Revving up boars with selenium improves sperm quality

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The role of selenium (Se) and vitamin E in sow diets is well accepted, but their role and function in the breeding boar is less well understood. Both selenium and vitamin E act as antioxidants and have a direct effect on sperm quality by protecting them from oxidative damage. However, each nutrient functions independently and although general deficiency symptoms, such as lower fertilisation rate, may be similar, the physiological reasons for these may differ.

Deficiency symptoms

Vitamin E deficiency causes testicular degeneration that affects the sperm cell within the testicular parenchyma.

Sperm structural damage occurs when diets do not contain sufficient vitamin E. The benefits of vitamin E are within or on the surface of the spermatozoa and not in the seminal plasma.

Supplemental vitamin E has been reported to increase the concentration of sperm in the boar ejaculate. However, vitamin E has no effect on sperm cell structure abnormalities, but serves as an antioxidant on the sperm cell.

	Selenium (mg/kg) 0	Selenium (mg/kg) 0.5	Vitamin E (IU/kg) 0	Vitamin E (IU/kg) 220
Semen				
Volume (ml)	158	212	175	195
Sperm motility (%)	60	88	72	76
Normal sperm (%)	24	62	41	45
Fertilisation				
Fertilisation rate (%)	73	98	89	83
Accessory sperm	14	60	36	38

Table 1. The effect of dietary selenium and vitamin E on aspects of boar fertility (Marin-Guzman et al., 1997).

Age (months)	Selenium (mg/kg) 0	Selenium (mg/kg) 0.5	Vitamin E (IU/kg) 0	Vitamin E (IU/kg) 220
5.4	3.0	4.6	4.3	3.3
6.2	6.5	7.7	6.8	7.3
9.0	7.3	10.6	9.6	8.2
18.0	12.1	19.1	16.5	14.6
ATP (nmol/10^6 sperm)	1.15	1.55	1.30	1.37

Table 2. The effect of dietary selenium and vitamin E on sperm production of boars of different age (x109) (Marin-Guzman et al., 2000).

Selenium, on the other hand, is essential for the normal development of spermatozoa and is incorporated into the mitochondrial capsule protein. It is also a component of glutathione peroxidase, an enzyme that protects cellular structures against free radical damage, as well as an antioxidant for cellular membrane lipids.

Se deficiency affects the integrity and morphology of the mid-piece of the sperm where the mitochondria are normally embedded. This influences motility, as well as the number of maturing spermatids and testicular sperm reserves.

Thus, both selenium and vitamin E affect sperm quality and hence fertilisation rate. However, selenium appears to play a greater role than vitamin E in that it is essential for sperm development and maturation.

Effect on semen quality

Several studies have demonstrated the importance of dietary selenium for boar fertility. Marin-Guzman et al. (1997) fed boars a diet with either 0 or 0.5ppm Se from sodium selenite and 0 or 220 IU vitamin E/kg. Adult boars fed the Se-supplemented diet produced greater volumes of semen, with higher concentrations of sperm which also had higher motility than those from boars fed the vitamin E supplemented diet.

There was no decline in sperm motility in the 16 week period of the trial and there were fewer abnormal sperm (Fig. 1). In addition, the sperm from the boars fed the Se-supplemented diet had higher fertilisation capacity which resulted in the fertilisation rate of inseminated gilts also being higher (Table 1).

In subsequent studies in 2000, they evaluated boars at different ages and body weights, when fed diets containing 0 or 0.5ppm Se from sodium selenite and 0 or 220 IU vitamin E/kg (Table 2). At 18 months of age, the Se fed boars had higher numbers of sperm reserves, whereas vitamin E had no effect on testicular sperm reserves. The plasma membrane connection to the tail piece was not as tightly bound in those boars fed diets without added selenium than in those that were fed Se supplemented diets. This affects motility.

The concentration of ATP in the spermatozoa of the boars fed 0.5ppm Se was 25% higher than that of boars fed 0ppm Se, and indeed, higher than when vitamin E was pro-

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Fig. 1. Effect of selenium or vitamin E on sperm motility (Marin-Guzman et al., 1997).

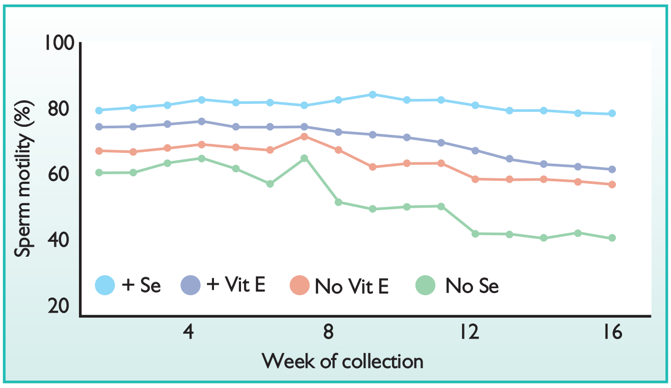
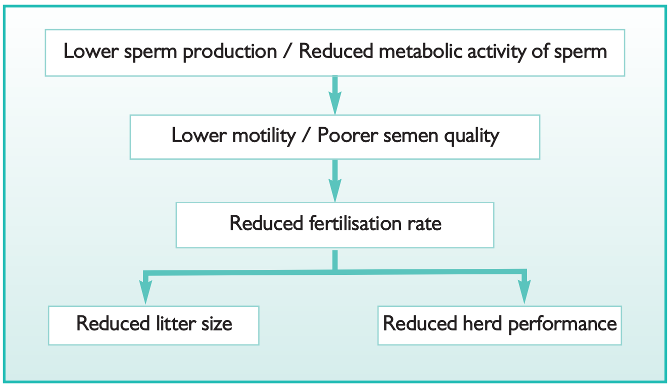


Fig. 2. The mechanisms by which low selenium status influences reproductive performance.



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vided (Table 2). The higher metabolic activity of the sperm in the ejaculate increased motility and enhanced fertilisation rate (Fig. 1).

The mechanisms by which low Se status influences reproductive performance is summarised in Fig. 2.

Effect of form of selenium

Jacyno et al. (2002) measured the reproductive performance of young boars receiving 0.2ppm Se from either inorganic selenite or from Se-yeast, as well as 30-60 IU vitamin E in their diet during both winter and summer.

There was no effect of treatment on the volume of the ejaculate or the percentage of motile sperm, but the concentration of spermatozoa and total spermatozoa produced were higher in boars fed the diets containing the organic Se (Table 3).

There was also a higher proportion of sperm with normal acrosomes and a lower percentage of sperm with minor or major morphological abnormalities. There was a significant increase in the results from the osmotic resistance test (ORT), indicating a higher fertilisation capacity of the sperm. Similarly, aspartate aminotransferase (Asp AT) was significantly reduced, indicating that the sperm cell membrane is intact and, as a consequence, the biological value of the semen is increased.

In a subsequent study in 2005, these authors evaluated the semen quality of young boars fed diets containing 0.2ppm Se from sodium selenite and 30 IU vit. E/kg compared with diets containing 0.2 and 0.4ppm Se from Se yeast and 60 IU vit. E/kg.

Again, they reported the superiority of the Se yeast compared with the inorganic sodium selenite (Table 3) and they concluded that supplementing the diet with 0.2mg Se from Se yeast and 60 IU vit. E/kg is sufficient for developing boars.

The results from these studies show that supplementation of diets with organic Se is superior to supplementation with inorganic Se, but in these studies the source of Se was confounded with the dietary level of vitamin E.

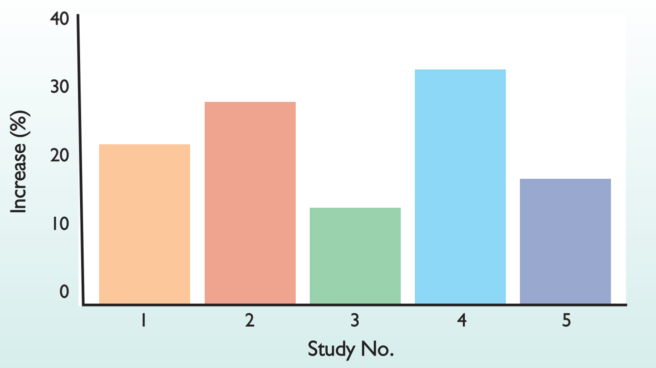

Fig. 3. The improvement in semen quality in boars fed Sel-Plex.

Recent studies from the USA (Estienne et al., 2008a) and Belgium (Rodriguez and Maes, 2009) have also reported a significant increase in sperm concentration and total sperm production when boars were fed Sel-Plex, organic selenium produced by Saccharomyces cerevisiae CNCM I-3060, Alltech compared with sodium selenite (Table 3).

Using in utero fertilisation (IVF) procedures, Estienne et al. (2008b) showed that the fertilisation rate of boars fed 0.3ppm Se from organic Se (Sel-Plex) was significantly higher than from boars fed a diet containing 0.3ppm Se from sodium selenite.

Groenewegen et al. (2006) have demonstrated that adding trace minerals from organic sources (Zn, Cu, Mn and Fe) and Se from Sel-Plex to diets of boars resulted in a 11.1% increase in semen concentration and a 9.7% increase in the number of tubes of semen produced (Table 3).

Fig. 3 summarises the responses for the various studies presented in Table 3.

Conclusion

These studies show the superiority of an organic over an inorganic source of Se for inclusion in the diet of boars for semen characteristics and fertilisation potential.

It is therefore suggested that boar diets be supplemented with 50-100 IU vitamin E and at least 0.3ppm Se from the most available sources.

Selenium yeast, such as Sel-Plex, with its active seleno-proteins, is more effective than inorganic sodium selenite at meeting the requirements of the modern boar. ■

References are available from the authors on request.

Table 3. The effect of selenium source on semen characteristics of developing and mature boars.

		Na Selenite	Se-Yeast	Change (%)
Jacyno et al. (2002)	Sperm concentration (106/cm3)	183a	224b	+22.4
	Total no. of sperm (109)	19.0a	23.7b	+24.7
	Defective sperm (%)	38.4a	22.8b	-40.6
	Osmotic resistance (ORT:%)	61.2a	74.0b	+20.9
	AspAT (u/109)	0.135a	0.076b	43.7
Jacyno et al. (2005)	Sperm concentration (106/cm3)	191a	246b	+28.4
	Total no. of sperm (109)	19.8a	26.8b	+35.4
	Defective sperm (%)	46.8a	23.4b	-50.5
	Osmotic resistance (ORT:%)	63.4a	77.2b	+21.9
	AspAT(u/109)	0.157a	0.083b	-47.1
Groenewegen et al. (2006)*	Semen concentration (cells/ml)	774a	860b	+11.1
	No. of tubes/ejaculate	30.0	32.9	+9.7
Estienne et al. (2008a)*	Sperm concentration (106)	184	243	+32.0
	Total no. of sperm (109)	27.7	36.0	+30.0
Estienne et al. (2008b)*	Fertilisation rate (%) Day 2	68	78	+14.7
	Fertilisation rate (%) Day 8	50	64	+28.0
Rodriguez and Maes (2009) *	Sperm concentration (106/ml)	434	511	+17.7
	Total sperm (109)	78.9a	87.8b	+11.3

* Se-Yeast: Sel-Plex. [a,b:] values with different superscript are significantly different ($p<0.05$). Low levels of AspAT (aspartate amino transferase activity) indicate that the sperm cell wall is intact and there is less leakage of AspAT.