ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF

POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 10 (6): 477-482, 2011
ISSN 1682-8356

Effect of Dietary Zinc on Semen Quality of Cobb 500 Broiler Breeder Males

Mahmood H.M. Amem[1] and Hazim J. Al-Daraji[2]
[1]Department of Animal Hygiene,
Kalar Technical Institute, Foundation of Technical Education, Sulaimaniya, Iraq
[2]Department of Animal Resources, College of Agriculture, University of Baghdad, Baghdad, Iraq

Abstract: The purpose of the present research was to evaluate the effect of dietary supplementation with different levels of zinc (0, 50, 75, 100 mg/kg diet) on semen quality of Cobb500 broiler breeder males. The four experimental diets were as follows: T1 = the basal diet (control) without any addition (0 Zn). T2 = 50 mg Zn (pure zinc)/kg diet. T3 = 75 mg Zn (pure zinc)/kg diet T4 = 100 mg Zn (pure zinc)/kg diet. The results showed that, Zinc supplementation had significantly ($p<0.05$) increased spermatocrit, ejaculate volume, mass motility, individual motility, while dead, abnormal sperm percentage and acrosome deformities were depressed ($p<0.05$) as affected by zinc supplementation throughout study. As well as, dietary treatments influenced sperm concentration and ejaculate volume during the experimental long. Moreover, results also revealed the superiority ($p<0.05$) of dietary treatments as compared with control group in respect of total mean of all semen quality.

Key words: Dietary supplementation, zinc, semen quality

INTRODUCTION

Several trace elements have been shown to be essential for testicular development and spermatogenesis; Zinc in human semen seems to play an important role in the physiology of spermatozoa. Zinc deficiency leads to gonadal dysfunction, decreases testicular weight and causes shrinkage of somniferous tubules. The gonads are the most rapidly growing tissues in the body and vital enzymes involved in nucleic acid and protein synthesis are zinc metalloenzymes (Bedwal and Bhauguna, 1994). The total zinc content in semen from mammals is high and zinc has been found to be critical to spermatogenesis. Deficiency of zinc associated with hypogonadism and insufficient development of secondary sex characteristics in humans (Prasad, 1991) and it can cause atrophy of the seminiferous tubules in the rat and hence failure in spermatogenesis (Millar *et al*., 1958; Underwood and Somer, 1977; Endre *et al*., 1990). High zinc concentrations have been reported to depress oxygen uptake in the sperm cell (Huacuja *et al*., 1973; Foresta *et al*., 1990) and albumin induced acrosome reaction (Foresta *et al*., 1990).

Head-tail attachment/detachment and nuclear chromatin condensation/decondensation are also influenced by seminal zinc (Kvist, 1980; Bjorndahl and Kvist, 1982). There have been conflicting reports on the effects of seminal zinc on sperm motility (Stankovic and Mikac-Devic, 1976; Danscher *et al*., 1978; Caldomone *et al*., 1979; Lewis-Jones *et al*., 1996). It has been demonstrated that chelating of zinc ions affects sperm motility (Saito *et al*., 1967; Danscher and Robbe, 1974) and it has been suggested that bioavailable zinc is bound to vesicular high molecular weight proteins rather than total seminal zinc should be a measure of the effect of zinc on sperm function (Bjorndahl *et al*., 1991; Carpino *et al*., 1998).

MATERIALS AND METHODS

This study was carried out at the Erbil Poultry Project, Erbil, Iraqi Kurdistan Region, Iraq during the period from 15th November 2008 to May 2009. A total number of (36) at 45 weeks old Cobb 500 broiler breeder's males were used. These birds were randomly distributed equally into four dietary treatments (T1 = the basal diet (control) without any addition (0 Zn). T2 = 50 mg Zn (pure zinc)/kg diet. T3 = 75 mg Zn (pure zinc)/kg diet T4 = 100 mg Zn (pure zinc)/kg diet) and each treatment was equally subdivided in to three replicates per group, each replicate constitutes 3 hens (9 males per group) on 12 floors pens. Birds were raised under similar environmental, managerial and veterinarian conditions. Birds were kept in a closed house; artificial lighting and drinking by nipples were provided through the experimental period (22 weeks). Commercial ration were provided for hen during experimental period. Birds were maintained for 16 hr light and 8 hr dark, also maintained hall temperature at (18-21°C) during the study period.

One type of zinc was used in the experiment: pure metal zinc. The imported zinc was obtained from Himedia - India, Himedia Laboratories. Ltd, Mumbai - India, by

Corresponding Author: Hazim J. Al-Daraji, Department of Animal Resources, College of Agriculture, University of Baghdad, Baghdad, Iraq

Table 1: Effect of supplemental dietary zinc on semen volume (ml) and Spermatocrit of Cobb 500 broiler breeder males at various age (Mean±SE)

Studied traits	Treatment	Age weeks 50	54	58	62	66	Total mean
SV (ml)	T1	0.570±0.198^{C}	0.666±0.150^{C}	0.670±0.318^{B}	0.558±0.106^{B}	0.543±0.224^{B}	0.601±0.20^{C}
	T2	0.760±0.797^{B}	0.677±0.130^{C}	0.690±0.251^{B}	0.551±0.254^{B}	0.530±0.165^{B}	0.641±0.32^{B}
	T3	0.813±0.710^{A}	0.850±0.220^{A}	0.870±0.168^{A}	0.760±0.208^{A}	0.770±0.173^{A}	0.813±0.29^{A}
	T4	0.826±0.210^{A}	0.796±0.188^{B}	0.701±0.511^{B}	0.790±0.366^{A}	0.780±0.111^{A}	0.778±0.27^{A}
Spermatocrit	T1	6.910±0.660^{C}	10.000±2.510^{B}	7.330±0.880^{C}	8.830±1.090^{C}	8.820±0.910^{B}	8.378±1.21^{B}
(%)	T2	11.660±1.200^{B}	15.000±1.000^{A}	12.660±1.850^{A}	14.830±0.160^{B}	14.000±2.300^{B}	13.630±1.30^{A}
	T3	14.330±2.840^{A}	16.330±1.200^{A}	9.330±2.900^{B}	13.830±2.160^{B}	11.830±1.160^{A}	13.130±2.05^{A}
	T4	11.600±1.330^{B}	14.660±2.400^{A}	11.000±1.000^{A}	18.000±1.600^{A}	12.660±0.800^{A}	13.580±1.42^{A}

T1 = Control 0 mg zn/kg diet, T2 = 50 mg zn/kg diet, T3 = 65 mg zn/lkg diet, T4 = 100 mg zn/kg diet. Means with common letter in a column are not significantly different ($p<0.05$). SV = Semen volume (ml)

Abu-Wail office (Health Street, Babul Muadham, Baghdad, Iraq).

Semen traits included in this study were semen volume, spermatocrit, sperm concentration, mass motility, individual motility, dead spermatozoa, abnormal spermatozoa, and acrosome deformities. The data of this experiment were analyzed statistically using the General Linear Models procedure of SAS (2000). Significant differences between treatment means are separated using the Duncan's multiple range test with 5% and 1% probability.

RESULTS AND DISCUSSION

Semen quality parameters: Means for some semen quality traits of all the zinc treatment groups and control group are presented in Table 1. Results showed that significant effect ($p<0.05$) of zinc supplementation (T3 and T4) on semen volume (ml) throughout the study and in total mean as compared with control group and T2, except at 58 week of age, which T4 had no significantly differ with T1 and T2, while T3 had highest value ($p<0.05$) in semen volume as compared with control group and the other experimental treatments (T2 and T4) at the same age, but there were no significant differences between T2 and T1 at 54, 58, 62 and 66 wk of age in semen volume. Significant differences were found between T1 and T3 in semen volume throughout the study. Total mean of ejaculate semen volume from 50 week to 66 week of age in T3 and T4 were increased significantly ($p<0.05$) as compared with control group and the dietary treatment (T2) with zinc supplementation. (0.813, 0.778) vs. (0.601, 0.641) respectively, also significant differences were found between T1 and T2, but no significant difference were found between (T3 and T4) in total mean semen volume (Table 1).

These results were in agreement with El-Masry *et al.* (1994) and Moce *et al.* (2000), who registered higher volumes ejaculates in animals supplemental Zinc (levels from 35 to 100 ppm) as compared to non - supplemented ones. In contrast, Oliveira *et al.* (2004) who reported that did not increase of mean volume ejaculate with supplemental dietary Zinc of rabbit breeders. The results of the present study also are in disagreement with Hong-Yu *et al.* (2006) who reported that there was no significant difference in ejaculate volume and sperm number of ejaculation and pH value ($p>0.05$) among fed with the different levels of Zinc to study the relationship between days of feed and seminal quality of ram. This amelioration in semen volume of supplemental dietary zinc or as total mean might directly be attributable to the increase in zn concentration in the diet which led to increase of testosterone concentration in blood plasma and other factors might possibly be involved in this variation in semen volume. The present study was involved in the feeding of 46 week old birds' cobb500 broiler breeders with zn for 24 weeks. It is probable that the animals might have enough time to respond of zn supplementation. Also, significant difference among the treatments in semen volume may be due to semen collection method, personality experience and the bird condition. Moreover, wide individual differences in seminal fluid production were attributed to variance in seminal fluid excreting from deferens (Cecil and Bakst, 1984). Data of Spermatocrit% (Table 2) showed that the differences between the dietary treatments groups (T2, T3 and T4) and control group were significantly increased ($p<0.05$) from 50 week of age to 66 wk of age, but there was no significant difference ($p>0.05$) between dietary treatments: T2 (50 mg Zn/kg diet) and T4 (100 mg Zn/kg diet) at 50 and 58 week of age. No significant differences were found between dietary treatments (T2 and T3) in Spermatocrit % at 62 wk of ages.

Also, there were no significant differences observed among dietary treatments in Spermatocrit % values at 54 week of age and in a total mean. On the other hand, as total mean of Spermatocrit % significant effect ($p<0.05$) was observed between experimental treatments as compared with control group (13.63, 13.13 and 13.58) vs. (8.378). This amelioration ($p<0.05$) in Spermatocrit % for these broiler breeder males fed on diet supplemented with zinc could be related to significant increment of testosterone concentration and also due to improvement of testis weight, somniferous tubules

Table 2: Effect of supplemental dietary zinc on semen quality parameters of Cobb 500 broiler breeder males at various ages (Mean±SE)

	Treatments							
	54 week of age				58 week of age			
Items	T1	T2	T3	T4	T1	T2	T3	T4
Sperm concentration (sperm x 10^9/ml)	0.94±0.381^C	1.293±0.993^B	2.18±0.738^A	2.833±1.071^A	2.27±0.245^C	3.540±0.762^A	3.426±0.826^A	2.713±0.306^B
Mass motility (%)	61.66±0.880^C	77.660±0.880^A	68.66±5.780^B	70.330±7.880^B	68.50±2.170^B	79.160±4.400^A	80.000±2.500^A	81.660±4.640^A
Individual motility (%)	63.33±0.880^C	78.330±0.880^A	72.33±5.040^B	70.660±7.310^B	65.66±2.960^B	80.000±3.780^A	80.660±1.850^A	82.330±3.710^A
Dead spermatozoa (%)	14.33±0.330^A	7.000±1.250^B	7.83±2.080^B	7.660±4.040^B	18.08±0.660^A	7.330±0.660^C	8.330±2.200^C	16.500±5.220^B
Abnormal spermatozoa (%)	20.00±2.880^A	18.330±3.330^B	14.33±2.330^B	15.000±2.880^C	25.00±0.000^A	18.330±4.400^B	13.330±2.200^B	15.000±0.000^B
Acrosome deformities (%)	15.83±4.600^A	12.160±5.460^B	9.00±2.080^C	8.830±0.830^C	17.50±1.440^A	13.330±1.660^B	10.830±3.000^C	9.930±0.830^C

	Treatments							
	62 week of age				66 week of age			
Items	T1	T2	T3	T4	T1	T2	T3	T4
Sperm concentration (sperm x 10^9/ml)	0.533±0.144^D	1.556±0.555^C	3.100±0.871^A	2.633±1.41^B	0.933±0.32^C	1.833±0.437^A	1.866±0.933^A	1.00±0.346^B
Mass motility (%)	74.000±9.450^B	82.330±5.620^A	83.330±7.260^A	86.660±1.66^B	67.500±2.88^C	83.330±4.400^A	81.660±1.660^A	75.83±2.200^B
Individual motility (%)	75.010±2.880^B	84.230±4.400^A	84.000±1.450^A	88.330±2.33^A	70.000±5.77^B	82.330±4.330^A	83.670±6.660^A	81.33±1.450^A
Dead spermatozoa (%)	20.910±2.810^A	11.000±1.000^C	18.830±2.520^B	16.660±0.83^B	32.830±1.48^A	18.330±1.200^B	19.330±1.760^B	17.33±3.920^B
Abnormal spermatozoa (%)	17.330±1.450^A	14.500±2.500^B	13.330±1.660^B	13.330±1.66^B	15.830±1.66^A	11.160±2.200^B	10.000±0.000^B	10.83±0.830^B
Acrosome deformities (%)	14.160±0.830^A	10.000±0.600^B	9.160±1.660^B	11.330±0.83^B	13.330±3.33^A	11.110±0.830^B	11.660±1.660^B	11.66±1.130^B

	Treatments			
	Total means of semen quality			
Items	T1	T2	T3	T4
Sperm concentration (sperm x 10^9/ml)	1.169±0.758^B	2.055±1.014^A	2.671±0.780^A	2.294±0.867^A
Mass motility (%)	67.910±5.050^B	80.620±2.650^A	78.410±6.640^A	78.620±7.080^A
Individual motility (%)	68.500±5.140^B	81.220±2.590^A	80.160±5.430^A	80.660±7.350^A
Dead spermatozoa (%)	21.530±7.990^B	10.910±5.260^A	13.580±6.350^A	14.530±4.600^A
Abnormal spermatozoa (%)	19.540±4.020^B	15.330±3.210^A	10.490±6.350^A	13.540±1.970^A
Acrosome deformities (%)	15.200±1.850^B	11.650±1.420^A	10.160±1.290^A	10.410±1.270^A

T1 = Control 0 mg zn/kg diet, T2 = 50 mg zn/kg diet, T3 = 65 mg zn/kg diet, T4 = 100 mg zn/kg diet. Mean with common letter in a same row are not significantly different ($p<0.05$)

diameter or may be attributed to significant increment ($p<0.05$) of germinative cells thickness. Others semen quality parameters are: Mass and individual motility, spermatozoa concentration dead and abnormal spermatozoa and acrosome deformities are shown in Table 2. Results also revealed that birds fed the different dietary treatments with zinc had higher ($p<0.05$) sperm concentration, mass and individual motility (Table 2). Throughout the study, no significant differences were found between T3 and T4 at 54 wks of age in mass, individual motility and sperm concentration, as well as among T2, T3 and T4 at 58 and 62 wk of age in mass and individual motility.

No significant differences were found between T2 and T3 in sperm concentration at 66 wk of age. Whereas, dietary treatments revealed the significantly decrease ($p>0.05$) throughout the experimental periods on dead, abnormal spermatozoa and acrosome deformities as compared with control diet.

The best motility recorded of dietary treatments (T2, T3 and T4) in the current study throughout experimental period was observed at 58, 62 and 66 wk of age respectively (Table 2). This may be attributed to the highest semen concentration of dietary treatments during these ages respectively. Spermatozoa motility and sperm concentration were positively and significantly correlated (Soller *et al*., 1965; Saeid and Al-Soudi, 1975), or it is probable that these periods are to be fitting and animals might have enough time to respond of zinc supplemented.

Moreover, the best motility and semen concentration recorded in the present study during those periods (54, 62 and 66 wk of age) which were considered as cold months. Al-Darraji *et al*. (2001) reported that sperm motility reached maximum value during cold months. Highest motility was also reported to occur during winter and spring and lowest values was to occur during summer (Hurter, 1964). On the other hand, the highest and lower sperm motility for Newhampshire males were noted during autumn through winter and spring through summer respectively (Voronine and Zabolotskii, 1970).

Results also revealed that sperm concentrations were significantly affected (Table 2) of males fed diets supplemented with different levels of zinc, in which the dietary treatment showed highest values than the control group during the experimental period. In addition, there was no significant difference in sperm concentration among dietary treatments (T3 and T4) at 54 and 58 wk of age and between T2 and T3 at 66 wks of age.

Results in Table 2 also indicated, the superiority ($p<0.05$) of T3 at 62 wk and 66 wk of age and of T2 and T4 at 54 and 58 wk of age of broiler breeder cocks regarding the concentration of spermatozoa. No significant differences were found at 54 wk and 62 wk of age among all the experimental groups on normal spermatozoa. Also, no significant differences were observed at 54 and 58 wk of age also at 62 and 66 wk of age among the experimental groups (T2, T3 and T4) on live and abnormal spermatozoa as well as on abnormal and live spermatozoa respectively. No significant differences were showed among dietary treatments (T2, T3 and T4) at 62 and 66 wk of age in regarding the percentage of acrosome deformities (Table 2). Also, Dietary treatments: T3 and T4 at 54 and 58 wk of age showed no significant difference in acrosome deformities, but significant differences were found between T2 and the later treatments (T3 and T4) at the same age in respect of this parameter. On the other hand, supplemental dietary zinc (T2, T3 and T4) had a significant effect on total mean of all semen quality parameters as compared with control group and the differences among the dietary treatments were not significant in respect of these characteristics. Saeid and Al-Soudi (1975) found a significant ($p<0.01$) positive correlation between percentage of dead and abnormal sperm. This indicates that conditions causing an increase in sperm mortality or abnormality probably responsible for increasing abnormality (Al-Darraji *et al*., 2001). Also, Hong-Yu *et al*. (2006) deduced that there was significant difference in sperm vitality and sperm abnormality ($p<0.05$) among the different levels of zinc added to diet of ram. Jian-bin *et al*. (2007) reported that there was no significant difference on survival state and live index of semen ($p>0.05$), the density of sperm in trial group I (60 mg Zn/kg diet) was significantly lower than that of the trial group II (180 mg Zn/diet) ($p<0.01$). As revealed in our study, zinc supplementation of broiler breeder males ameliorate mass and individual motility and decrease dead and abnormal sperms. This may be due to zincs role on depress oxygen uptake. Therefore, Zn may function as a metabolic inhibitor in turkey semen, therefore decreasing sperm motility and prolonging survivability in the sperm storage tubules (Bakst, 1985; Bakst and Richards, 1985). On the other hand, Calvin *et al*. (1975) found that Zn is concentrated in the tail region of the sperm. Also, studies showed that Zn is crucial in membrane stability and for mechanical properties of accessory fibers, tail morphology and sperm motility (Swarup and Sekhon, 1976). Jian-bin *et al*. (2007) reported that there was no significant difference on survival state and live index of semen ($p>0.05$), the density of sperm in trial group I (60 mg Zn/ kg diet) was significantly lower than that of the trial group II (180 mg Zn/diet) ($p<0.01$).

As revealed in this study, zinc supplementation of broiler breeder males ameliorate mass and individual motility and decrease dead and abnormal sperms. This may be due to zincs role on depress oxygen uptake. Therefore, Zn may function as a metabolic inhibitor in turkey semen, therefore decreasing sperm motility and prolonging survivability in the sperm storage tubules (Bakst, 1985; Bakst and Richards, 1985). On the other

hand, Calvin *et al.* (1975) found that Zn is concentrated in the tail region of the sperm. Also, studies showed that Zn is crucial in membrane stability and for mechanical properties of accessory fibers, tail morphology and sperm motility (Swarup and Sekhon, 1976).

It has also been shown that Zn is involved in the control of sperm motility through its association with ATP in contraction and its regulation of phospholipids energy reserves (Hidiroglou and Knipfel, 1984). Moreover, this amelioration of semen quality parameters may be attributed to the decrease of seminal plasma glucose, which was positively correlated with spermatozoa activity and its metabolism. In a study by Jianguo and Zhinian (1990) on 12 study Holestein bull were chosen to measure the testosterone concentration in serum and seminal plasma by (125)1 Radioimmuno-Assay (RIA) and correlation between testosterone levels and semen quality. The results showed that significant differences were found between individuals, the testosterone concentration was positively correlated with the semen quality. Furthermore, data of semen quality (Table 2) showed that the differences among all the experimental groups at 62 wk and 66 wk of age were not significant and the control group gave the highest increase in acrosome deformities than the other experimental groups throughout experimental period. On the other hand, least percentage of acrosome deformities was recorded by T4 at the 54 wk of age in this study (8.83) versus control group (15.83). Significant differences were found between T2 and T3 and between T4 and T2 at 54 and 58 of age in acrosome deformities, but there were no significant differences between experimental treatments (T2 and T3 and T4) at 62 and 66 wk of age, which revealed that they had significantly decreased as compared with control group in respect of this parameter (acrosome deformities).

Hang *et al.* (2006) deduced that the rate of acrosome intactness in sperm with normal morphology group was higher than that of sperm with abnormal morphology group ($p<0.01$). The comparisons between normal sperm density group and abnormal density group showed that the rate of acrosome intactness was not significantly different ($p>0.05$). The rate of sperm with normal morphology in normal acrosome intactness rate group was higher than that of abnormal acrosome intactness rate group ($p<0.01$). It is concluded that there were close relationships between the rate of sperm with normal morphology and the rate of acrosome intactness in men.

REFERENCES

Al-Darraji, H.J., D.H. Al-Hassani, B.T.O. Al-Tikriti and M.H. Abd Alabbass, 2001. The influence of breed and season on semen quality of cocks. IPA. J. Agric. Res., 11: 152-162.

Bakst, M.R. and M.P. Richards, 1985. Concentration of selected cations in turkey serum and oviductal mucosae. Poult. Sci., 64: 555-563.

Bakst, M.R., 1985. Zinc reduces turkey sperm oxygen uptake *in vitro*. Poult. Sci., 64: 564-566.

Bedwal, R.S. and A. Bhauguna, 1994. Zinc, copper and selenium in reproduction. Experimentia, 50: 626-640.

Bjorndahl, L. and U. Kvist, 1982. Importance of zinc for human head tail connection. Acta Physiol. Scand., 116: 51-55.

Bjorndahl, L., S. Kjellberg and U. Kvist, 1991. Ejaculatory sequence in men with low sperm chromatin-zinc. Int. J. Androl., 14: 174-178.

Caldomone, A.A., M.K. Freytag and A.T. Cockett, 1979. Seminal zinc and male fertility. Urology, 13: 280-281.

Calvin, H.I., F.H. Hwang and H. Wohlrab, 1975. Localization of zinc in a dense fibre - connecting piece fraction of rat sperm tails analogous chemically to hair keratin. Biol. Reprod., 13: 228-239.

Carpino, A., L. Siciliano and M.F. Petrone, 1998. Low seminal zinc bound to high molecular weight proteins in as the nozoospermic patients: Evidence of increased sperm zinc content in oligoasthenozoospermic patients. Hum. Reprod., 13: 111-114.

Cecil, H.C. and M.R. Bakst, 1984. Testicular weights, ductus deferens, semen volumes and sperm concentration of turkeys with high and low ejaculate volumes. Poult. Sci., 63: 1432-1437.

Danscher, G. and H. Robbe, 1974. Effects of two chelating agents, oxine and diethyl dithio carbamate (antabuse), on stainability and motility of human sperms. J. Histochem. Cytochem., 22: 981-985.

Danscher, G., R. Hammen and E. Fjerdingstad, 1978. Zinc content of human ejaculate and the motiliuty of sperm cells. Int. J. Androl., 1: 576-581.

El-Masry, K.A., A.S. Nasr and T.H. Kamal, 1994. Influences of season and dietary supplementation with selenium and vitamin E or zinc on some blood constituents and semen quality of new Zealand white rabbit males. World Rab. Sci., 1: 79-86.

Endre, L., F. Beck and A. Prasad, 1990. The role of zinc in human health. J. Trace Elem. Exp. Med., 3: 333-375.

Foresta, C., E. De Carlo and M. Zorzi, 1990. Possible significance of seminal zinc on human spermatozoa functions. Acta Eur. Fertil., 21: 305-308.

Hang, G., L. Rui-Zhi and S. Yan, 2006. The correlation between rate of acrosome intactness and rate of sperm with normal morphology and sperm density. Maternal and child health Care of China, 05, 041. www.Cnki. comm.on.

Hidiroglou, M. and J.E. Knipfel, 1984. Zinc in mammalian sperm: A review. J. Dairy. Sci., 1: 1175-1185.

Hong - Yu, Liu, J. Yuan and R. Yang, 2006. Relationship between zinc and seminal quality of ram. J. Anhui Agri. Sci., 17: 063, Beijing, China (Abstr.).

Huacuja, L., A. Sosa and N.M. Delgado, 1973. A kinetic study of the participation of zinc human spermatozoa metabolism. Life Sci., pp: 1383-1394.

Hurter, K.P., 1964. Investigation on the influence of season on spermatogenesis in the domestic fowl with particular reference to morphologically altered spermatozoa. Vet. Med. Dissertation. Tievaraztl. Hochsch. Honover., pp: 71.

Jian-bin, Liu, Li, Da-di and Y. Bo-hui, 2007. Effect of dietary zinc level on production performance and semen quality of roosters. Acta Ecologiue Animalis Domastici, 4. (Abstr.).

Jianguo, L. and I. Zhinian, 1990. Studies on the correlation between testosterone levels in serum and seminal plasma and semen quality. In 1 stud Bull. J. Agric. Univ. Hebei, 2: 14 China.

Kvist, U., 1980. Sperm nuclear chromatinde condensation ability. An *in vitro* study on study ejaculated human spermatozoa. Acta Physiol. Scand. Suppl., 486: 1-24.

Lewis-Jones, D.I., I.A. Aird and M.M. Biljan, 1996. Effect of sperm activity on zinc and fructose concentration in seminal plasma. Hum. Reprod., 11: 2465-2467.

Millar, M.J., M.I. Fischer and P.V. Elcoot, 1958. The effect of dietary zinc deficiency on three productive system of the male rat. Can. J. Biochem. Physiol., 36: 557-569.

Moce, E., M. Arouca, R. Lavara and J.J. Pascual, 2000. Effect of dietary zinc and vitamin supplementation on semen characteristics of high growth rate males during summer season. In : Word Rabbit Congress, 7, Valencia. Proceedings. Valencia, (S.N.). CD-Rom.

Oliveira, C.E., C.A. Badu, W.M. Ferreira, E.B. Ka Mwa and A.M.Q. Lana, 2004. Effects of dietary zinc supplementation on spermatic characteristics of rabbit breeders. Procedings 8th World Rabbit Congress - September, 7-10, Puebla, Mexico.

Prasad, A.S., 1991. Discovery of humen zinc deficiency and studies in an experimental human model. Am. J. Clin. Nutr., 53: 403-412.

SAS, 2000. SAS / STAT User's Guide, Version 6.12. SAS. Inst. Inc., Tekirdag, Turkey. Pp. 32-57.

Saeid, J.M. and K.A. Al-Soudi, 1975. Seasonal variation in semen characteristics of white leghorn, New Hampshire and indigenous chicken in Iraq. Br. Poult. Sci., 16: 97-102.

Saito, S., I.M. Bush and W.F.J. Whitmore, 1967. Effects of certain metals and chelating agents on rat and dog opididymal spermatozoan motility. Fertil. Steril., 18: 517-529.

Soller, M., N. Snapir and H. Schindler, 1965. Heritability of semen quantity, concentration and motility in White Rock roosters and their genetic correlation with rate of gain. Poult. Sci., 44: 1527-1529.

Stankovic, H. and D. Mikac-Devic, 1976. Zinc and copper in human semen. Clin. Chim. Acta, 70: 123-126.

Swarup, D. and Sekhon, 1976. Correlation of vitamin A and zinc concentration of seminal plasma to fertility of bovine semen. Nutr. Rep. Int., 13: 37-42.

Underwood, E.J. and M. Somer, 1977. Zinc: Trace Elements in Human and Animal Nutrition, 4th Edn., Academic Press, New York, pp: 196-242.

Voronine, M.S. and V.M. Zabolotskii, 1970. An investigation of semen quality in new Hampshire cocks. Razu. Genet. Sel. Khoz. Zhivot., 14: 124-129 (Russ).