The effects of organic and inorganic zinc supplemented in breeder hens' rations on hatching traits and chick quality (II)*

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Abstract: In the study, the effects of different forms of organic and inorganic zinc minerals supplemented to rations of breeding laying hens were investigated on hatching traits and chick quality. The study was conducted in Ankara Poultry Research Institute and laying line was composed of 216 Barred Rock hens with 18 Rhode Island Red roosters. The study initiated with 48 weeks of age hens and continued for 16 weeks. Totally 6 experimental group was formed by adding different forms of organic or inorganic zinc minerals in rations. The control and experimental group rations were composed of 17% crude protein and 2800 kcal/kg metabolizable energy. The control group rations were prepared by using zinc-free mineral mix. In addition to non-zinc group, the first, second, third, fourth and fifth groups received respectively 60 mg/kg of Zinc-Avila, $ZnSO_4$, Zinco-RedoxMin, ZnO and $ZnCl_2$. According to our results, 60 mg/kg zinc supplementation did not affect the hatching power, fertility and mortality rates whereas 60 mg/kg Zn-RedoxMin supplementation improved the chick quality and weight ($p<0.05$). However, chick conversion rate was not influenced.

Keywords: Hatching traits, organic and inorganic zinc, breeder hens

Damızlık yumurta tavuğu rasyonlarına organik ve inorganik çinko ilavesinin kuluçka özellikleri ve civciv kalitesi üzerine etkileri

Öz: Bu araştırmada, damızlık yumurta tavuğu rasyonlarına farklı formda organik ve inorganik çinko ilavesinin kuluçka özellikleri ve civciv kalitesi üzerine etkileri araştırılmıştır. Araştırma Ankara Tavukçuluk Araştırma Enstitüsü'nde yürütülmüş ve araştırmanın hayvan materyalini, toplam 216 adet Barred Rock tavuğu ile 18 adet Rhode Island Red horozu, yumurtacı hattı oluşturmuştur. Denemeye 48 haftalık yaşta başlanmış ve 16 hafta sürdürülmüştür. Rasyona farklı formda organik veya inorganik çinko ilavesi yapılarak 6 deneme grubu oluşturulmuştur. Kontrol ve deneme grupları rasyonları ortalama % 17 ham protein ve 2800 kcal/kg metabolik enerji içerecek şekilde düzenlenmiştir. Kontrol grubu çinko içermeyen mineral karması ile hazırlanmıştır. Çinko içermeyen gruba ek olarak, birinci gruba 60 mg/kg Çinko-Avila, ikinci gruba $ZnSO_4$, üçüncü gruba Çinko-RedoxMin, dördüncü gruba ZnO, beşinci gruba $ZnCl_2$ katılmıştır. Araştırma rasyonuna farklı formda 60 mg/kg çinko ilavesinin yumurtadan çıkış gücü, döllülük oranı ve

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ölüm oranını etkilemediği, 60 mg/kg Zn-RedoxMin'in civciv kalitesi ve ağırlığını iyileştirdiği (P<0.05), civcive dönüşüm oranını etkilemediği sonucuna varılmıştır.

Anahtar sözcükler: Kuluçka özellikleri, organik- inorganik çinko, damızlık tavuk

Introduction

In breeder laying hens, nutrient requirements significantly affect the optimal reproductive performance, embryogenesis and output power. Malnutrition in female breeders negatively influences the normal embryo and chick development and malnutrition in male breeders leads to the decrease in the quality of semen and mating activities (23). Therefore, breeder poultries are fed in order to maintain the egg yield, protect their health and produce fertilized eggs which provide all nutrients needed for the chick development (14). In addition to feeding breeder hens with nutrient rich rations, it has recently been emphasized that nutrients with trace minerals also affect the yield of breeders.

Zinc is an essential mineral for all farm animals and it is the mineral among others which has the higher biological activity. This element is important for growth (5), intracellular functions, strengthening of the immune system, protein synthesis, and carbohydrate metabolism, acid-base balance of the organism, fertility, infertility and in various enzyme structures (20,21). Meanwhile, it is also important for hormonal functions (6) and bone development (13,16). Increased levels of pure Zn supplementation significantly increased the ratio of fertilized eggs, hatching power of the eggs laid in the incubation, hatching power from fertilized eggs, and the penetration of sperms into the egg ($p<0.05$) whereas it decreases the embryonic death rate (2).

Organic and inorganic Mn, Zn, Cu and Cr mixture supplementation did not lead to the significant difference between groups in terms of vitality, fertilized eggs and hatching rates. However, high levels of organic (methionine chelate) Mn, Zn, Cu and Cr (respectively; 80, 60, 5 and 0.15 mg/kg) significantly increased the hatching power and hatchability (P<0.05) (24). Increasing levels of pure (elemental) Zn supplementation (0, 50, 75 and 100 mg/kg Zn) significantly increased the rate of fertilized egg and hatchability (2) ($p<0.05$), decreased the embryonic death in breeder broiler laying hens. Supplementation of Zn did not affect the fertilized egg rate and hatching power in Breeder White-Leghorn laying hens (19). The aim of this study is to examine the effects of the addition of organic and inorganic forms of zinc in breeder laying hen rations on hatching traits and chick quality.

Materials and Methods

Animal Samples: In this study, Barred Rock-1 (BAR-1) hens belonging to the mother line and Rhode Island Red-1(RIR-1) cocks belonging to the father line were used. These brown color hens were 48 weeks of age and they were obtained from Ankara Poultry Research Institute. Totally 216 BAR-1 hens and 18 RIR-1 roosters were used in the study.

Feed Material: The main ration was used and its feed composition is summarized in Table 1. The second period ration of the laying hen contained 17% HP and 2800kcal/kg ME according to the report of NRC (15). Inorganic zinc minerals which were added to the feed were supplied from a foreign commercial firm (Merck) and organic zinc mineral were supplied from the local commercial firm.

Table 1: The composition of the basic ration of laying hens used in the study

Tablo 1: *Çalışmada kullanılan rasyon bileşenleri*

Ingredients	(%)
Corn	52.65
Full-fat bean	17.40
Soybean meal	6.59
Sunflower meal	8.47
Corn gluten meal	2.33
Limestone	10.20
Dicalcium phosphate	1.5
Salt	0.35
DL-Methionine	0.11
Vitamin premix[1]	0.1
Mineral premix[2]	0.1
Salmonella prevention	0.2
Total	100

[1]Each 2.5 kg feeds contains: Vit A 12.000.000 IU; Vit D_3 2.400.000 IU; Vit E 30.000 IU; Vit K_3 2.500 mg; Vit B_1 3.000 mg; Vit 7.000 mg; Niasin 20.000 mg; Cal- D-pant 6.000 mg; Vit B_6 4.000 mg; Vit B_{12} 15 mg; Folic Acid 1000 mg; D-Biotin 45 mg; Cholin chlorid 125.000 mg and Vit C 50.000 mg.[2] Each 1 kg feeds contains: Mn 80.000 mg; Fe 40.000 mg; Zn 60.000 mg; Cu 5.000 mg; Co 500 mg; I 2000 mg; Se 150 mg

Trial Scheme: Totally 216 hens were randomly put in 3-storey compact type individual cages. There were 6 group and 4 subgroups of hens. In each subgroup, there were 9 hens. Totally 1300 cm^2 area was provided per hen in individuals' cages. Cage system was vertically divided into 24 parcels and three hens were placed on each floor of the same parcel. Study groups and hens were randomly distributed to the parcels. The study continued for 16 weeks. The trial scheme can be seen in Table 2. The study was performed in Ankara Poultry Research Institute. Hens were fed in a group. In the study, mainly corn-soy feed was used. Feeds and water were provided as *ad libitum* and 14 hours lightening per day including the day light was provided to hens.

Table 2: Trial scheme

Tablo 2: *Deneme planı*

Treatment groups	**Supplement**
Control	Non supplement Zn
Zn-Avila	Organic 60 ppm Zn suppl.
$ZnSO_4.7H_2O$	Inorganic 60 ppm Zn suppl.
Zn-RedoxMin	Organic 60 ppm Zn suppl.
ZnO	Inorganic 60 ppm Zn suppl.
$ZnCl_2$	Inorganic 60 ppm Zn suppl.

Feed analysis: Nutritional analysis of raw materials of trial feeds were analyzed in Ankara Poultry Research Institute Laboratory. Trial mixed feeds were prepared according to the results of these analyses. Raw feed materials, sugar, starch analyses were determined according to methods specified by AOAC (3). Metabolizable energy levels were determined by using data of the study performed by Vogt et al. (22).

Hatching parameters: Sperms of cocks in each group were collected in tubes and artificial insemination was performed in breeder hens with the help of injecting the sperms in individual cages. Upon insemination, eggs of each hen were marked and all eggs were left in the incubator under appropriate conditions for 7 days in accordance with pedigree system. Fertilization control was performed for eggs which were left for 18 days in the incubator and unfertilized or death embryos were removed. Eggs which were transferred to the hatching machine and features which are written below were determined upon hatching. Hatching traits were repeated four times as in the 4., 8., 12. and 16. weeks of the study.

Hatchability: (the number of alive chicks coming out of the egg /the total number of eggs placed in incubators)*100

Hatching Power: (the number of alive chicks coming out of the egg/number of fertilized eggs placed in incubation)*100

Early embryo deaths: (the number of death embryos in the 0-6 days of hatching/the number of fertilized eggs)*100

Mid-term embryo deaths: (the number of death embryos in the 6-19 days of hatching/ the number of fertilized eggs)*100

Late (under eggshell) embryo deaths: (the number of death embryos in the 19-21 days of hatching/the number of fertilized eggs)*100

Chick Quality Parameters: Criteria for chick quality were calculated by assessing the characteristics which were determined by Pasgar score (4). The highest level was accepted as 10 points. Categories for agility, belly, legs and beak were recorded and 1 point was subtracted from total scores for each abnormality. All female chicks were evaluated in terms of quality criteria and the score of each chick was summed, divided to the number of chicks and finally mean scores of groups were calculated.

Chick Weight: All of the healthy chicks which came out of eggs were weighed as subgroups and mean chick weight was calculated.

Chick Conversion Rate: It was calculated as percentage. The calculation was made by dividing the mean chick weight to the initial egg weight.

Statistical Analysis: In order to perform statistical analyses, Minitab 17 statistics program was used. The importance control of the difference between groups were determined by using one way variance analysis (one-way ANOVA) and Tukey multiple comparison test was performed in order to determine which groups were significantly different than others. When p value was lower than 0.05 ($p<0.05$), it was accepted as statistically significant. Data were represented as mean±standard error (SEM).

Results

The second period nutrient amounts of the ration and the metabolic energy values of the hen which was used in the study can be seen in Table 3.

Table 3: Metabolizable energy values and amounts of nutrients used in the ration

Tablo 3: *Rasyonda kullanılan bileşenler ve metabolize enerji miktarları*

Chemical Analysis	
Dry Matter,%[3]	91.2
Crude Protein,%[3]	16.9
Crude Fiber,%[3]	3.5
Crude Ash,%[3]	12.8
Ether Extract,%[3]	5.5
ME,kcal/kg[3]	2835
Ca, %	4.1
Digest. P,%	0.38
Methionine,%	0.40
Met.+cystine,%	0.72
Lysin,%	0.80
Tryptophane,%	0.19
Linoleic acid,%	2.71
Zinc, ppm	60

[3] *Calculated by using values of analyses.*

Results of hatchability were separately evaluated and hatching power and fertility rate assessments can be seen in Table 4. Accordingly, there was no statistical significant difference between study groups.

Table 4: Effects of different forms of zinc supplementation on the fertility rate and hatching power

Tablo 4: *Farklı çinko takviye formlarının fertilite oranı ve kuluçkadan çıkma gücüne etkileri*

Treatment Groups	N	Fertility Rate(%) X±Sx	Hatching power (%) X±Sx
Control	16	93.26±5.15	94.97±4.17
Zn-Avila	16	90.28±5.95	94.79±3.65
$ZnSO_4.7H_2O$	16	92.26±3.59	95.02±3.09
Zn-RedoxMin	16	92.77±4.22	94.17±3.73
ZnO	16	92.54±4.12	96.05±2.15
$ZnCl_2$	16	91.05±4.57	94.02±4.22
P		0.458[-]	0.654[-]

-: The difference between groups was not statistically significant (p>0.05).

In Table 5, the early, mid-term and late death rates related to hatchability were shown. Accordingly, there was no statistical significance between group in terms of performances which were emphasized (p>0.05).

Table 5. Effects of different forms of zinc supplementation on early, mid-term or late death rates

Tablo 5: *Farklı çinko takviye formlarının erken, orta ve uzun dönem ölüm oranlarına etkisi*

Treatment Groups	N	Early Term (%)	Mid-Term (%)	Late-Term (%)
		X±Sx	X±Sx	X±Sx
Control	16	3.81±3.78	0.43±1.21	4.31±3.91
Zn-Avila	16	5.79±4.69	0.78±1.21	3.89±3.28
$ZnSO_4.7H_2O$	16	4.46±3.38	0.56±1.28	3.82±3.07
Zn-RedoxMin	16	3.33±3.57	0.49±1.42	4.69±3.69
ZnO	16	4.99±3.46	0.42±0.91	2.98±1.99
$ZnCl_2$	16	4.17±4.05	0.70±1.26	3.9±2.86
P		0.538-	0.949-	0.766-

-: The difference between groups was not statistically significant (p>0.05).

Chick quality, chick weight and chick conversion rate were evaluated and the conclusions were summarized in Table 6. In the study, chick weight and quality were significantly affected by the source of Zn whether it was in the inorganic or organic forms ($p<0.05$). Chick weight and quality values were higher in a group fed by organic Zinc (Zinc-RedoxMin) compared to others. There was no significant difference between study groups in terms of chick conversion rate ($p>0.05$).

Table 6: Effects of different forms of zinc supplementation on chick quality, chick weight and chick conversion rate

Tablo 6: *Farklı çinko takviye formlarının tavuk kalite, ağırlık ve yararlanma oranlarına etkileri*

Treatment Groups	N	Chick Quality	Chick Weight (g)	Chick Conversion Rate (%)
		X±Sx	X±Sx	X±Sx
Control	16	$9.06±0.24^b$	$35.82±1.8^b$	61.09±1.90
Zn-Avila	16	$9.37±0.25^{ab}$	$35.87±1.33^b$	61.27±1.59
$ZnSO_4.7H_2O$	16	$9.21±0.25^b$	$35.87±1.0^b$	60.79±1.98
Zn-RedoxMin	16	$9.78±0.98^a$	$37.17±0.79^a$	62.12±2.09
ZnO	16	$9.25±0.26^b$	$35.86±1.06^b$	60.97±1.45
$ZnCl_2$	16	$9.49±0.22^{ab}$	$36.58±1.41^{ab}$	61.22±1.83
P		0.001*	0,003*	0.405

*a,b: the difference between values which are represented with different letters in the same column is statistically significant. *:p<0.01*

Discussion and Conclusion

Different forms of zinc supplementation in feed of laying hens did not show any effects on fertilized egg rate, hatching power and embryonic deaths ($p>0.05$). The results obtained about hatching parameters are as follows; Abdullah et al. (1) performed a study on hatching parameters of laying hens and showed that Zn supplementation level in the ration of breeder White-Legnorn laying hens did not influence the fertilized egg ratio and hatching power and these results were also similar to findings of study performed by Stahl et al. (19). Kidd et al. (11) also found no significant difference in fertilization and hatching rate when 80mg/kg supplementation of Zn in the form of ZnO or Z-methionine. Similarly, it was observed in another study that 160 mg/kg Zn supplementation in the form of $ZnSO_4$, and Zn amino acid (AvilaZn) or the equal mixture of these two forms to the basal ration containing 40mg/kg Zn did not affect the fertilization and hatching rates of breeder broilers (8).

In order to detect the effects of Zn supplementation on fertilization performance and the immune system of chicks in rations of breeder broilers, ZnO and Zn methionine were supplemented to corn-soybean meal or sorghum-corn-soybean meal based rations. Zn added to both rations did not influence the fertilized egg ratio, hatching power, chick hatching weight and immunity parameters (13). In breeder broilers (9), 100mg/kg Zn supplementation in the ration which was containing already 75mg/kg Zn increased the egg yield and chick production and decreased the rate of non-classified eggs. Zn level in breeder broiler rations had no or little effect on fertilization yield and growth. It was determined that the Zn supplementation increased the immunity of chicks and the resistance of them against diseases.

Unlike these findings, Shrivastav and Shukla (18) showed that Zn level of the ration did not influence the fertilized egg ratio significantly and hatching power was the maximum and embryo deaths were the minimum in a group fed with rations containing 75 and 100 mg/kg Znin quail. Similar results were also found in the study of Amen and El-Daraji (2) in which they examined the effects of Zn supplementation in the ration of laying hens on hatching traits. In this study (2), increasing amounts of Zn were added to rations and it significantly increased the fertilizer egg ratio, hatching power of eggs which were incubated, hatching power of fertilized eggs and penetration of the sperm into the egg ($p<0.05$) and decreased the embryonic death rate in broiler breeder chicken.

In a study, which was conducted with Cobb type of female breeders fed with control group rations containing inorganic minerals (Se-0.3 ppm, Zn-100 ppm and Mn-100 ppm) and study group corn-soybean pulp based rations containing organic minerals (Se-0.2 ppm, Zn- 30 ppm and Mn- 30 ppm). Embryo determination was performed for eggs obtained from control and study groups. The maximum fertilization and hatching performance and the minimum embryonic death were observed in groups who were fed with organic minerals (17).

It was found that different trace mineral applications did not affect the hatching and fertilized egg ratio. However, high levels of organic (methionine chelate) Mn, Zn, Cu and Cr (respectively; 80, 60, 5 ve 0.15 mg/

kg) significantly increased the hatching power and hatching performance ($p<0.05$) (24). Differences in hatching parameters between this study and some other studies can be explained by the application of the insemination technique in order to obtain fertilized eggs.

In this study, chick quality and chick conversion rate values were found similar to results of other studies. In the study of Flinchum et al. (7), the study groups of aged hens were fed with basal rations with 100 mg/kg Zn which were additionally supplemented with 40 or 80 mg/kg Zn (in the form of Zn-methionine). The hatching chick weights and 4 weeks live weight increments were significantly higher in a study group compared to control group. The results of the study performed by Kidd et al. (10) in which they determined the effects of supplementation of Zn in the breeder broiler rations on chick performances and immune system of chicks were in accordance with results of our study. Organic Zn methionine supplementation increased the live weights of chicks and these findings were similar to results of the current study.

Unlike these results, Stahl et al. (19) found that Zn supplementation in the rations of parents did not affect the live weight and chick quality.

Effects of the addition of different organic and inorganic 60 mg/kg zinc sources in Barred Rock brown laying hen rations on the hatching performance and chick quality egg quality were examined. According to results of the study, it was shown that there was no significant difference between study groups in terms of the fertilized egg ratio, hatching power, hatching, embryonic deaths and chick conversion rate. Chick weight and chick quality of groups fed with organic zinc (Zinc-RedoxMin) were higher compared to other groups. As a result of the study, it was concluded that the effects of different organic Zn supplements on the breeder laying hen rations should be examined.

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