



## Effects of dietary zinc supplementation during a forced molt on subsequent hen performance and egg quality

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### Abstract

A total of 200 Hy-Line Brown commercial layer hens (64 weeks of age), were used in this study to investigate the impacts of different dietary zinc supplementation during a forced molt on subsequent hen performance and egg quality. The hens were randomly divided into (5) treatment groups of 40 hens each treatment. There were four replicate cages per treatment. The hens in the treatment 1 (control) were fed a layer ration containing 0 ppm ZnO, water and feed were provided *ad libitum* and received 16 hours of light/day, treatment (2) were fed a layer ration containing 28000 ppm Zn as zinc oxide for 11 days, treatment (3) 37000 ppm ZnO for 9 days, treatment (4) 46000 ppm ZnO for 7 days, and treatment (5) on-again, off-again program (ON-OFF). The experimental period was divided into seven periods (1) 64-66, (2) 67-69, (3) 70-72, (4) 73-75, (5) 76-78, (6) 79-81, (7) 82-84 weeks. The results indicated that different levels of dietary zinc were improved Hen Day (H.D) egg production and egg weight at periods 70-72, 73-75, 76-78, 79-81, 82-84 weeks, except treatment 37000 ppm ZnO in period 70-72 was reduced in both egg production and egg weight, yolk and white weight improved also in these five periods above, feed intake was improved in two periods 70-72 and 73-75 weeks, feed conversion ratio was decreased in two periods 73-75 and 76-78 weeks, compared to both control and ON-OFF program. Haugh unit was improved in dietary zinc treatments and ON-OFF program in all periods except period 64-66 weeks compared to control. The percentage of weight loss was increased in the period 64-67 weeks for all treatments except control. Different dietary zinc supplementation was increased the concentration of zinc in yolk from 10.20 ppm (control) to 32.84, 29.61 and 51.08 and, white from 3.50 ppm (control) to 5.96, 5.90 and 6.37 ppm for 28000, 37000 and 46000 ppm during fed them with Zn for 11, 9 and 7 days, respectively, but the concentration of zinc in yolk and white was reduced week by week after following the refeeding of a control diet and was normally by week 6.

### Introduction

Egg production and quality, decline significantly at the end of the laying cycle, and consequently force molting that has been used by the producers to improve performance. Quality and egg production improve significantly after the molting period compared to the premolt period (Alodan and Mashaly, 1999). Other benefit of force molting to rejuvenate the egg laying performance of commercial laying hens and it is

profitable for producers. The main objective of forced molt is to cause flocks to cease egg production and that they enter a non-reproductive state (Webster, 2003). Force molting has been used by several methods such as feed withdrawal (Christmas et al., 1985, Webster, 2003, Alodan and Mashaly, 1999), water withdrawal (Alodan and Mashaly, 1999), due to feed and water withdrawal are highly stressful to the layer hens, thus leading groups for the animal rights have been pressing for an end to force molting by feed and water withdrawal. For this reason researchers have studied alternative methods to feed and water withdrawal (Aygun, 2013). Feeding high dietary zinc is successful method of inducing rest for laying hens (Alodan and Mashaly, 1999, Bar et al., 2003, Berry and Brake, 1985, Park et al., 2004, Breeding et al., 1992, Berry and Brake, 1987), low sodium (Berry and Brake, 1985, Berry and Brake, 1987), low calcium (Breeding et al., 1992). Generally several researchers indicated that egg weight, yolk, albumin and shell quality and the rate of egg production are improved significantly in postmolt period compared to the premolt period (Alodan and Mashaly, 1999, Durmus et al., 2004, Lee, 1984, Park et al., 2004, El-Deek and Al-Harathi, 2004, Hassanabadi and Kermanshahi, 2007, Christmas et al., 1985, Zimmermann et al., 1987). Therefore, this research was designed to investigate the impacts of different dietary zinc supplementation during a forced molt on subsequent hen performance and egg quality in Hy-Line Brown commercial layer hens, 64 weeks of age.

### Materials and Methods

A total of 200 commercial Hy-line Brown layer hens, (64) weeks of age were utilized in this experiment, which was carried out at the poultry research farm, department of animal science, faculty of agriculture, University of Sulaimani. The hens were reared for 21 weeks throughout the experiment. They were randomly divided into (5) treatments were as follow: T1) control, T2) 28000ppm, T3) 37000ppm, T4) 46000ppm ZnO and (T5) on gain-off gain program of 40 hens each, are described in (Table1). The two molting programs used to compare their impacts on body weight, rate of egg production and quality, and concentration of zinc in yolk and albumin by collecting (3) eggs daily in each treatment randomly. Hens were fed in (T2) zinc program a layer ration containing 28000 ppm of zinc as zinc oxide for 11 days, (T3) 37000 ppm for 9 days and (T4) 46000 ppm for 7 days, and the light was decreased to 8 hours/day, on day 12, 10, 8 birds were fed control layer ration 90 gm feed/hen respectively for two weeks and then hens were returned to the control layer ration *ad libitum*, water was provided *ad libitum*, and received 16 hours of light/day. Treatment (5) on-gain-off gain program, water and feed were removed for the first two days and on days 4, 6, 8. Hens were fed the control ration at 45 g per/hen and water was provided for *ad libitum* consumption on days 3, 5, 7 and 9. They were fed 90 gm feed per/hen on days 10 throughout 60. The light was reduced to 8 hours/day until day 60. On day 61, hens were returned to control feed and received 16 hours of light/days as described by (North and Bell, 1990). The flock was fed a layer diet 16.50% crude protein and 2800 Kcal ME/KG as described in (Table2). Hens were weighed throughout the experiment every week to investigate rates of body weight loss, feed intake and the amount of feed also were measured every week. Eggs were weighed for average egg weight. Three eggs each treatment was conducted daily to determine the necessary measurements for assess the quality attributes as well as to measurement zinc concentration in the yolk and albumin. The atomic absorption spectrophotometer was used for concentration of zinc in yolk as well as albumin, it consists of eight turret lamps with a wavelength range of 190-900 nm. The analytes of yolk and albumin were detected at 213.86 nm.

**Table 1: Experimental design of control, three levels of dietary zinc and on-gain off-gain (ON-OFF) forced molting programs**

Treatments	Day of experiment	Feed	Water	Light h/d
T1	1 to end of the experiment	Full feed layer ration <i>ad libitum</i>	Provided	16
T2	1 to 11 12 26 days	Full feed layer ration containing 28000 ppm ZnO Full feed layer ration 90 gm/ hen for two weeks Full feed layer ration <i>ad libitum</i>	Provided Provided Provided	8 16 16
T3	1 to 9 10 24 days	Full feed layer ration containing 37000 ppm ZnO Full feed layer ration 90 gm/ hen for two weeks Full feed layer ration <i>ad libitum</i>	Provided Provided Provided	8 16 16
T4	1 to 7 8 22 days	Full feed layer ration containing 46000 ppm ZnO Full feed layer ration 90 gm/ hen for two weeks Full feed layer ration <i>ad libitum</i>	Provided Provided Provided	8 16 16
T5	1 to 2 3 4 5 6 7 8 9 10 to 60 61 days	None 45 g per hen None 45 g per hen None 45 g per hen None 45 g per hen None 45 g per hen 90 g per hen Control layer ration <i>ad libitum</i>	None Provided None Provided None Provided None Provided None Provided Provided Provided	8 8 8 8 8 8 8 8 8 8 8 16

**Table 2: Layer diet composition and calculated analysis**

Ingredients	%
Wheat	70.12
Soybean meal (44% CP)	17
Corn oil	2.56
Limestone	8.56
Dicalcium Phosphate	1.50
Salt	0.16
*Premix	0.10
Total	100
Nutrient Calculated Analysis	
CP%	16.50
ME Kcal/kg	2800

\*Vitamin and minerals premix (Poultry –Vit, made in Syria) provided per kg of the diet: Vit. A, 6000000IU; D3, 1500000IU; E, 5000 mg; Vit. C, 10000 mg; K3, 1500 mg; B1, 1500 mg; B2, 2000 mg; B6, 1000 mg; B5, 3000 mg; B12, 10 mg; Folic acid, 200 mg; Biotin, 50 mg; Methionine, 20000 mg; Choline, 50000 mg; Lysine, 30000 mg; Calcium Phosphate, 50000 mg; Sodium 100 mg; Cooper Sulfate, 5000 mg; Sulfate, 10000 mg; Cobalt Carbonate, 100 mg; Nicotine Amide, 20000 mg.

Statistical analysis was performed by completely randomized design program (Factorial C.R.D), with three replicates. The statistical model used for analysing data obtained was:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + e_{ijk}$$

Where:

i = 1, 2,.....5 (treatments)

j = 1, 2,.....7 (Periods)

k= 1, 2, 3 (replicates)

To determine the significant of difference among treatments and periods were used least significant difference (L.S.D) (Steel and Torrie, 1960). Level of significance used in all results was  $p \leq 0.05$  and  $p \leq 0.01$ .

### Results and Discussion

The effect of forced molting at different periods on body weight and rate of body weight loss after molting are shown in (Table 3). The hens subjected to (28000, 37000 and 46000ppm ZnO) lost 28.5, 23.1, and 13% of their initial body weight by day 11, 9, 7 of the experiment, respectively, which were greater than the loss in hens in the ON-OFF (11.5%). Feeding ZnO at 28000, 37000, 46000 ppm and ON-OFF program at period (64-66) weeks resulted higher body weight loss as compared to control might be due to decrease in muscle mass, utilization of adipose tissue, decrease in liver weight and involution of the reproductive organs(El-Deek and Al-Harathi, 2004). Highest body weight in treatment T2/79-81 weeks, and lowest weight in T3/64-66 weeks. The highest body weight loss in T2/64-66 weeks. The results indicate that the use of different levels of zinc, were resulted in a successful method of force molting, which is a reduction in the weight gradually and then regain the weight. Body weight is reduced for ZnO treatments and ON-OFF program during period 64-66 weeks, but rate of body weight loss increased in same period. These results are in agreement with those of (El-Deek and Al-Harathi, 2004) who reported a 16 and 21% reduction in body weight for broiler breeder hens fed 2 and 3% ZnO respectively, (Alodan and Mashaly, 1999) reported a 15.2 and 12% reduction in body weight for commercial strain (Dekalb) Single comb white leghorn fed ZnO at 20000 ppm and On-OFF program, and (McCormick and Cunningham, 1984b) reported a 17% reduction in body weight for pullets fed ZnO at 2%. In addition (Palafox and Elodie, 1980) who investigated a 15.9% reduction in body weight for pullets fed 20 mg/gm ZnO.

**Table 3: Effect of force molting on body weight and body weight loss%**

Periods (Age, week)	Body weight (kg)					Body weight loss (%)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
64-66	1.805	1.711	1.551	1.694	1.771	1.573	10.320	8.140	4.340	5.890
67-69	1.710	1.712	1.710	1.754	1.778	3.103	3.163	2.853	0.670	5.060
70-72	1.751	1.735	1.680	1.789	1.739	0.057	0.540	1.370	0.250	2.437
73-75	1.785	1.778	1.766	1.826	1.774	0.037	3.793	1.360	0.740	1.440
76-78	1.798	1.815	1.779	1.790	1.749	0.330	0.000	0.943	0.533	0.607
79-81	1.825	1.840	1.800	1.795	1.753	1.003	1.737	1.223	0.167	0.640
82-84	1.767	1.820	1.789	1.790	1.757	1.017	1.847	0.667	0.000	0.000
L.S.D( $p \leq 0.05$ )	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
L.S.D( $p \leq 0.01$ )	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

T1: control, T2: 28000 ppm ZnO, T3: 37000 ppm ZnO, T4: 46000 ppm ZnO, T5: ON-OFF Program N.S : Non Significant

Feed intake in T2, T3 and T4 which provided zinc was lower 375.1, 247.5 and 90.5 gm/bird during 11, 9 and 7 days respectively compared with control. Feed intake is reduced at period 64-66 weeks for ZnO treatments and ON-OFF program compared to control, due to loss in appetite associated with high dietary levels of ZnO may be attributed to toxic effects of the compound or to a reduction in palatability (Jackson et al., 1986). Feed intake is highest in T3/70-72 weeks, and it is lowest in T3/64-66 weeks. Feed conversion ratio is improved at periods 73-75 and 76-78 weeks in T2, T3 and T4 compared to control and ON-OFF program (Table 4).

**Table 4: Effect of force molting on feed intake and feed conversion ratio**

Periods (Age, week)	Feed intake (g/hen/week)					Feed conversion ratio (kg feed/kg egg)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
64-66	817.92	467.95	373.72	407.36	477.32	10.600	17.030	2.513	14.330	31.360
67-69	755.51	737.59	704.03	792.54	577.50	11.173	10.173	10.700	7.633	5.057
70-72	744.64	817.39	822.86	809.42	681.26	3.667	3.250	6.453	2.770	7.290
73-75	779.35	791.93	804.13	809.00	802.76	3.700	2.580	2.527	2.243	3.677
76-78	719.25	740.31	735.47	688.45	747.45	3.583	2.713	2.967	2.217	3.657
79-81	713.55	729.26	682.72	680.33	754.71	3.537	3.181	3.497	2.630	4.090
82-84	657.95	711.17	670.01	694.79	70733	3.697	3.270	3.600	3.990	3.830
L.S.D (p≤0.05)	136.77 2	136.772	136.772	136.772	136.772	N.S	N.S	N.S	N.S	N.S
L.S.D (p≤0.01)	181.58 5	181.585	181.585	181.585	181.585	N.S	N.S	N.S	N.S	N.S

T1: control, T2: 28000 ppm ZnO, T3: 37000 ppm ZnO, T4: 46000 ppm ZnO, T5: ON-OFF Program N.S : Non Significant

(T2) and (T3) ceased egg production by day 5 and the (T4) by day 6 of the study. Hens returned to egg production by day 9, 18 and 8 respectively, was the first day of egg production. Hen day egg production (H.D) was better and the results of this study showed that hens in treatments T2, T3 and T4 were higher in egg production compared to the control and ON-OFF program (Table 5), particularly after 64-66 and 67-69 weeks until end of the experiment. This result could be due to body weight loss that the higher body weight loss, the higher postmolt production also indicated that induced molting leads to the involution of reproductive tract, which is proportional to the loss of body weight, and that the rebuilding of the reproductive tract would lead to the removal of fat accumulation and therefore increased tissue efficiency (Brake, 1992). Highest hen day egg production in T4/73-75 weeks, which is feed 46000 ppm ZnO for 7 days and lowest hen day egg production in T3/64-66 weeks, which is feed 37000 ppm ZnO for 9 days. Highest egg weight was recorded in T3/73-75 weeks, and lowest egg weight was recorded in T3/64-66 weeks. Forced molting had no significant effects on egg weight when compared to control birds, but egg weight in T2, T3 and T4 was slightly higher compared to the T1 and T5, could be due to the involution of the uterus, which appears to reduce the fat accumulation in the glandular epithelium of the uterus and lead to an increase in the efficiency of glandular epithelium (Brake, 1992). This result is in agreement with those of (Bar et al., 2001, Christmas et al., 1985, Said et al., 1984), who found that different induced molting programs did not significantly affect egg weight when compared to the control.

**Table 5: Effect of force molting on egg production and egg weight (g)**

Periods (Age, Week)	Egg production (Hen day %)					Egg weight (g)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
64-66	19.00	5.42	4.88	6.12	11.97	64.65	45.90	20.49	42.97	62.91
67-69	13.41	12.74	15.66	27.19	21.05	65.38	70.56	64.24	67.33	65.80
70-72	39.55	54.21	29.32	56.56	17.41	67.34	72.73	68.92	71.25	64.72
73-75	38.09	59.80	61.99	70.37	42.86	65.16	73.30	74.34	73.10	67.16
76-78	34.96	54.48	50.86	60.78	39.85	66.29	71.83	70.69	72.64	65.88
79-81	38.63	46.97	42.20	52.11	33.67	67.70	70.18	70.47	72.06	68.36
82-84	33.12	45.59	39.26	36.43	33.35	64.68	71.32	70.64	70.38	67.00
L.S.D ( $p \leq 0.05$ )	9.355	9.355	9.355	9.355	9.355	N.S	N.S	N.S	N.S	N.S
L.S.D ( $p \leq 0.01$ )	12.425	12.425	12.425	12.425	12.425	N.S	N.S	N.S	N.S	N.S

T1: control, T2: 28000 ppm ZnO, T3: 37000 ppm ZnO, T4: 46000 ppm ZnO, T5: ON-OFF Program N.S : Non Significant

The effect of forced molting at different periods on yolk weight and albumin weight at different periods of postmolt production is presented in (Table 6). Highest yolk and albumin weight in T4/73-75 and T3/73-75 weeks, respectively. While, lowest weight of yolk and albumin in T3/64-66 weeks. The weight of yolk and albumin are improved after period 64-66 weeks in T2, T3 and T4. This results are in agreement with those of (Roland and Brake, 1982, Berry and Brake, 1987, Stevenson and Jackson, 1984) who reported that the yolk and white weight improved after force molting.

**Table 6: Effect of force molting on yolk and albumin weight (g)**

Periods (Age, week)	Yolk weight (gm)					Albumin weight (gm)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
64-66	16.593	12.367	5.780	10.867	16.203	39.610	28.063	11.897	27.003	38.773
67-69	16.723	17.867	17.033	17.343	16.527	41.467	45.257	40.433	42.317	40.703
70-72	16.573	17.977	17.673	17.617	16.373	43.493	47.167	44.160	45.890	40.903
73-75	16.633	18.277	18.533	18.673	16.980	41.713	47.147	48.117	47.010	42.597
76-78	16.840	17.920	17.690	18.627	16.577	42.250	45.953	45.400	46.517	42.053
79-81	17.220	17.567	17.847	18.333	16.570	43.220	45.540	45.520	46.260	43.200
82-84	16.840	17.643	17.920	17.767	16.563	40.937	46.543	44.943	45.260	43.280
L.S.D ( $p \leq 0.05$ )	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
L.S.D ( $p \leq 0.01$ )	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

T1: control, T2: 28000 ppm ZnO, T3: 37000 ppm ZnO, T4: 46000 ppm ZnO, T5: ON-OFF Program N.S : Non Significant

The weight of shell and Haugh Unit (H.U) in T1, T2, T3, T4 and T5 were shown in (Table 7). Highest shell weight in T5/79-81 weeks. While lowest in T3/64-66 weeks. Highest H.U in T2/70-72 weeks, but lowest H.U in T3/64-66 weeks. Generally the H.U at periods 67-69, 70-72, 73-73 76-78, 79-81, 82-84 weeks in T2, T3, T4 and T5 are superior compared to T1, can be due to improve egg weight and high of albumin in these periods consequently H.U depends on egg weight and high of albumin.

**Table 7: Effect of force molting on shell weight(g) and Haugh Unit**

Periods (Age,week)	Shell weight (g)					Haugh Unit				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
64-66	8.447	5.473	3.260	5.433	7.933	84	58	29	59	86
67-69	7.187	7.430	6.777	7.650	8.567	88	89	92	90	89
70-72	7.273	7.583	7.080	7.417	7.440	92	97	96	95	95
73-75	6.813	7.870	7.687	7.417	7.273	90	94	94	94	93
76-78	7.203	7.990	7.593	7.500	7.243	89	91	91	94	95
79-81	7.253	7.080	8.420	7.793	8.593	91	93	91	92	92
82-84	6.900	6.803	7.770	7.350	7.140	88	91	88	91	91
L.S.D (p≤0.05)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
L.S.D (p≤0.01)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

T1: control, T2: 28000 ppm ZnO, T3: 37000 ppm ZnO, T4: 46000 ppm ZnO, T5: ON-OFF Program N.S : Non Significant

The effect of different levels of ZnO (T2, T3 and T4) on the concentration of zinc in both yolk and albumin are higher, especially when provided birds 28000, 37000 and 46000 ppm ZnO with feed in the beginning of the study for 11,9 and 7 days respectively compared to T1 and T5. The concentration of zinc in both yolk and albumin were decreased after feed hens control diet (Table 8). Highest zinc concentration in both yolk as well as albumin in T4, can be due to feed which is provided for this treatment is higher in ZnO (46000ppm) compared to 28000 and 37000ppm ZnO, and high concentration of zinc in yolk and albumin during provide 28000,37000 and 46000 ppm ZnO, can be due to few egg production (a very limited number of eggs), which is the zinc element accumulation in this a small number of eggs, the concentration of zinc is reduced in both in yolk and albumin when feed hens control diet, thus confirm the high concentration zinc in eggs non-continues. This result is in agreement with those of (Hassanabadi and Kermanshahi, 2007, McCormick and Cunningham, 1984a).

**Table 8: Zinc concentration in Yolk and White**

Weeks	Zinc concentration in Yolk (ppm)					Zinc concentration in White (ppm)				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5
During provided ZnO with feed	10.20	32.84	29.61	51.08	10.22	3.50	5.96	5.90	6.37	3.54
Week (1) after hens feed control diet	10.15	*None	None	None	10.25	3.46	None	None	None	3.61
Week (2) after hens feed control diet	10.18	28.43	None	19.02	10.20	3.53	5.49	None	6.08	3.40
Week(3) after hens feed control diet	10.12	21.37	16.93	18.73	10.18	3.41	4.63	4.90	4.02	3.38
Week (4) after hens feed control diet	10.14	13.05	15.32	12.47	10.15	3.37	4.50	4.75	4.05	3.45
Week (5) after hens feed control diet	10.16	10.50	11.70	10.43	10.17	3.29	3.80	4.05	3.70	3.32
Week (6) after hens feed control diet	10.12	10.31	10.13	10.22	10.14	3.25	3.46	3.52	3.44	3.30
SE± M	10.15 ± 0.03	19.42 ± 9.68	18.11 ± 8.11	18.85 ± 10.72	10.17 ± 0.04	3.97 ± 0.89	4.64 ± 0.96	4.12 ± 0.9	4.24 ± 0.99	4.06 ± 0.94

T1: control, T2: 28000 ppm Zn, T3: 37000 ppm Zn, T4: 46000 ppm Zn, T5: ON-OFF Program

\*None: treatment without egg production

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