Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.

ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2004
Volume 7
Issue 1
Series ANIMAL HUSBANDRY

KOŁODZIEJ A., JACYNO E. 2004. EFFECT OF DIETARY SELENIUM AND VITAMIN E SUPPLEMENTATION ON REPRODUCTIVE PERFORMANCE OF YOUNG BOARS **Electronic Journal of Polish Agricultural Universities**, Animal Husbandry, Volume 7, Issue 1.
Available Online http://www.ejpau.media.pl

EFFECT OF DIETARY SELENIUM AND VITAMIN E SUPPLEMENTATION ON REPRODUCTIVE PERFORMANCE OF YOUNG BOARS

Anita Kołodziej, Eugenia Jacyno
Department of Pig Breeding, Agricultural University of Szczecin, Poland

ABSTRACT

The studies were carried out on 40 young boars of the line 990. On their 70 days of age, the boars were divided into two groups; the control group received 0.2 mg Se and 30 mg vitamin E while the experimental group received 0.5 mg Se + 60 mg vitamin E per 1 kg of feed mixture. The feeding test was carried on from 70 days until 180 days of age. During the experiment the boars were subjected to live evaluations, i.e. testes volume, libido level, semen characteristics, as well as selenium concentration and glutathione peroxidase (GSH-Px) activity in blood serum and seminal plasma. The boars of the experimental group, compared with the control, showed significantly ($p \leq 0.05$) higher sperm concentration and total sperm count, significantly lower ($p \leq 0.05$) percentage of spermatozoa with major or minor morphological changes, elevated ($p \leq 0.05$) percentage of spermatozoa with normal acrosome, and significantly higher ($p \leq 0.01$) ORT values. GSH-Px activity was higher ($p \leq 0.05$) in seminal plasma of the control group boars.

Key words: selenium, vitamin E, boars, reproductive performance

INTRODUCTION

Selenium represents an integral component of glutathione peroxidase (GSH-Px), an enzyme which, along with vitamin E, protects cell internal structures against free radicals and is an antioxidant for cellular membrane lipids [2, 7]. Besides a number of functions, selenium with vitamin E play an important role in reproductive processes of both males and females of livestock animals. High concentrations of selenium in testes and epididymides indicates its importance for the processes of production and maturation of spermatozoa [6,8,14]. Scarce reports

on studies performed on boars [12, 13, 14] have demonstrated that an addition of 0.5 ppm selenium to feed rations applied in young boar raising significantly and positively influenced both semen quality (sperm motility, concentration, and morphology) and the conception rate.

So far, selenium requirements have not been precisely established either for swine or for other livestock animals. According to the NRC [15] or the Polish Swine Feeding Standards [16], selenium requirements of swine ranges between 0.1 and 0.3 mg per 1 kg of ration. In the European Union, 0.5 mg of Se per 1 kg of ration is considered as a safe and legally acceptable level. In today's practice in Poland, the ration fed to young boars is supplemented with premixes containing 30 mg of vitamin E and 0.2 mg of Se per 1 kg.

The aim of the present paper is to estimate the influence of increased addition of dietary selenium and vitamin E on reproductive performance of young boars.

MATERIALS AND METHODS

The studies were carried out at the State Center of Pig Hybridization in Poland on the 40 young boars of the 990 synthetic line. The boars were fed on the same diet from 30 to 70 days of age. At 70 days, the boars were divided into two groups (control and experimental). In each group there were 20 boars. The alocation to the groups was made with analogues method, i.e. from one litter one boar was asigned to a group. A feeding test was carried out from 70 to 180 days of age. During the feeding test the boars of the control group were fed on standard diet, which contained 0.2 mg Se and 30 mg vitamin E per 1 kg. The experimental group received 0.5 mg Se and 60 mg vitamin E per 1 kg of the ration.The boars were housed in individual pens. The daily feed ration was gradually increased along with the increasing body weight. Chemical composition and nutritive value of the diets are given in Table 1.

Table 1. Chemical composition and nutritive value of complete mixtures (in 1 kg)

Item	Mixtures	
	control	experimental
Metabolizable energy (MJ)*	12.8	12.8
Dry matter (g)	883	878
Crude ash (g)	55.2	60.3
Crude protein (g)	180	181
Ether extract (g)	22.5	19.1
Crude fibre (g)	27.8	24.2
N-free extractives (g)	598	594
Lysine (g)	9.6	9.7
Methionine (g)	3.4	3.5
Methionine+cystine (g)	6.1	6.0
Threonine (g)	6.3	6.6
Vitamin A (j.m)	7700	7700
Vitamin E (mg)	30.0	60.0
Selenium (mg)	0.20	0.53

*Calculated from Polish Swine Feeding Standards (1993).

The body weight of the boars, their daily gains, and feed conversion for the test period were determined at the age of 70 and 180 days. At age of 70 and 180 days the testes were measured and their volume was established [26]. Upon completion of the test (from 180 days of age on) the boars were trained to mount the phantom, and the collection of semen began, which was carried out with gloved hand technique. During the semen collection, the animal sexual activity was evaluated using the number of leaps and the time elapsed to effective mounting, as well as the time of ejaculation.

Immediately after the collection and filtration of ejaculate, its following characteristics were determined: ejaculate volume, percentage of motile spermatozoa, concentration of spermatozoa in 1 cm^3 (cytometric method in Bürker`s chamber), and total number of spermatozoa in ejaculate.

The minor and major morphological changes of the semen [3] and the grade of acrosome defects [20] were determined in the preparatins [10]. The osmotic resistance test (ORT) of acrosomalmembranes was performed according to Schilling and Vengust [21]. In seminal plasma obtained by centrifugation of the fluid fraction of the

semen, the content of selenium as well as the activity of GSH-Px and aspartate aminotransferase (AspAT) were determined. Prior to the analyses, the plasma was stored at -20°C.

At 180 days of age, blood from jugular vein was collected and, after centrifugation, the serum was frozen at -20°C.

GSH-PX activity in serum and seminal plasma according to Paglia and Valentine [18]. The activity of AspAT was measured with the kinetic method, and AspAT activity was converted as per $1x10^9$ of spermatozoa. The selenium concentrations in the premix, Se Yeast, blood serum, and seminal plasma were determined with the fluorometric method according to Watkinson [25].

The basic nutrient concentrations in the feeds were determined with standard methods, and amino acids were measured using an automatic analyser (Beckman Instruments Inc.).

The data were statistically analysed using Statistica PL software, by means of one-way analysis of variance.

RESULTS AND DISCUSSION

The results presented in Table 2 demonstrate that the boars of both control and experimental groups achieved similar levels of particular traits in live evaluation. Similar body weight gains and feed efficiency in the control group correspond to the results by Mahan and Parrett [11], who did not find any influence that adding 0.1, 0.3, or 0.5 ppm Se to rations for young growing or older pigs could have on their daily gains or feed efficiency.

Table 2. Growth rate, meatiness and selection index of young boars

Traits		Groups	
		control	experimental
Body weight (kg)			
- at 70 days of age	$\bar{x}$ s	22.1 3.5	20.9 2.3
- at 180 days of age	$\bar{x}$ s	110 7.1	109 9.1
Daily gain to 180 day of life (g)	$\bar{x}$ s	610 40.0	604 48.7
Meatiness (%)	$\bar{x}$ s	58.8 1.7	57.8 1.7
Selection index (pts)	$\bar{x}$ s	122 9.8	116 10.2

On the moment of starting the experiment, the boars had similar volume of both testes (Table 3). Application of elevated amount of Se + vitamin E positively influenced their testes size at 180 days of age. The experimental group boars exhibited by 29 cm^3 larger total testes volume compared with those of the control group. The differences found between the groups were, however, statistically non-significant. No clear results were obtained while analysing an effect of selenium on testes size. Wallace et al. [24] observed underdevelopment of testes and reduced production of spermatozoa in mice receiving selenium-deficient diets. Marin-Guzman et al. [12], on the other hand, observed very similar sizes of testes in boars that had been fed on rations containing 0 and 0.5 ppm of Se during their growth.

Increasing selenium addition from 0.2 to 0.5 mg and vitamin E from 30 to 60 mg per 1 kg of ration did not influence libido of the boars. Thus, reports of other authors that selenium is beneficial to boars' sexual activity [4] has not been confirmed in our experiment.

Ejaculate volume in both groups of boars was similar (Table 3). The semen of the experimental group boars showed significantly higher ($p \leq 0.05$) sperm concentration and total sperm count compared to the control group. Morphological evaluation of spermatozoa in the ejaculates of the boars demonstrated that an addition of 0.5 mg Se + 60 mg vitamin E to 1 kg of feed reduced considerably the percentage of morphologically changed spermatozoa. The numbers of spermatozoa with major or minor morphological changes as well as with defective acrosomes was significantly lower ($p \leq 0.05$) in the ejaculates of the experimental boars than in those of the control boars (Table 3).

Table 3. Testes volume, sexual activity, semen traits, selenium (Se) content and activity of glutathione peroxidase in the semen plasma and blood plasma of young boars

Traits		Groups	
		control	experimental
Volume of both testes (cm^3)			
- at 70 days of age	$\bar{x}$ s	11.9 5.4	12.1 3.0
- at 180 days of age	$\bar{x}$ s	625 118	654 176
Time mounting upon phantom (s)	$\bar{x}$ s	330 136	312 111
Number of mounts	$\bar{x}$ s	1.6 0.7	1.5 0.7
Time of ejaculation (s)	$\bar{x}$ s	179 31.5	180 35.1
Ejaculate volume after filtration (cm^3)	$\bar{x}$ s	106 38.4	109 10.9
Motile spermatozoa (%)	$\bar{x}$ s	70.8 6.1	74.6 6.1
Concentration of spermatozoa (n $x10^6$ cm^{-3})	$\bar{x}$ s	191^a 48.1	240^b 81.9
Total sperm count (n $x10^9$)	$\bar{x}$ s	20.2^a 8.0	26.2^b 9.3
Spermatozoa with major defects (%)	$\bar{x}$ s	11.0^a 5.0	7.5^b 5.9
Spermatozoa with minor defects (%)	$\bar{x}$ s	14.0^a 6.9	9.2^b 5.1
Spermatozoa with normal acrosome (%)	$\bar{x}$ s	85^A 9.3	91^B 5.0
Osmotic resistance test – ORT (%)	$\bar{x}$ s	56^A 9.2	69^B 13.4
AspAT ($mU \cdot 10^{-9}$ spermatozoa)	$\bar{x}$ s	119 72	66 30.3
Se in semen plasma ($\mu g \cdot ml^{-1}$)	$\bar{x}$ s	0.043^a 0.017	0.051^b 0.002
GSH-Px in semen plasma ($U \cdot ml^{-1}$)	$\bar{x}$ s	0.317^a 0.146	0.240^b 0.085
Se in blood plasma ($\mu g \cdot ml^{-1}$)	$\bar{x}$ s	0.264 0.049	0.281 0.045
GSH-Px in blood plasma ($U \cdot ml^{-1}$)	$\bar{x}$ s	4.01 0.014	4.29 0.012

Statistical significance: a, b – $p \leq 0.05$; A, B – $p \leq 0.01$.

A positive effect of selenium on sperm concentration and morphology has been confirmed also by other authors [9, 12]. It was demonstrated in studies on boars [12, 13] that adding vitamin E alone in an amount of 220 IU/kg of ration was of little effect in relation to morphological changes in spermatozoa or other traits. This implies that both antioxidants, Se + vitamin E, which act synergistically, should be administered jointly [5, 17].

The values of the osmotic resistance test (ORT) were higher ($p \leq 0.01$) in the semen of the experimental group of boars, which indicates better quality of their semen. A strong, positive correlation between ORT results and semen fertilising capacity [21, 23].

A comparison of AspAT activity in seminal plasma of the boars in particular groups indicates that an addition of 0.5 mg Se + 60 mg vitamin E per 1 kg of ration prevented cellular membrane damage in spermatozoa. AspAT

activity in seminal plasma of the experimental group boars was, as converted to 10^9 sperm, by 53 mU lower than that in seminal plasma of the control group boars. The difference between the groups was, however, non-significant. The results of our studies have confirmed those reported by other authors [22] that selenium prevents structural damage of spermatozoan cellular membranes.

Selenium concentration and GSH-Px activity (Table 3) in blood serum of the boars receiving elevated levels of selenium and vitamin E in the ration were by approx. 6% higher compared to the control boars, which had been fed on standard mixture with a lower amount of selenium + vitamin E. The differences between the groups were, however, non-significant. Other authors have not found a clear relationship between the quantity of this microelement in feeding ration and its concentration as well as GSH-Px activity in porcine blood serum. Marin-Guzman et al. [12] found statistically significant increase in selenium content and GSH-Px activity in blood serum of boars obtaining 0.5 ppm Se in ration during growing. Mahan and Parrett [11], on the other hand, who applied 0.1, 0.3 and 0.5 ppm Se in the form of sodium selenite in the ration found very similar selenium concentration and GSH-Px activity in the blood serum of growing and adult pigs.

Elevated addition of selenium from 0.2 mg to 0.5 mg and vitamin E from 30 mg to 60 mg per 1 kg of the ration increased by about 16% ($p \leq 0.05$) the concentration of this microelement in seminal plasma. On the other hand, GSH-Px activity was by 32% lower ($p \leq 0.05$) in seminal plasma of the experimental boars, despite the fact that the latter exhibited much better semen quality than the boars of the control group.

The results obtained confirm the suggestion that most selenium in an organism occurs in proteins other than, as it was once assumed, in GSH-Px [19]. Higher selenium concentration in seminal plasma of the experimental group boars enables a conclusion that the element is a component of other selenoproteins that positively influence the boars' reproductive performance. New selenoproteins have been identified over the recent years, e.g. selenoprotein-P, which is beneficial to animal reproduction [1].

CONCLUSIONS

Increased addition of selenium and vitamin E to balanced feed mixtures fed to growing boars, from the currently recommended standard amounts (0.2 mg Se + 30 mg vitamin E per 1 kg) to 0.5 mg Se + 60 mg vitamin E per 1 kg has a minor effect on testes size and libido traits of the boars; whereas it positively influences both quantitative and qualitative semen traits.

REFERENCES

1. Arthur J.R., 1994. The biochemical function of selenium: relationships to thyroid metabolism and antioxidant systems. The Rowett Research Institute Annual report 1993. The Rowett Research Institute, Aberden, Scotland.
2. Bartle J.L., Senger P.L., Hillers J.K., 1980. Influence of injected selenium in dairy bulls on blood and semen selenium, glutathione peroxidase and seminal quality. Biol. Reprod. 23, 1007-1013.
3. Blom E., 1981. Ocena morfologiczna wad plemników buhaja, II. Propozycja nowej klasyfikacji wad plemników [Studies on seminal vesiculitis in the bull: II. Proposal for a new classification of the spermiogram]. Medycyna Wet. 37, 239-242 [in Polish].
4. Bronicki M., Dembiński Z., 1991. Rola selenu w reprodukcji świń [The role of selenium in reproduction of pigs]. Medycyna Wet. 47, 10, 464-465 [in Polish].
5. Gabryszuk M., 1994. The effect of selected minerals and vitamin E on the reproduction. Anim. Sci. Pap. Rep. 12,1, 53-61.
6. Heimann E.D., Smith M.F., Morris J.S., Gall T.J., Elmore R.G., Morrow R.E., 1984. Relationships among spermatozoal anormalities and the selenium concentration of blood plasma, semen, and reproductive tissues in young bulls. Anim. Reprod. Sci. 7, 315-321.
7. Hidiroglou M., 1982. Selenium in the ruminant genital system and mammary glands (reviev). Ann. Rech. Vet. 13, 133-141.
8. Kotowska E., Kotowski B., 2001. Znaczenie selenu i witaminy E w reprodukcji świń [Significance of selenium and E witamin in pig reproduction]. Prz. Hod. 7, 9-11 [in Polish].
9. Liu C.H., Chen Y.M., Zhang J.Z. Huang M.Y., Su Q., Lu Z.H., Yin R.X., Shao G.Z., Feng D., Zheng P.L., 1982. Preliminary studies on influence of selenium deficiency to the developments of genital organs and spermatogenesis of infancy boars. Acta Vet. Zootech. Sin. 13, 73-77.
10. Łyczyński A., Pawlak H., 1975. Unasienianie trzody chlewnej [Insemination the swine]. PWRiL, Poznań [in Polish].
11. Mahan D.C., Parrett N.A., 1996. Evaluating the efficiacy of Se-enriched yeast and sodium selenite on tissue Se retention and serum glutathione peroxidase activity in grower and finisher swine. J. Anim. Sci. 75, 2994-3003.
12. Marin-Guzman J., Mahan D. C., Chung Y.K., Pate J.L., Pope W.F., 1997. Effects of dietary selenium and vitamin E on boar performance and tissue responses, semen quality, and subsequent fertilization rates in mature gilts. J. Anim. Sci. 75, 2994-3003.

13. Marin-Guzman J., Mahan D.C., Pate J.L., 2000a. Effect of dietary selenium and vitamin E on spermatogenic development in boars. J. Anim. Sci. 78, 1537-1543.
14. Marin-Guzman J., Mahan D.C., Whitmoyer R., 2000. Effect of dietary selenium and vitamin E on the ultrastructure and ATP concentration of boar spermatozoa, and the efficiacy of added sodium selenite in extended semen on sperm motility. J. Anim. Sci. 78, 1544-1550.
15. National Research Council, 1998. Nutrient Requirements of Swine, 10th Ed., National Academy Press, Washington, D.C.
16. Normy Żywienia Świń [Polish Norm of Pigs Nutrition]. 1993. Instytut Fizjologii i Żywienia Zwierząt PAN, Jabłonna, 1-87 [in Polish].
17. Norton S.A., McCarthy F.D., 1986. Use of injectable vitamin E and selenium-vitamin E emulsion in eves and suckling lambs to prevent nutritional muscular dystrophy. J. Anim. Sci. 62, 496-508.
18. Paglia D.E., Valentine W.N., 1967. Studies on quantitative characterization of erytrocyte glutathione peroxidase. J. Lab. Clinical Med. 70, 158-169.
19. Pehrson B.G., 1994. Selen w żywieniu – potencjał biologiczny jego organicznych i nieorganicznych związków [Selen in feeding - Bioavailability of organic and inorganic forms]. Ann. Europ. Lecture Tour Alltech, Warszawa, 55-76 [in Polish].
20. Pursel V.G., Johnson L.A., Rampacek G.B., 1972. Acrosome morphology of boar spermatozoa incubated before cold shock. J. Anim. Sci. 34, 55-64.
21. Schilling E., Vengust M., 1987. Frequency of semen collection in boars and quality of ejaculates as evaluated by the osmotic resistance of acrosomal membrane. Anim. Repr. Sci. 56, 1065-1076.
22. Segerson E.C., Getz W.R., Johnson B.H., 1981. Selenium and reproductive function in boars fed a low selenium diet. J. Anim Sci. 53, 1360-1367.
23. Udała J., Krasnosielska-Warchoł D., Rozen J., Radoń W., 1996. Przydatność testu oporności osmotycznej (ORT) w ocenie zdolności zapładniającej nasienia knurów [The usefulness of osmotic resistance test (ORT) for evaluation of the fertilizing capability of boar semen]. Zesz. Nauk. PTZ Prz. Hod. 26, 83-90 [in Polish].
24. Wallace E., Calvin H.I., Cooper G.W., 1983. Progressive effects observed in mouse sperm during course of three generations of selenium deficiency. Gamete Res. 4, 377-387.
25. Watkinson, J.H. 1966. Fluorometric determinations of selenium in biological material with 2,3, diaminonaphtalene. Anal. Chem. 38: 92-103.
26. Young L.D., Leymaster K.A., Lunstra D.D., 1986. Genetic variation in testicular development and its relationship to female reproductive traits in swine. J. Anim.Sci. 63, 17-26.

Anita Kołodziej, Eugenia Jacyno
Department of Pig Breeding
Agricultural University of Szczecin
Doktora Judyma 10, 71-460 Szczecin Poland
e-mail: A.Kolodziej@biot.ar.szczecin.pl
