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Effect of Induced Moulting in Male and Female Line Broiler Breeder Hens by Zinc Oxide and Feed Withdrawal Methods on Post Molt Performance Parameters

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Abstract: A study was conducted to evaluate zinc oxide and total feed withdrawal techniques to induce moulting in two heavy breeds viz., Red Cornish (male line) and White Plymouth Roock (female line) and their effects on body weight, reproductive organs, egg production, feed consumption, feed efficiency, egg characteristics, fertility, hatchability and mortality. 180 male line Cornish, 180 female line white Plymouth Rock above 60 weeks of age were selected and distributed to 60 pens with 6 birds in each pen. Three experimental treatments consisting of control, zinc oxide (25,000 pm) and feed withdrawal till the end of production, were allotted to 10 pens for each treatment in each row separately for both the breeds. Changes in reproductive organs were studied on '0' day of the trial, at 0 and at 50% production. The Cornish layers lost an average about 16% due to zinc oxide and about 14.9% due to feed withdrawals and the Rock layers lost about 21.74 and 16.18%, respectively. In both the breeds the reproductive organs loss was more in feed withdrawal groups when compared to zinc oxide groups. Hen day egg production in Cornish in the treated groups did not differ significantly from the control, whereas, in Rock, a significant increase in hen day egg production was noticed in both the treatments. Rock layers consumed slightly higher quantity of feed compared to Cornish layers throughout the four 28 day periods. In both breeds the eggs from control birds had significantly low Haugh unit score when compared to those from moulted groups. There was no significant difference in fertility and hatchability due to different methods of moulting in both the breeds. However, Rock hens showed slightly higher fertility and hatchability than the Cornish hens. Mortality rate did not vary between the breeds. In conclusion, the feed withdrawal method appears to be better in inducing moult in broiler breeder hens than the zinc oxide method.

Key words: Moulting, broiler breeder hens,zinc oxide, feed withdrawal, performance

Introduction

Moulting is a natural phenomenon in birds during which they replace old plumage with the new one, reduce feed intake, reduce body weight and stop laying. The practice of induced moulting has been beneficial in extending the productive lives of birds which would otherwise be culled as soon as they reached a lower level of egg production. Moulting in laying hens can be induced by using photoperiod, feed withdrawal, mineral supplementation. Induced moulting can result in increased egg production and egg quality. It reduces mortality, production cost and investments in new batches and hatcheries. Moulting involves reproductive quiescence (Burton and Burton, 1980).

Induction of moulting through high dietary mineral such as zinc (Cantor and Johnson, 1984; Yousaf *et al*., 1998; El-Deek and Al-Harthi, 2004; Moore *et al*., 2004; Ocak *et al*., 2004; Ahmed *et al*., 2005; Yousaf and Ahmad, 2006; Koch *et al*., 2007; Koelkebeck and Anderson, 2007) have been successfully used. Feed withdrawal is the primary procedure in hens to induce moulting and stimulate multiple egg laying cycles (Hembree *et al*., 1980; Brake, 1993; Holt, 1995; Hussein, 1996; Yousaf, 1996; Yousaf, 1998; Bell, 2003; Biggs *et al*., 2004; Chowdhury *et al*., 2004; El-Deek and Al-Harthi, 2004; Oguike *et al*., 2004; Kubena *et al*., 2005; Khoshoei and Khajali, 2006).

Number of studies have been conducted in an attempt to develop effective methods to moult hens without the use of feed removal, like high zinc in diets (Berry and Brake, 1987; McCormick and Cunningham, 1987) and low sodium diets (Whitehead and Shannon, 1974). Present study was conducted to evaluate different methods like high level zinc oxide in the diet and total feed withdrawal to induce moulting in two heavy breeds viz., Cornish (male line) and White Plymouth (female line) and their effects on body weight, reproductive organs, egg production, feed consumption, feed efficiency, egg characteristics, fertility, hatchability and mortality.

Materials and Methods

Total out of 360 birds (180 male line Cornish, 180 female line white PMR) above 60 weeks of age were selected and distributed to 60 pens with 6 birds in each pen. Three experimental treatments consisting of control, zinc oxide (25,000 pm) and feed withdrawal till production stops, were allotted to 10 pens of each

Table 1: Composition and Nutrient content of the experimental diet

Ingredients	(%)
Corn	57.00
Peanut cake	16.50
Deoiled rice bran	12.00
Fish meal	8.00
Mineral premixture	2.50
Oyster shell	4.00
Calculated Analysis (as-is-basis)	
Crude protein	17.38
ME (kcal kg^{-1})	2750
Calcium	3.16
Salt	100g
Vitamin A	82500 IU kg^{-1}
Vitamin B2	50 mg kg^{-1}
Vitamin D3	12000 IU kg^{-1}
Vitamin K	10 mg kg^{-1}
Vitamin B1	4 mg kg^{-1}
Vitamin B6	8 mg kg^{-1}
Vitamin B12	40 ug kg^{-1}
Niacin	60 mg kg^{-1}
Calcium panthonate	40 mg kg^{-1}
Vitamin E	40 mg kg^{-1}
Furazolidone	20(%) W/W

Mineral mixture, contained in addition to calcium and phosphorus, 3 mg of iodine, 2 mg of cobalt, 78 mg of zinc, 13 mg of copper, 130 mg of iron, 2 mg of selenium and 96 mg of manganese

treatment in each row separately for both the breeds. Two birds from each treatment were sacrificed at beginning, at 0 egg production and at 50% egg production after moulting to study the changes in reproductive organs. The control continued with practical broiler breeder diets (Table 1) till the end of experimental period. The standard managemental practices were followed without any additional photo period. Feed was given adlibitum to control, zinc oxide and feed withdrawal group without restrict to water for all groups. Body weight was recorded initially before housing in breeding pens, egg production after reaching cessation of egg production and start of egg production.

Parameters studied

Egg production: The rate of lay during post moulting period was recorded as hen day egg production for 4 periods of 28 days each.

Feed consumption and feed efficiency: Data on feed consumption during the end of each period was recorded. The efficiency was calculated as kg feed consumed to every dozen eggs produced at the end of each period.

Haugh unit and shell thickness: At the end of last 3 periods, two eggs from each pen were broken to study Haugh unit and shell thickness.

Fertility and hatchability: The calculation of data on productive performance, young cocks of same breed was introduced in each pen. After 5 days hatching eggs were collected for 10 days. The fertility and hatchability was expressed on total eggs set and also a fertile eggs set.

Change in reproductive organs: Two birds from each treatment were sacrificed on the 1st day before the start for experiment, on cessation of egg production and after reaching 50% egg production. The reproductive organs including ovary was weighed on fresh basis. The regression in weight and their physical conditions were noted.

Mortality: Mortality if any during the period were recorded.

Data were subjected to one way analysis of variance (Snedecor and Cochran, 1967) and the means were compared by Duncan's multiple range test (Duncan, 1955).

Results and Discussion

The effects of the addition of zinc oxide to diet and feed withdrawal methods to induce moulting were evaluated against non-treated controls.

Zinc oxide: Zinc oxide fed birds of Cornish and Rock breed took 25 and 22 days to reach cessation of egg production. During this period few birds lost little plumage at the neck and at the back in both the breeds. The birds were active during treatment period without mortality. Zinc oxide treated group results were not significantly superior to feed withdrawal group.

Feed withdrawal method: Birds of both the breed (Cornish and Rock) under this method took 14 days to reach cessation of egg production rest of results were significant to the feed and no feed difference. The birds under this treatment took long time to reach cessation of egg production compared to feed withdrawal method. This is in conformity with the results reported by Cunningham and McCormick (1985) and Goodman *et al*. (1986).

Body weight: The Cornish layers lost an average about 16% due to zinc oxide and about 14.9% due to feed withdrawals significantly for the corresponding figures for Rock layers were about 21.74 and 16.18%, respectively (Table 2). The results are in conformity with the observations made by several researchers (Creger and Scott, 1979; McCormick and Cunningham 1984b; Hurwitz *et al*. 1975). Bird and Sunde (1982), reported a body weight loss of 17-0%. Feed withdrawal had a similar effect on the magnitude of body weight loss between the two breeds. Whereas zinc oxide treatment did exert a greater loss in body weight of Rock layers when compared to Cornish layers for which no explanation can be attributed except the breed variation.

Table 2: Effect of Zinc oxide and feed withdrawal methods of moulting on body weight before experiment, at 0% egg production (g) and reproductive organs weight (g) before experiment, at 0% and at 50% egg production

		Body weight				Reproductive organs weight					
		Before experiment		At zero% egg production		Before experiment		At zero% egg production		At 50% egg production	
Breed	Treatment	Mean	SE	Mean	SE	(%)	SE	(%)	SE	(%)	SE
Red	T_1	3766.66	37.88	3909.99^b	35.10	4.54	0.04	4.82	0.44	4.19	0.22
Cornish	T_2	3841.11	71.13	3218.27^a	89.83	3.43	0.27	2.86	0.90	4.42	0.33
	T_3	3729.63	41.08	3170.73^a	53.33	4.06	0.90	1.04	0.44	4.07	0.02
White	T_1	3535.18	56.55	3738.70^b	73.84	4.22	0.36	4.60	0.48	4.23	0.05
plymouth	T_2	3587.03	60.58	2807.05^a	90.31	3.90	0.26	1.56	0.01	4.55	0.50
Rock	T_3	3543.02	45.93	2969.81^a	45.07	3.40	0.21	0.96	0.45	4.96	0.83

Means bearing common superscript(s) are not significantly difference ($p<0.05$)

Table 3: Effect of Zinc oxide and feed withdrawal methods of moulting on hen day egg production (%) and fertility (%)

		Hen day egg production (%)								
		Period I		Period II		Period III		Period IV		
Breed	Treatment	(%)	SE	(%)	SE	(%)	SE	(%)	SE	Mean±SE
Red	T_1	39.65^b	4.41	42.98^a	3.10	36.01^a	2.84	34.85^a	3.47	38.37±3.46
Cornish	T_2	23.52^a	3.90	49.51^b	3.05	42.87^a	2.75	43.74^b	3.80	39.91±3.38
	T_3	19.58^a	2.40	50.14^b	3.00	40.60^a	3.44	39.74^b	2.70	37.51±2.89
White	T_1	29.69^a	3.64	35.25^a	2.70	30.86^a	3.35	32.36^a	2.34	32.04±3.00
plymouth	T_2	20.57^a	2.26	50.30^b	2.42	50.59^b	3.52	53.60^b	2.67	45.02±2.72
Rock	T_3	22.15^a	2.11	55.50^b	2.77	55.33^b	2.30	50.86^b	2.85	45.47+2.51

		Fertility (%)						
		Hatch I		Hatch II		Hatch III		
Breed	Treatment	SE	(%)	SE	(%)	SE	(%)	Mean±SE
Red	T_1	83.54	2.06	91.42	1.37	88.32	2.82	87.76±2.08
Cornish	T_2	91.46	2.70	87.44	3.08	90.98	2.71	89.97±2.83
	T_3	86.96	4.44	89.93	2.70	88.85	4.04	88.04±3.73
White	T_1	89.45	2.60	89.08	2.92	91.60	4.17	90.06±3.23
Plymouth	T_2	91.59	1.10	91.36	2.70	90.10	2.82	91.03±2.21
Rock	T_3	91.40	2.07	89.11	2.75	89.11	2.75	89.87±2.52

Means bearing common superscript(s) are not significantly different ($p<0.05$)

Reproductive organs: The reduction in weight of the reproductive organs (Ovary and Oviduct) when critically viewed, it was observed that there was a difference in the initial of 0.18-1.11% in case of Rock breed corresponding to zinc oxide and total feed withdrawal groups when compared to control group of corresponding breeds. At cessation of production level, it was statistically reduced to 1.92 and 3.78% due to zinc oxide and feed withdrawal in Cornish breed and effectively. But the corresponding figures for Rock breed were 3.04 and 3.64% which were more severe when compared to the Cornish breed. In both the breeds the weight loss of reproductive organs was severe in feed withdrawal groups when compared to zinc oxide groups. This may be due to severe stress and reduced level of gonadotrophic hormones (Tanabe *et al.*, 1981; Dickerman and Bahr, 1989).

Soon after the moulting period, the reproductive organs were rejuvenated as evident by higher values at 50% production level during postmoult period. This may be due to the initiation of the normal productive functional activity of the reproductive organs under the influence of gonadotrophic hormones. The results of the present study are in agreement with the reported results of McCormick and Cunnigham (1984a) and Berry and Brake, (1985) under zinc oxide and (Brake and Thaxton, 1979; Ingram *et al.*, 1982; Dickerman and Bahr, 1989) under feed withdrawal.

Hen-day egg production: While the layers under control group (T_1) continued to lay eggs, Cornish layers took 12 days and 14 days to reach cessation of egg production under zinc oxide and feed withdrawal, respectively, but for Rock layers took 22 and 14 days, respectively. As such on 26th day of the experimental period after cessation of egg production in all the test groups the layers were switched back to the normal feeding.

From the observation it was evident that the control layers continued to lay eggs at a similar production level in both the breeds of layers as the period advanced (Table 3). The Cornish layer breed on zinc oxide and feed withdrawal diet did lay significantly less number of

Table 4: Effect of Zinc oxide and feed withdrawal methods of moulting on feed consumption during post moult period (g/bird/day) and feed conversion ratio (FCR) (kg feed/dozen of eggs)

		Feed consumption								
		Period I		Period II		Period III		Period IV		
Breed	Treatment	g	SE	g	SE	g	SE	g	SE	Mean±SE
Red	T_1	133	0.44	136	2.76	133	2.97	138	2.90	136±2.27
Cornish	T_2	133	-	138	3.20	138	3.29	142	3.53	137±2.51
	T_3	133	1.22	134	1.55	136	2.37	136	2.37	134+2.47
White	T_1	136	2.77	142	3.44	142	3.44	143	4.15	140±3.45
Plymouth	T_2	138	2.55	142	3.82	143	4.48	144	4.37	141±3.81
Rock	T_3	134	2.78	134	1.60	136	1.83	137	1.83	135±2.01
		Feed conversion ratio (FCR)								
		Period I		Period II		Period III		Period IV		
Breed	Treatment	g	SE	g	SE	g	SE	g	SE	Mean±SE
Red	T_1	5.13^{a}	1.20	4.18	0.52	4.91	0.50	5.39	0.70	4.90±0.73
Cornish	T_2	8.07^{ab}	1.62	3.5	0.23	3.92	0.30	4.03	0.50	5.08±0.66
	T_3	9.33^{b}	1.44	3.34	0.27	4.02	0.30	4.33	0.31	5.26±0.58
White	T_1	4.58^{a}	0.33	5.37^{b}	0.54	7.42^{b}	0.10	5.71^{b}	0.62	5.77±0.44
Plymouth	T_2	10.61^{b}	2.50	3.24^{a}	0.14	3.74^{a}	0.31	3.33^{a}	0.16	5.23±0.78
Rock	T_3	7.94^{ab}	0.90	3.09^{a}	0.23	3.13^{a}	0.20	3.33^{a}	0.18	4.37±0.38

Means bearing common superscript(s) are not significantly different ($p<0.05$)

egg during the 1st phase of 28 days. Next 3 periods continued to lay non-significantly more than three counter parts on control diets till the end of experimental period. The average hen-day egg production for control (T_1) zinc oxide (T_2) and feed withdrawal (T_3) Cornish layers at the end of 4th period were 38.37, 39.91 and 37.51%, respectively. Unlike Cornish layers, Rock layers though obviously laid significantly less number of eggs during the first 28 day postmoult period, when compared to control group improved egg production rate statistically during different periods. Further zinc oxide (T_2) and feed withdrawal T_3 groups period significantly higher number of eggs when compared to those on Cornish group (T_1) the average percentage egg production for control (T_1) zinc oxide (T_2) and feed withdrawal (T_3) for Rock layers at the end of both periods were 32.04, 45.02 and 45.47%, respectively.

Thus due to either methods of moulting there was a non-significant increase in egg production of Cornish layers and a significant increase in case of Rock layers when compare to that of control birds. This trend of egg production pattern observed in the present study is in full conformity with the results obtained by Brake and McDaniel (1981) by feeding zinc oxide recorded hen-day egg production of 44-57% in broiler females. And in case of moult induced by feed withdrawal Olefirenko and POPOV 1980 recorded an egg production of dam line B1 and L4 of 42.5 and 45.9%, the sire line P4 25% in one feeding regimen and 38.0, 33.0 and 39.2%, respectively in second feeding regimens.

The present result confirms, that the incorporation of high level zinc reduces feed intake by 10-15% from the normal level (Decuypere and Verheyen, 1986) and recorded zinc oxide accumulation in the kidney (130 mg g^{-1}), liver (290 mg g^{-1}), Pancreas (860 mg g^{-1}). McCormick and Cunningham (1984b) zinc interferes with the insulin secretion possibly by reducing intracellular with insulin secretion the activity of calmodulin, results in reduced insulin secretion, increase glucose level in blood and urine leads to dehydration, fat and protein catabolism (Ghafgazi *et al*., 1981). Zinc also disturbs the normal calcium deposition in the bones and increases elimination through feaces and urine (Scott and Creger, 1997) this may be relevance in the importance of calcium ions in regulating hypothlamo hypophysical activity. With regard to the feed withdrawal results in deceased lutinizing hormone levels (LH) in serum (Tanabe *et al*., 1981; Decuypere *et al*., 1984). Lower serum progesteron by (P4) levels after feed withdrawal (Etches *et al*., 1984; Dickerman and Bahr, 1989).

The present results confirm that the molt subjected birds though under go a great degree of stress yet are capable of rejuvanating their reproductive organs notably the ovary in conjunction with the pituitary hormones (Brake and Thaxton, 1979; Ingram *et al*., 1982; McCormick and Cunningham, 1984a; Berry and Brake, 1985; Dickerman and Bahr, 1989). The gradual increase and significantly persisted egg production observed with the moulted birds clearly indicates that the broiler breeders can also be subjected to induced moulting in a way the egg type layers are moulted (Brake and McDaniel, 1981; Hazan and Yalcin, 1988, 1989).

Feed consumption: Rock layers consumed slightly higher quality of feed compared to Cornish layers throughout the four 28 day periods. The average feed

Table 5: Effect of zinc oxide and feed withdrawal methods of moulting on shell thickness (mm) and Haugh score

		Shell thickness						
		Period II		Period III		Period IV		
Breed	Treatment	mm	SE	mm	SE	mm	SE	Mean±SE
Red	T_1	0.26[a]	0.008	0.27[a]	0.61	0.26[a]	0.01	0.26+0.21
Cornish	T_2	0.31[b]	0.013	0.30[b]	0.008	0.30[b]	0.006	0.30+0.009
	T_3	0.29[ab]	0.09	0.28[a]	0.004	0.28[ab]	0.006	0.28+0.033
White	T_1	0.28	0.014	0.28	0.011	0.28	0.008	0.28+0.008
plymouth	T_2	0.31	0.014	0.29	0.012	0.28	0.007	0.29+0.011
Rock	T_3	0.30	0.008	0.28	0.11	0.30	0.005	0.29+0.008
		Haugh score						
		Period II		Period III		Period IV		
Breed	Treatment	HUS	SE	HUS	SE	HUS	SE	Mean±SE
Red	T_1	76.00	4.06	63.33[a]	6.95	64.66[a]	4.37	68.00±5.13
Cornish	T_2	80.22	2.46	79.22[b]	1.58	91.00[b]	2.57	83.48±2.20
	T_3	83.11	2.58	81.22[b]	1.63	83.33[b]	2.43	82.55±2.21
White	T_1	72.33[a]	5.67	76.66[a]	2.57	75.55[a]	2.74	74.84±3.99
Plymouth	T_2	80.55[ab]	2.53	86.77[b]	3.35	86.11[b]	3.19	84.48±3.02
Rock	T_3	84.55[b]	3.85	88.11[b]	2.10	86.77[b]	3.41	86.48±3.12

HUS-Haugh unit score, Means bearing common superscript(s) are not significantly different ($p<0.05$)

consumption in Cornish birds was 136, 136 and 134 g/hen/day, respectively. Under control, Zinc oxide and feed withdrawal groups the corresponding values for Rock breed was 140, 141 and 135 g/hen/day. The values under the present study are in confirmed with those of (Brake and McDaniel, 1981).

Feed efficiency: Feed efficiency during 1st 28 day period, the Cornish layer under control had consumed significantly less feed to produce dozen of eggs when compared to those on fee withdrawal group, while the birds which had been moulted with Zinc oxide treatment was intermediate. However during the subsequent periods, Cornish layers could convert the feed to eggs in a better manner, although non-significant. The average feed conversion ratio values (Table 4) at the end of experimental periods were 4.90, 4.87 and 5.25 kgs per dozen eggs produced, respectively. As expected and similar to Cornish, the moulted Rock layers were not efficient in converting feed to eggs as those of control birds, during the 1st 28 day period, which was significantly better than Zinc oxide. However, the moulted Rock layers unlike the Cornish layers from the 2nd 28 day period onwards could convert the feed to eggs significantly better than that of their controlled counterparts. The average values at the end 4 the period were 5.78, 5.23 and 4.08, respectively, for control Zinc oxide and feed withdrawal methods. The feed efficiency values were not significantly different between the moulting methods. The present results on feed efficiency during 2nd, 3rd and 4th periods in case of Rock treatments are in confirmative with those of (Brake and McDaniel, 1981; Padilha and Costa, 1985).

Haugh unit and shell thickness: Haugh unit scores during 1st 28 days period in Cornish layers were same but in later period in both breeds the eggs from control birds had significantly low Haugh unit score when compared to those from moulted groups and there was significant difference between moulting methods (Table 5). The average pooled Haugh scores over the periods for Cornish breeds under control, Zinc oxide feed withdrawal groups (68.00, 83.48 and 82.55, respectively), for the Rock under control, zinc oxide and feed withdrawal (74.84, 84.48 and 86.48, respectively). The effect of moulting to cause higher Haugh score unit of eggs has reflected by the formation of more intense thick while clearly indicates that the magnum portion of such hens became highly active and secrete more protein for consolidation of thick white. This is in conformation with the results of Zimmermann *et al.* (1987) and Bougon *et al.* (1989) who reported improved albumen quality in moulted birds.

Shell thickness in Cornish layers was affected by different moulting methods. In control diets was significantly lower than zinc oxide diets in all the periods, but it was non-significantly different from feed withdrawal treatment. The shell thickness was almost similar among Zinc oxide treatment and feed withdrawal groups the mean values for the last 3 periods were 0.26, 0.30 and 0.28 mm for control, Zinc oxide and feed withdrawal treatments, respectively. Whereas the shell thickness was not affected by different moulting methods employed in Rock breed. The pooled mean values for the last 3 periods were 0.28, 0.29 and 0.29 mm for control, Zinc oxide and feed withdrawals groups, respectively in Rock breeds. The results indicates that shell thickness decrease as age advances and is in

Table 6: Effect of zinc oxide and feed withdrawal methods of moulting on hatchability (%) on total eggs set (TES) and on fertile eggs set (FES)

		TES						
		Hatch I		Hatch II		Hatch III		
Breed	Treatment	(%)	SE	(%)	SE	(%)	SE	Mean±SE
Red	T_1	53.87[a]	5.36	70.15[a]	4.12	63.00[a]	5.90	62.35±5.13
Cornish	T_2	71.82[b]	7.90	71.74[a]	7.40	77.20[b]	4.61	73.59±6.64
	T_3	72.10[b]	6.10	79.84[b]	4.91	74.85[b]	4.30	75.60±5.10
White	T_1	66.74[a]	7.90	74.90	5.93	77.93	8.43	72.65±7.42
Plymouth	T_2	76.76[ab]	3.57	80.77	4.31	77.40	3.35	78.32±3.74
Rock	T_3	80.81[b]	2.90	79.90	4.23	76.67	3.10	79.19±3.41
		FES						
		Hatch I		Hatch II		Hatch III		
Breed	Treatment	SE	(%)	SE	(%)	SE	(%)	Mean±SE
Red	T_1	63.58[a]	5.09	77.69[a]	3.44	70.80	5.64	70.73±4.72
Cornish	T_2	77.64[ab]	6.84	77.22[a]	6.44	84.73	3.70	80.53±5.66
	T_3	83.55[b]	5.22	86.42[b]	4.31	83.87	3.20	84.62±4.24
White	T_1	73.45[a]	7.56	83.67	4.40	82.82	6.60	79.99±6.19
Plymouth	T_2	86.36[ab]	3.43	87.59	3.20	86.40	2.60	86.80±3.08
Rock	T_3	88.37[b]	2.00	87.31	3.90	85.12	3.30	86.94±3.07

Means bearing common superscript(s) are not significantly different ($p<0.05$)

Table 7: Effect of zinc oxide and feed withdrawal methods of moulting on mortality (%)

Breed	Treatment	Mortality during treatment (%)	Mortality after treatment (%)	Total (%)
Red	T_1	1.85	11.11	12.96
Cornish	T_2	3.70	14.81	18.51
	T_3	-	7.40	7.40
White	T_1	7.40	5.55	12.95
Plymouth	T_2	1.85	14.14	16.66
Rock	T_3	-	11.11	11.11

agreement with the results of Hasen (1967); McDaniel *et al.* (1979) and Yousaf (2006a, 2006b). Meluzzi *et al.* (1987) indicated an improvement in shell thickness over premoult period.

Fertility and hatchability: At the end of experimental period the mean values of fertility during the last periods of experiment were 87.76, 89.76 and 88.04% for control, Zinc oxide and feed withdrawal groups, respectively in Cornish. Corresponding values for Rock breed were 90.6, 91.03 and 89.87%, respectively, in control, Zinc oxide and feed withdrawal groups. There was no significant difference in fertility due to different methods of moulting in both the breeds. These results are in confirmity with Bell *et al.* (2004) who recorded the positive effects in the farm of enhanced productivity, reduced costs and reduced investments in breeder farms, rearing farms and hatcheries. Gerry (1979) observed no improvement in fertility and over control birds when broiler males and females parents were force moulting using several methods.

The average hatchability values expressed on total egg set pooled over hatches were 62.35, 73.59 and 75.60%, respectively under control, zinc oxide and feed withdrawal in Cornish layers (Table 6). The corresponding values for Rock layers were 72.65, 78.32 and 79.19%, respectively. Barring the 1st hatch of Rock breed, there were no significant difference between the treatments under any given hatch and the breed on fertile egg set showed differences during 1st hatch between 3 dietary regimes for both Cornish and Rock breeds. However, they got nullified during subsequent hatches and the pooled hatch values were 70.73, 80.85 and 84.53% respectively, for control, Zinc oxide and feed withdrawal groups of Cornish breeds. The corresponding values for Rock breed were 79.99, 86.80 and 86.94% for control, Zinc oxide and feed withdrawal groups, respectively. Though the pooled averages were statistically similar in all the groups of given breeds, yet the eggs obtained from hens which were moulted either by Zinc oxide or feed withdrawal methods tended to have higher hatchability percentage. This trend may be due to dam effect which correspond to the earlier report of Hazan and Yalcin (1988).

Mortality: Mortality during the moulting period the was 1.85, 3.70 and 0% in control (Table 7). Zinc oxide and feed withdrawal methods, respectively of Cornish breed. The corresponding values for Rock breed were 7.4, 1.85 and 0%, respectively. On PM examination it was revealed that all the birds irrespective of treatment died due to fatty liver syndrome.

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