469.00	3306.00
Crude protein, %	21.06	20.96	17.12	15.66	14.48	14.48	13.00

[a] Inorganic Se (Sodium selenite) or organic Se (Se-enriched yeast – Sel-Plex 2000) was added to the non-supplemented control diet to achieve a level of 0.3 ppm Se in the final diet.
[b] Starter vitamin premix provided 6.8 IU/kg Vit E, 4.4 ppm menadione and 0.1 ppm pyridoxine in the nursery 1 and 2 diets at 0.02% on an as fed basis.
[c] Grower vitamin premix provided 1360.85 IU/kg Vit A, 136.09 IU/kg Vit D3, 6.8 IU/kg Vit E, 14.99 ppm Niacin, 12.49 ppm Pantothenic acid, 0.02 ppm Vit B12 and 3.50 ppm Riboflavin in the nursery 1 and 2, grower 1 and 2 and finisher 1 and 2 diets at 0.05% on an as fed basis.
[d] Trace mineral provided 20 ppm Cu, 0.75 ppm I, 70 ppm Fe, 50 ppm Mn and 90 ppm Zn in the nursery 1 and 2, grower 1 and 2 and finisher 1 and 2 diets at 0.05% on an as fed basis.

vitamin E levels. Other research has shown that selenium supplementation with organic selenium improved sperm concentration in the ejaculate, but reduced sperm motility parameters and resistance to oxidative stress (Lopez et al., 2010). Consequently, what is not clear is whether supplementation of diets adequate in selenium can improve semen quality in boars and whether the source of the supplemental selenium is an important consideration.

Finally, because boar semen is typically stored for one to four days prior to insemination, it is reasonable to speculate that any dietary treatment that changes the composition of semen may also influence the quality of extended semen. Marin-Guzman et al. (1997) observed 2 and 3-fold increases in concentrations of selenium in seminal plasma and spermatozoa in their study. Whether or not these elevated levels of selenium at the time of collection can mitigate decreases in the quality of stored semen over time is not known. Research by Speight et al. (2012) suggests that selenium supplementation with organic selenium does help reduce the decreases seen in sperm motility post-extension. Therefore, the objectives of this study were to determine the effects of supplemental selenium on semen production and sperm quality in boars fed diets adequate in selenium and to determine whether any changes observed in the neat ejaculates were also present in extended semen during storage.

2. Materials and methods

2.1. Animals and housing

All procedures with animals were approved by the North Carolina State University Institutional Animal Care and Use Committee (IACUC ID # 07-063-A).

A total of 30 crossbred male piglets produced by breeding Yorkshire x Landrace x Large White sows to Hampshire x Duroc x Pietran boars were used. Male piglets were weaned at 20.9 ± 0.2 days of age and moved into a nursery room with side-wall baffle ventilation. During the five week nursery phase, male piglets were housed in groups of 2 in 0.91 m by 1.82 m pens and provided *ad libitum* access to feed and water. Young adult boars were then moved into a curtain-sided underslat ventilated finishing facility at 55.9 ± 0.2 days of age. Young adult boars were housed in the same groups of 2 established during the nursery phase in 1.8 × 2.8 m pens and also had *ad libitum* access to feed and water during the 14 week finishing period. At approximately 160 days of age, young adult boars were moved to individual stalls (2 m × 0.7 m) in another environmentally controlled barn with curtain-sided, underslat ventilation Supplemental ventilation for cooling during the summer months was provided by fans and a drip cooling system that were set to activate when ambient temperatures reached 23 °C and 26 °C, respectively. The young adult boars were provided *ad libitum* access to water and were hand-fed daily.

2.2. Experimental design

At weaning, 30 boars were weighed and placed in groups of 2 beginning with the heaviest and ending with the lightest. Each pair was randomly assigned to 1 of 15 pens in the nursery barn and then each pen was randomly assigned to dietary selenium treatments. Boars were fed one of three dietary selenium treatments from weaning through the remainder of the study: 1) a basal diet containing no supplemental selenium (control); 2) the basal diet supplemented with 0.3 parts per million (ppm) of sodium selenite (inorganic); or 3) the basal diet supplemented with 0.3 ppm of selenium enriched yeast (Sel-Plex 2000, Alltech Biotechnology Center, Nicholasville, KY; organic). The basal diets were composed of corn and soybean meal and formulated to meet all NRC requirements for growing boars except for the control diet which did not receive any supplemental selenium (NRC, 1998). Calculated analyses for metabolizable energy (kcal/kg) and crude protein (%) for all diets and the length of time that boars received each diet are shown in Table 1.

Between 160 and 190 d of age, eighteen boars (n = 6 per treatment) were trained to collect from a dummy sow. At 202 d of age the trained boars were randomly assigned within dietary treatment to be collected once per week on either Tuesday or Thursday. This occurred between January and May. Immediately after this 5-month period, all boars were subjected to a multiple collection frequency of six collections in four days. This occurred in June. Ejaculates collected during the second week in January, March, and May and the final ejaculate during the multiple collection sequence were transported to the laboratory where comprehensive sperm analyses were performed. All other