Animal Reproduction Research Institute,
Al Haram, Giza, Egypt.

EFFECT OF DIETARY ZINC SUPPLEMENTATION ON REPRODUCTIVE PERFORMANCE OF ZARAIBI MALE GOATS

(With 3 Tables)

By
MAHA S. ZIADA and M.A. HEGAZY

(Received at 13/3/2004)

تأثيرإضافة الزنك على الكفاءة التناسلية لذكور الماعز الزرايبى

مها سليمان زيادة ، محمد أحمد حجازى

لقد إستهدف هذا البحث دراسة تأثير إضافة الزنك للعليقة على الكفاءة التناسلية لذكور الماعز الزرايبى. وفى هذه الدراسة تم إستخدام عشرة ذكور من الماعز الزرايبى بمزرعة التجارب الخاصة بمعهد بحوث التناسليات الحيوانية حيث يتراوح أعمارهم من ١٩ – ٢٠ شهرا. وفى هذه التجربة تم تغذية ذكور الماعز لمدة ١١ اسبوعا على المستوى الغذائى الطبيعى الذى يحتوى على ٢٣,٣٦ مجم/كجم من الزنك مضافا للعليقة الجافة وتم تجميع السائل المنوى من الحيوانات اسبوعياً فى الاسابيع السبعة الأخيرة حيث أعتبرت فترة الأسابيع الاربعة الاولى فترة تمهيدية. وبعد انتهاء هذه المدة (١١ اسبوع) تم تغذية نفس الذكور على نفس المستوى الغذائى مع اضافة ٠٠,١٩ ٪ من سلفات الزنك للخليط المركز. وقد أسفرت النتائج عن تحسن معنوى فى حجم قذفة السائل المنوى (١,١٠ مللى) وتركيز الحيامن (٥,٤٣ X 10^9 حيمن /مللى) ونسبة الحركة الفردية للحيامن (٨٥,٧٤ ٪) ونسبة الحيامن الحية (٨٨,٦ ٪) عن مثيلاتها فى العينات الضابطة (٠,٩ مللى و ٤,٦٢ X 10^9 حيمن /مللى و ٨٠,١٪ و ٨٣,٢٨ ٪ على التوالى). أيضا أدى اضافة الزنك للعليقة الى انخفاض معنوى فى درجة تركيز أيونات الهيدروجين فى السائل المنوى (٦,٤٢) ونسبة الحيوانات المنوية المشوهة (٥,٨٧ ٪) ونسبة القلنسوات المشوهة (٤,٠ ٪) عن مثيلاتها فى العينات الضابطة (٦,٤٧ و ٧,٦٨ ٪ و ٤,٧٤ ٪ على التوالى). وبصرف النظر عن طريقة التغذية فى التجربة وجد أن هناك فرق معنوى بين التيوس متمثلا فى تركيز الحيوانات المنوية لكل مللى من السائل المنوى وأيضا نسبة الحيامن المشوهة. ومن هذه الدراسة نستخلص أن تغذية ذكور الماعز الزرايبى على النظام الغذائى الجيد مضافا اليها ٠,١٩٪ من سلفات الزنك يؤدى إلى تحسن ملحوظ فى كفاءتها التناسلية.

SUMMARY

Ten Zaraibi male goats aged 19 - 20 months were used in the present study. They were kept at the experimental farm of Anim. Reprod. Res. Instit. Al-Ahram, Giza Province. They were fed for 11 weeks on a basal diet containing about 23.36 mg/kg zinc on dry matter basis. Semen collection was carried out weekly along the last 7 weeks, where the first 4 weeks was considered as an adaptation period. After the end of the 11 weeks, the same animals were fed on the same diet supplemented with 0.19% of zinc sulphate added to the concentrate mixture. The results revealed a significant ($P< 0.05$) improvement in semen volume (1.10ml), sperm concentration($5.43x10^9$/ml), percentage of individual sperm motility (85.74%) and percentage of live spermatozoa (88.6 %) in treated than that for pre-treated samples (0.90 ml, 4.62 $x10^9$/ml, 80.1% and 83.28%, respectively). On the contrary, pH (6.42), percentages of abnormal spermatozoa (5.87%) and those with acrosomal defects (4.0%) were decreased significantly ($P < 0.05$) by adding zinc to the ration of tested bucks than those determined in pre-zinc addition samples (6.47, 7.68% and 4.74%, respectively). Buck individualities were found prominent for some parameters; sperm concentration and percentages of abnormal spermatozoa. ($P< 0.05$). It can be concluded that dietary zinc supplementation is effective in improving semen quality of Zaraibi goats.

Key words: *Zinc supplementation, reproductive performance, zaraibi male goats*

INTRODUCTION

The wide distribution of goats in the tropics and sub-tropics reflects their ability to adapt to a variety of environments. The inherent characteristics of goats such as resistance to dehydration, preference for browse and wide-ranging feeding habits, enable them to thrive in regions with very little rainfall (Chehadah *et al*, 2001).

In less developed countries, it is easier to increase the population and productivity of goats, which can overcome the increase demand for additional animal protein feed. Livestock-production efficiency is largely dependent on reproductive performance. Several factors are known to affect the reproductive potential of farm animals, one of which is the nutritional factor (Mahmoud, 2001). Under-nutrition and deficiency of specific nutrients could interfere with the synthesis of hormones involved in reproduction. In other case nutrition might affect rate at which a hormone destroyed by metabolism or even the sensitivity to hormone of its target organ (Mc Donald *et al*, 1990). Semen characteristics were assessed for the prediction of male fertility.

Zinc is an essential nutrient for animals functioning entirely on enzymatic systems and being involved in protein synthesis, carbohydrate metabolism and many other biochemical reactions (Vallee, 1959). Next to calcium and magnesium, zinc is the most concentrated intracellular divalent cation (Keen and Graham, 1989). A field study indicated that, the usual Egyptian rations are lacking in zinc (Attia *et al*, 1987). Because of the scarcity of data available literature on the influence of zinc on reproductive potentials in native breeds (Zaraibi) of male goats, therefore, the present study aimed at determining the effect of dietary zinc supplementation on some reproductive performance of goats.

MATERIAL and METHODS

Ten Zaraibi male goats aged 19 - 20 months were used in the present study. They were kept at the experimental farm of Animal Reproduction Research Institute, Al-Ahram, Giza Province.

At the beginning of the experiment, and for a period of 11 weeks, the animals were fed (according to NRC, 1980) on a basal diet, containing 23.36 mg/kg Zinc on dry matter basis. Semen collection was carried out weekly along the last 7 weeks, where the first 4 weeks prior to semen collection was considered as an adaptation period. After the end of the 11 weeks, the same animals were fed on the same diet supplemented with 0.019% of zinc as zinc sulphate added to the concentrate mixture ($ZnSO_4$; 36%) of zinc group in order to increase the zinc level to about 100 mg/kg diet DM for 15 weeks. The physical and the chemical composition of the basal diet are shown in table(1).

Semen was collected weekly along the last 8 weeks. It was evaluated using the standard laboratory techniques for its volume, pH, concentration and individual motility. Percentages of live spermatozoa and abnormal spermatozoa were counted using negrosin-eosin stained smears according to Blom, (1972). The percentages of spermatozoa with acrosomal defects were recorded in smears stained by fast green stain according to Wells and Awa (1970).

Statistical analysis:

Statistical analysis was performed according to Snedecor and Cochran (1967).

Table 1: The physical and chemical composition of the experimental diet.

Item	Percentage (as fed basis)
Ingredient:	
Yellow corn, ground	22.93
Soya bean meal	11.97
Wheat bran	20
Berseem hay	13.73
Wheat straw	30.00
Lime stone	0.807
Common salt	0.500
Chemical composition:	
Dry matter, %	88.6
Crude protein, %	12.4
Zn, ppm	25.98
Nutrient value:	
Metabolizable energy	2.13

RESULTS

Data gathering in tables (2 and 3) showed the effect of dietary zinc on semen characteristics in Zaraibi goats. Zinc supplementation was found to be highly effective on all examined semen parameters. Semen volume (ml), sperm concentration ($x10^9$ / ml), individual motility (%) and live spermatozoa (%) were significantly ($P<0.05$) improved by adding zinc to the animals ration (1.10 ± 0.03 ml, 5.43 ± 0.47 x 10^9, 85.75 ± 0.55 % and 88.6 ± 0.45%, respectively) than that for samples before zinc addition (0.90 ± 0.03 ml, 4.62 ± 0.64 x 10^9, 80.1 ± 0.64 % and 83.28 ± 0.54%, respectively). On the other hand, semen pH, percentages of abnormal spermatozoa and those with acrosomal defects were decreased significantly ($P<0.05$) by adding zinc to the ration of tested bucks (6.42 ± 0.01, 5.87 ± 0.21% and 4.0 ± 0.13%, respectively) than those determined in samples before zinc addition (6.47 ± 0.01, 7.68 ± 0.26 % and 4.74 ± 0.14%, respectively). Buck individualities were recorded as prominent ($P<0.05$) for some parameters; sperm concentration and percentages of abnormal spermatozoa ($P< 0.05$).

DISCUSSION

The male reproductive function depends upon extraneous agents among which nutrition ranks first in importance. Early investigators of nutritional aspects of male fertility, particularly those concerned with problems in farm animals, relied chiefly upon examination of ejaculated spermatozoa because semen may vary quantitatively and qualitatively with diet and nutritional status of the animal (Mann and Lutwak-Mann, 1981).

Zinc has been recognized for several decades as indispensable for normal fertility, particularly in the male animal (Chaney, 1992). In the last few years, the research is focused on the elucidation of the the multiple functions of this nutrient and more particularly of the beneficial effects for health and reproduction at doses which are much higher than nutritional requirements.

The reported increase in reproductive potentials in response to adding zinc to animal ration has been reported in bulls by Pitts *et al.* (1966) and in buffalo by Khalifa (1997). The present work has also indicated a strong association between zinc feeding and most evaluating semen parameters.

In regard to semen volume and concentration, the findings of the present work indicated that, dietary supplementation of Zaraibi male goats with zinc resulted in a highly significant increase in ejaculate volume and concentration of spermatozoa. In agreement with our data, Hidiroglou (1979) explain the increase in ejaculate volume might be due to the normal functions of the accessory sex glands are dependant on zinc. Saleh *et al.* (1992) found that goat sperm density and total number of sperm per ejaculate were significantly improved after dietary supplementation with zinc. However, contradictory findings were given by Pitts *et al.* (1966) who did not find any significant effect of zinc deficiency or supplementation on the concentration of bull spermatozoa or on total number of sperm produced.

In the current study, dietary supplementation of Zaraibi male goats with zinc caused a highly significant decrease in pH of the semen. The possible cause of the significant decrease in pH is the stimulatory effect of zinc on biosynthesis of ascorbic acid and citric acid (McDowell, 1989 and Nagorna-Stasiak *et al*, 1993).

Concerning sperm motility, the present work demonstrated highly significant increase in individual motility. Our data may support the findings of Brandis and Granach (1990), who observed that addition of vitamins C, D3 and E, zinc, copper, cobalt, iodine, manganese and carotene to the daily rations of Russian Black Pied bulls resulted in an increase in the post-thawing sperm motility. Khalifa (1997) has also found an increase in individual buffalo sperm motility after dietary supplementation with zinc and vitamin E. Regarding the functional significance of zinc in relation to sperm motility, Baccotti *et al* (1973), claimed that, zinc was important for the mechanical properties of the accessory fibers of the sperm tail and for sperm motility. Moreover, zinc was found to regulate the metabolism of cyclic guanosine monophosphate (Santos-Sacchi *et al*, 1980).

With respect to percent of live sperm, the current investigation indicated that, dietary supplementation of Zaraibi male goats with zinc resulted in a highly significant increase in live sperm percent. In agreement with our records, Danek and Wisniewski (1992) on stallion, Abd El-Moneim and Tharwat (1996) on rabbit bucks and Khalifa (1997) on buffalo bulls, recorded a high percentage of live sperm in the semen of zinc-supplemented animals.

After dietary supplementation of Zaraibi goats with zinc, the present data revealed a highly significant reduction in percent of both abnormal spermatozoa and abnormal acrosome. Similar effect was observed by Brandis and Granach (1990), who reported that, daily addition of vitamins C, D3, and E, zinc, copper, iodine, manganese and carotene to the rations of Russian Black Pied bulls resulted in an increase in the percentage of spermatozoa with intact acrosomes. In regard to biological effects of zinc on morphology, Mann and Lutwak-Mann (1975), reported that, the toxicity of molecular oxygen to spermatozoa was linked to the formation of highly reactive free radical, namely the superoxoide anion radical as well as formation of hydrogen peroxides which was found to induce oxidation of the polyunsaturated fatty acids content of sperm phospholipids leading to formation of the highly toxic lipid peroxides which could cause an irreversible damage to spermatozoa. Concomitantly, zinc may exert a protective effect on sperm membranes by scavenging free radicals (superoxid anions) and subsequently reduce the formation of lipid peroxide.

From this study, it can be concluded that supplementation of goat diets by 0.19% zinc over that recommended by NRC is highly effective for enhancing semen quality.

REFERANCES

Abd El-Monem, A. E. and Tharwat, E. E. (1996): Benificial use of zinc sulfate for improving semen characteristics and fertility of rabbit bucks during summer season. Proc. 9th Cong. Egypt. Soc. Anim. Reprod., Shebin El-Kom, Menofyia. p. 44.

Attia, A. N. Awadalla, S. A. Esmail, E. Y. and Hady, M. M. (1987): Role of some microelements in nutrition of water buffalo and its relation to production. Effect of zinc supplementation. Assiut Vet. Med. J., 18:91.

Baccotti, B., Pallini, A. and Burrini, A.G. (1973): The accessory fibers of the sperm tail. 1. Structure and chemical composition of the sperm tail. J. Submicrosc. Cytol., 5:237.

Blom, E. (1972): The ultrastructure of some characteristics sperm defects and a proposal for a new classification of the bull spermiogram. VII Symp. Int. Dizootecmia, Milano, pp.125.

Brandis, B. M. and Granach, V. G. (1990): The effect of premix and animal protein on semen quality in bulls. Zootekhniya, 6:61.

Chaney, S. G. (1992): Microelements. In Textbook of biochemistry with clinical correlations. 2nd ed. Edited by Devlin, T. M., John Wiley and Sons, New York.

Chehadeh, R.Y., Ziada, M. S. Ghallab, A.M. and Seida, A.A.M. (2001): Freezability of Zaraibi goat semen in relation to different diluents, egg yolk concentration and glycerol levels. Thirteenth Ann. Cong. Egypt. Soc. Anim. Reprod. Fert. P. 189.

Danek, J. and Wisniewski, E. (1992): Changes in semen quality in Zinc-deficient stallions. Medycyna Weterynaryjna, 48:566.

Hidiroglou, M. (1979): Trace element deficiencies and fertility in ruminants. J. Dairy Sci., 62:1195.

Keen, C. L. and Graham, T. W.(1989): Microelements. In clinical biochemistry of domestic animals. 4th ed. Edited by Kaneko, J., Academic Press, New York.

Khalifa, T. A. A. (1997): Effect of vitamin E and zinc supplementation on sexual behavior and some semen characteristics of buffalo bulls. M.V. Sc. Vet. Thesis. Cairo Univ.

Mahmoud, M. A. (2001): Effect of stress on reproduction and maternal physiology and behaviour in sheep. pH. D. Thesis, Fac. Vet. Med. Cairo Univ.

Mann, T. and Lutwak-Mann, C. (1975): Biology of fertilization. In Aging gametes. Edited by Blandau, R. J., Karger, Basel, Cambridge.

Mann, T. and Lutwak-Mann, C. (1981): Male reproductive function and semen. Springer-Verlag, Berlin, Heidelberg, New York.

Mc Doland, P., Edward, R.A. and Grenhalgh, J.F. (1990): Animal Nutrition 4th edition, ELBS, Longmann, England.

McDowell, (1989): Vitamins in animal nutrition-Comparative aspects to human nutrition. Academic Press, Inc. San Diego, New York, London.

Nagorna-Stasiak, B., Lechowski, J. and Lazuga-Adamczyk, A. (1993): The effect of zinc on synthesis and absorption of vitamin C in chickens. Medycyna Weterynaryjna, 49: 331.

Pitts, W. J., Miller, W. J., Fosgate, O. T., Morton, J. D. and Clifton, C. M. (1966): Effect of zinc deficiency and restricted feeding from two to five months of age on reproduction in Holstein bulls. J. Dairy Sci., 49: 995.

Saleh, I., Ibrahim, A. M. and Yousri, R.M. (1992): The effect of dietary zinc, season and breed on semen quality and body weight in goats. World Rev. Anim. Prod., 27:9.

Santos-Sacchi, J., Gordon, M., and Williams, W. L. (1980): Potentiation of the cGMP- induced guinea-pig acrosome reaction by zinc. J. Experimental Zoology, 213:289.

Snedecor, G.W. and Cochran (1980): Statistical Methods 7thed. J.B.H.Publishing comp., Oxford.

Vallee, B. L. (1959): Biochemistry, physiology and pathology of zinc. Physiology Revs., 39:443.

Wells, M. F. and Awa, O. A. (1970): New technique for assessing acrosomal characteristics of spermatozoa. J. Dairy Sci., 53:227.

Table 2 : Effect of zinc supplementation (Zn supp.) on semen volume (ml), pH and sperm concentration ($x10^9$) of Zaraibi goats. (mean ± se)

Buck no.	semen volume (ml)		Overall mean	PH		Overall mean	Sperm concentration ($x10^9$)		Overall mean
	Control	Zn supp.		Control	Zn supp.		Control	Zn supp.	
1	0.9±0.04	1.20±0.07	1.02±0.07	6.54±0.04	6.42±0.02	6.48±0.02	5.53±0.02	5.72±0.21	5.62±0.15 ^{a}
2	1.0±0.11	1.11±0.08	1.11±0.08	6.48±0.03	6.42±0.02	6.45±0.01	4.51±0.40	5.35±0.14	4.88±0.24 ^{ab}
3	1.0±0.11	1.08±0.07	1.08±0.07	6.46±0.01	6.45±0.02	6.45±0.01	4.27±0.28	5.47±0.21	4.81±0.23 ^{ab}
4	1.0±0.06	1.13±0.06	1.13±0.06	6.44±0.01	6.42±0.02	6.43±0.01	4.54±0.14	5.50±0.20	4.97±0.17 ^{b}
5	0.9±0.05	1.02±0.06	1.02±0.06	6.54±0.01	6.42±0.01	6.48±0.02	4.31±0.14	4.97±0.06	4.61±0.12 ^{ab}
6	0.9±0.05	1.02±0.06	1.02±0.06	6.48±0.03	6.42±0.01	6.45±0.02	4.37±0.15	5.55±0.19	4.89±0.20 ^{b}
7	1.1±0.08	1.16±0.06	1.16±0.06	6.44±0.01	6.42±0.02	6.43±0.01	4.38±0.15	4.97±0.06	4.64±0.11 ^{ab}
8	1.1±0.04	1.16±0.04	1.16±0.04	6.44±0.01	6.42±0.01	6.43±0.01	4.65±0.17	5.60±0.20	5.07±0.18 ^{ab}
9	1.1±0.10	1.13±0.06	1.13±0.06	6.46±0.02	6.40±0.03	6.43±0.02	4.77±0.16	5.65±0.18	5.16±0.16 ^{ab}
10	1.0±0.06	1.13±0.06	1.13±0.06	6.48±0.03	6.42±0.01	6.45±0.02	4.85±0.25	5.52±0.16	5.15±0.17 ^{ab}
Overall mean	0.9±0.03	1.10±0.03*	1.10±0.03	6.47±0.01*	6.42±0.01	6.45±0.01	4.62±0.64	5.43±0.47*	4.98±0.70

A,b.....etc. within columns are significantly different on at least ($p<0.05$). * significant from the control group on at least ($P<0.05$).

Table 3 :Effect of zinc supplementation (Zn supp.) on percentages of sperm motility, live sperm, abnormality and acrosomal defects of goats. (mean ± se):

Buck no	Motility %		Overall Mean	Live %		Overall mean	Abnormal sperm %		Overall mean	Acrosomal defects %		Overall mean
	Control	Zn supp.		Control	Zn supp.		Control	Zn supp.		Control	Zn supp.	
1	78.0±2.15	86.25±0.94	81.66±1.63	84.0±2.05	88.00±1.71	85.77±1.38	5.4±0.43	4.0±0.30	4.77±0.32 ^{a}	5.2±0.49	3.75±0.18	4.55±0.32
2	81.0±1.58	85.0±1.54	82.77±1.17	84.8±1.32	90.25±1.04	87.22±1.10	5.8±0.31	5.0±0.31	5.44±0.23 ^{cd}	4.4±0.20	4.0±0.30	4.22±0.17
3	82.0±1.69	85.0±1.54	83.33±1.15	84.4±1.09	88.75±1.25	86.33±0.98	7.6±0.57	6.0±0.30	6.88±0.38 ^{bc}	4.4±0.20	3.75±0.18	4.11±0.16
4	81.0±1.58	87.5±1.09	83.88±1.29	85.0±1.33	89.75±0.83	87.11±1.01	7.6±0.43	5.3±0.35	6.55±0.42 ^{bc}	5.0±0.53	4.0±0.30	4.55±0.23
5	80.0±1.33	85.0±1.54	82.22±1.17	81.6±1.70	86.75±0.89	83.88±1.18	10.0±0.59	7.75±0.35	9.00±0.46 ^{a}	5.2±0.31	5.0±0.18	5.11±0.28
6	82.0±1.03	87.5±1.09	84.44±1.04	83.2±0.97	88.75±1.04	85.66±1.02	8.2±0.67	6.0±0.30	7.22±0.47 ^{bc}	4.8±0.31	4.25±0.30	4.55±0.23
7	80.0±2.31	86.25±0.94	82.77±1.51	83.0±1.19	87.75±0.83	85.11±0.96	8.2±0.62	6.0±0.30	7.22±0.45 ^{bc}	4.4±0.33	4.5±0.53	4.44±0.19
8	78.0±2.15	85.0±1.54	81.11±1.60	81.6±1.37	88.25±0.99	84.55±1.23	9.0±0.59	5.25±0.56	7.33±0.65 ^{bc}	5.4±0.33	3.25±0.35	4.44±0.37
9	80.0±1.33	85.0±2.18	82.22±1.35	83.8±1.67	89.25±1.46	86.22±1.29	8.0±0.59	6.75±0.35	7.44±0.37 ^{b}	3.6±0.20	3.75±0.21	3.66±0.13
10	79.0±2.46	85.0±1.54	81.66±1.63	81.4±2.08	88.5±1.17	84.55±1.52	7.0±0.59	6.75±0.35	6.88±0.33b ^{bc}	5.0±0.59	3.75±0.35	4.44±0.37
Ov m	80.1±0.64	85.75±0.5*	82.61±0.52	83.28±0.54	88.6±0.45*	85.64±0.45	7.68±0.26*	5.87±0.21	6.87±0.19	4.74±0.1*	4.0±0.13	4.41±0.11

A,b..etc.within columns are significantly different on at least ($P<0.05$).* significant from the control group on at least($P<0.05$).Ov m=overall mean