

Zinc Oxide as an Effective Mineral for Induced Moulting: Effects on Post Moul Performance of Laying Hens in the Humid Tropics

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Abstract

The aim of this study was to evaluate the ability of using zinc oxide salts to induce moulting, and their effects on post moul performance and organ characteristics of laying hens. Two hundred (75 weeks of age) Isa Brown hens were randomly assigned to five Treatments (T) groups of 40 hens, each namely; T₀-non-moulted hens and T₁, T₂, T₃, T₄, representing moulted hens fed, respectively, 0.5%, 1.0%, 1.5% and 2.0% Zinc Oxide (ZnO) supplementation per kg diet for 14 days. Organ evaluations of the hens were carried out 7 days post moul. Body weight loss and decline in feed intake of the birds were higher (P<0.01) for moulted hens. Cessation of egg production occurred earlier (P<0.05) in the same groups of birds. During post moul, the moulted hens exhibited greater (P<0.01) percentage body weight gain, when compared with the non-moulted hens. Feed intake and hen-day egg production of birds on 1.0%, 1.5% and 2.0% ZnO supplementation was higher (P<0.01), than those of other treatments. Feed conversion ratio was better (P<0.05) for the same groups of birds. Moulting with ZnO treatment influence highly (P<0.01) the number of days to resumption of egg production, with hens on 2.0% ZnO resuming egg production much later than hens on 0.5%, 1.0%, and 1.5% ZnO treatments. The ovary, liver and kidney of the hens were affected (P<0.05) by the dietary ZnO contents. A greenish coloration of the liver was observed in hens fed 1.5% and 2% ZnO supplementation. These results demonstrate that in order to achieve good post moul performance of laying hens in the humid tropics, farmers should practice the use of 1% ZnO inclusion per kg diet, as an effective method to achieve induced moulting.

Keywords: Egg production; Organ; Forced moulting; Body weight

Introduction

The rate of increase in human population, especially in many developing countries already suffering from chronic hunger and malnutrition, demands that new strategies intended at guarantying food security in developing economies of the world is developed.

An effective means of ensuring rapid transformation in animal protein consumption and food security situation in developing countries is the application of various management strategies in poultry production, aimed at increasing the supply of meat and eggs to local communities faced with severe challenges of food insecurity. A method in poultry production designed to maximize egg production in laying hens is the practice of forced moulting. Force moulting, which is the practice of provoking complete flock of hens to moul simultaneously, aimed at extending egg production for more than one year [1], is not a common practice in many developing countries of the world. The practice has been extensively used as a management tool in many developed economies. The practice of force moulting completely halts reproductive function and precipitates a loss of feathers by the hen. However, egg production eventually resumes and increases rapidly to a profitable rate, following this artificial moul [2].

Several methods have been used by farmers to induce moul in laying hens. Among the various methods, feed removal or deprivation seems to be the most common method of practice by farmers. In recent years, however, the growing global concerns for animal rights and welfare have raised concerns over the practice of feed withdrawal, as a method of moulting [3]. For instance, researchers and public health authorities have identified the method as a significant risk factor for the infection of laying flocks with *Salmonella enteritidis*; the most important pathogen inside eggs, and known to be transmitted to humans [3]. Many researchers also subscribed that the practice of feed withdrawal is inhumane, and should be handled with utmost

caution [4-6]. As an alternative to fasting laying hens as a method of inducing moul, several studies have advocated a non-feed withdrawal method, involving the manipulation of dietary minerals like sodium, calcium, iodine and zinc [6-8], etc. These alternative methods have been successfully used by scientist to induce moul in hens, and enhance the post moul egg production. Zinc is one of the several micronutrients that have attracted increased attention, because of their important role in maintaining health and nutrients condition. It is essential for physiologic and metabolic functions such as physical growth, immuno-competence, reproductive function, and neuron behavioral development [9]. Although abundant information exists in literature on the practical application of zinc salts as a means of achieving moulting in hen raised under temperate environment, there is a dearth of information on its application in the tropics, especially in most developing countries, where the method is uncommon. The study therefore was aimed at evaluating the effectiveness of using zinc oxide as a moulting agent for laying hens, on organ characteristics, and post moul production performance.

Materials and Methods

The study was conducted at the poultry unit of the Department of

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Animal Science Teaching and Research Farm, University of Nigeria Nsukka. The study lasted for a period of twelve (12) weeks. Two hundred (75 weeks of age) Isa Brown laying hens were randomly selected from the flock raised at the poultry unit of the Department of Animal Science, Teaching and Research Farm, University of Nigeria, Nsukka. The birds were housed one per cage and allowed 2 weeks for acclimation. During this period, birds were given vitamins supplementation, and were allowed full access to a formulated layer diet and water (Table 1). Egg production was also monitored to ensure that all hens were healthy and producing.

Feed ingredients	Composition (%)
Maize	48.00
Wheat offal	12.00
Soya bean meal	16.00
Palm kernel cake	12.00
Fish meal	2.00
Bone meal	5.00
Limestone	4.00
Lysine	0.25
Methionine	0.25
Vitamin Mineral Premix	0.25
Salt	0.25
Total	100
Proximate	
Crude protein	16.50
Crude fibre	2.50
Moisture	5.00
Ash	14.35
Ether extract	12.5
Nitrogen free extract	49.15

Vitamin and trace mineral premix per kilogram of diet provided: Vitamin A 10,000 IU; Vitamin D3 2,000 IU; Vitamin E, 20IU; Vitamin K3 2mg; Vitamin B1 2mg; Vitamin B2 5mg; Vitamin B6 5mg; Vitamin B12 10mg; Niacin 30mg; Panthotenic acid 10mg; Folic acid 0.74mg; Zinc 25mg; Copper 10mg; Iron 120mg; Manganese 60mg; Selenium 0.2mg.

Table 1: Percentage and proximate composition of the experimental diet.

	Treatments					Prob.
	T ₀	T ₁	T ₂	T ₃	T ₄	
Moult phase						
Body weight (kg)						
Day 0	1.79 ± 0.05	1.81 ± 0.04	1.82 ± 0.04	1.80 ± 0.04	1.75 ± 0.03	0.09 ^{NS}
Day 14	1.78 ± 0.04 ^a	1.70 ± 0.03 ^b	1.69 ± 0.04 ^b	1.59 ± 0.03 ^c	1.50 ± 0.03 ^c	0.00 ^{**}
Body weight loss (%)	0.56 ± 0.06 ^c	6.03 ± 5.86 ^b	7.17 ± 5.72 ^b	11.93 ± 5.34 ^{ab}	14.81 ± 9.38 ^a	0.00 ^{**}
Feed intake (g)	98.69 ± 1.04 ^a	77.29 ± 1.68 ^b	81.04 ± 0.66 ^b	72.64 ± 0.96 ^{bc}	64.54 ± 2.32 ^c	0.00 ^{**}
Cessation of lay (day)	0.00 ± 0.00 ^d	9.29 ± 0.74 ^a	7.00 ± 0.52 ^b	5.27 ± 0.39 ^c	5.12 ± 6.51 ^c	0.00 ^{**}
Post moult						
Body weight (kg)						
Day 0	1.78 ± 0.04	1.70 ± 0.03	1.69 ± 0.04	1.59 ± 0.03	1.45 ± 0.03	-
Day 14	1.83 ± 0.04	1.89 ± 0.04	1.87 ± 0.05	1.83 ± 0.02	1.85 ± 0.02	0.16 ^{NS}
Body weight gain (%)	2.51 ± 0.13 ^d	10.04 ± 0.02 ^c	10.63 ± 0.21 ^c	15.07 ± 0.14 ^b	21.90 ^a ± 0.41 ^a	0.00 ^{**}
Feed intake (g/hen/day)	101.54 ± 2.10 ^b	104.32 ± 1.81 ^{ab}	107.28 ± 1.98 ^a	106.31 ± 3.91 ^a	108.81 ± 2.63 ^a	0.05 [*]
FCR (g/g egg weight)	1.69 ± 0.03 ^a	1.63 ± 0.04 ^{ab}	1.54 ± 0.03 ^b	1.55 ± 0.02 ^b	1.60 ± 0.04 ^{ab}	0.02 [*]
Hen-day production (%)	60.60 ± 4.08 ^c	77.79 ± 2.67 ^b	83.58 ± 1.07 ^a	79.32 ± 2.78 ^{ab}	80.92 ± 4.23 ^a	0.02 [*]
Resumption of lay (days)	0.00 ± 0.00 ^d	4.54 ± 0.93 ^c	6.61 ± 1.21 ^c	9.89 ± 0.79 ^b	16.71 ± 1.13 ^a	0.00 ^{**}

^{a,b,c,d}: means on the same row with different superscripts are significant at 5% or 1%; NS: not significant; * = P<0.05; ** P<0.01; Prob-Probability.

Table 2: Effects of ZnO induced moult on performance of commercial layers.

Moult period

After acclimation, layers were randomly assigned to five treatment groups (T₀, T₁, T₂, T₃ and T₄) with 40 hens, each divided into 4 replicate groups of 10 hens, following completely randomized design. The experimental layers of groups T₀ were fed 120 g daily of the compounded layer diet, without additional ZnO (control group), whereas layers of groups T₁, T₂, T₃ and T₄ were fed additional 0.5%, 1.0%, 1.5% and 2.0% ZnO supplementation per kg feed for 14 days. This was aimed at inducing moulting in the layers. Water was given *ad libitum* to the birds of all groups, and the lighting programme was 12L: 12D. During moult, individual body weights of the hens were monitored at day 0 (initial live body weight) and at day 14 (final live body weight). Feed intake was measured by weighing the leftover feed, less the original amount of feed offered to the birds. The number of days to cessation of lay of each group of birds was also recorded.

Post moult

At the end of 14 days moult period, layers of all groups were fed the compounded layers diets for 8 weeks period. At day 7 after the end of moult, 8 birds per treatment were randomly selected and humanely slaughtered, and the heart, lung, liver, gizzard, kidney and ovaries were excised and weighed, using an electronic weighing scale (Mettler Toledo). Organ weights were expressed as relative weight (% of body weight). Post moult body weight of layers of each treatment groups was taken on day 14 post moult. Feed intake, feed conversion ratios (calculated on the basis of feed intake/g egg weight), and percentage hen-day production (Ratio of number of eggs produced to the number of layers times 100), were also determined.

Statistical analysis

All data were analyzed using the PROC ANOVA statement of SAS software [10]. Differences in mean of the parameters among treatment groups were compared at 5% level of significance (P<0.05), using Duncan's multiple range test.

Results

Results of the effect of zinc induced moult of commercial laying hens on post moult performance are presented in table 2.

Moulting period

Induction of moulting with ZnO caused great ($P < 0.01$) decline in the body weight, feed intake, and number of days to cessation of egg production in laying hens, compared to the non-moulted hens (control). Moulded birds in T_4 showed greater ($P < 0.01$) percentage loss in body weight (15.41%), than those of moulded hens in T_1 (6.03%) and T_2 (7.17%). The percentage weight loss of moulded hens in T_3 (11.93%) was intermediate among the treatments. Percentage body weight loss (0.56%) of the non-moulted hens was very minimal and negligible. Feed consumption of the non-moulted hens was higher ($P < 0.01$), compared to the moulded birds. A greater reduction in feed intake of the moulded hens was observed for hens in T_4 (2.0% ZnO supplementation). Feed intake declined progressively, as the amount of ZnO supplementation increased. Although, the non-moulted birds continued egg production throughout the duration of the experiment, highly significant ($P < 0.01$) variations in the number of days to cessation of egg production was witnessed among the moulded groups of hens. Birds in T_3 and T_4 stopped egg production on day 5 after ZnO treatment, compared to those hens in T_1 and T_2 which ceased egg production on day 9 and day 7, respectively.

Post-moulting period

Fourteen days after withdrawal of ZnO treatment, body weight of the moulded hens compared with the non-moulted hens were similar ($P > 0.05$). Percentage gain in body weight of the hens in T_4 (21.90%) during the same period was higher ($P < 0.05$), than those of hens in other treatments. Moulded hens in T_1 (10.04%) and T_2 (10.63%) gained similar amount of body weight during post-moult, which differed greatly ($P < 0.01$) from those of moulded hens in T_3 (15.07%). Feed intake of moulded hens in T_2 (107.28 g/hen/day), T_3 (106.31 g/hen/day) and T_4 (108.81 g/hen/day) were found to be higher ($P < 0.05$), compared to those of the non-moulted hens (T_0), during the post-moult period. However, feed consumption of hens in T_0 (101.54 g/hen/day) and T_1 (104.32 g/hen/day) were similar ($P < 0.05$) in the same period. Moulting of laying hen using ZnO caused a significant ($P < 0.05$) decline in post-moult feed conversion ratio. Feed conversion ratio of hen in T_2 (1.54 g/g egg weight) and T_3 (1.55 g/g egg weight) were significantly ($P < 0.05$) lower than those of the non-moulted hen (T_0 , 1.69 g/g egg weight). No significant differences ($P > 0.05$) in feed conversion ratio were observed for hens in T_1 (1.63 g/g egg weight) and T_4 (1.60 g/g egg weight). Percentage hen-day egg production differed ($P < 0.05$) among the various treatment groups. Hen-day egg production of birds in T_2 (83.58%) and T_4 (80.92%) were higher and differed ($P < 0.05$) from

those of hens in T_0 (60.6%) and T_1 (77.79%). Although, hen-day egg production of moulded hens in T_3 (79.32%) compared well with other non-moulted hens ($P > 0.05$), its value differed ($P < 0.05$) from those of the non-moulted hens. The moulting method had a highly significant ($P < 0.01$) effect on the length of time (days), it took the hens to return to egg production. Moulded hens in T_4 resumed egg production much later (16.71 days), than those of other moulded hens (T_1 , 4.54 days; T_2 , 6.61 days and T_3 , 9.89 days) ($P < 0.01$). The number of days to resumption of egg production of moulded hens in T_1 and T_2 were comparable, but different ($P < 0.01$) from the length of time, it took hens in T_3 to resume egg production during the post-moulting period. The non-moulted hens (T_0) continued egg production throughout the duration of the experiment.

The results of the effects of ZnO supplementation on organ characteristics of moulded hens showed significant ($P < 0.05$) variations among treatments in the relative weights of ovary, liver and kidney (Table 3). The relative weights of the ovary of hens in T_3 (2.69%) and T_4 (2.77%) were higher, and differed ($P < 0.05$) from those of moulded hens in T_2 (1.57%). The relative weights of ovary of non-moulted hens (T_0 , 1.95%) and moulded hens in T_1 (1.86%) were similar ($P > 0.05$). Highly significant ($P < 0.01$) variation in the relative weight of kidney was found between the moulded and non-moulted hens. Moulded hens in T_2 had higher ($P < 0.01$) kidney weights than those in other treatments. Lower weight of kidney was observed in the non-moulted hens (T_1 , 0.11%), and it differed ($P < 0.01$) from the weight of kidney of hens in T_4 (0.14%). Weight of kidney of hens in T_1 and T_3 (0.12%) were not different ($P > 0.05$). The moulting treatments affected ($P < 0.05$) the weight of the liver of the moulded hens. The relative weight of the liver was higher for hens in T_2 (3.16%) and differed ($P < 0.05$) from those in all other treatments. Relative weight of liver of hens on T_0 (2.35%), T_1 (2.40%), T_3 (2.04%) and T_4 (2.22%) were similar ($P > 0.05$). Physical observation of the organs showed greenish colouration on the liver of hens in T_3 and T_4 (Figures 1-5). The greenish colouration was prominent on the liver of hens in T_4 .



Figure 1: Liver of hens on T_0 .

Parameters (%)	Treatments					Prob.
	T_0	T_1	T_2	T_3	T_4	
Live weight (kg)	1.70 ± 0.12	1.83 ± 0.17	1.70 ± 0.06	1.65 ± 0.08	1.68 ± 0.13	0.88 ^{NS}
Ovary	1.95 ± 0.04 ^{ab}	1.86 ± 0.27 ^{ab}	1.57 ± 0.32 ^b	2.69 ± 0.27 ^a	2.77 ± 0.50 ^a	0.05 [*]
Kidney	0.10 ± 0.00 ^c	0.11 ± 0.01 ^{bc}	0.19 ± 0.01 ^a	0.12 ± 0.01 ^{bc}	0.14 ± 0.12 ^b	0.00 ^{**}
Heart	0.43 ± 0.02	0.42 ± 0.05	0.44 ± 0.01	0.42 ± 0.03	0.42 ± 0.00	0.03 ^{NS}
Lung	0.38 ± 0.08	0.41 ± 0.03	0.36 ± 0.01	0.45 ± 0.04	0.36 ± 0.07	0.67 ^{NS}
Liver	2.35 ± 0.10 ^b	2.40 ± 0.29 ^b	3.16 ± 0.05 ^a	2.04 ± 0.14 ^b	2.22 ± 0.05 ^b	0.00 [*]
Gizzard	2.84 ± 0.02	2.78 ± 0.05	2.59 ± 0.01	22.64 ± 0.19	2.71 ± 0.16	0.54 ^{NS}

^{ab}: means on the same row with different superscripts are significant at 5% or 1%
NS: not-significant; * = $P < 0.05$; ** $P < 0.01$; Prob.-Probability

Table 3: Effect of ZnO moult on organ characteristics of laying hens.

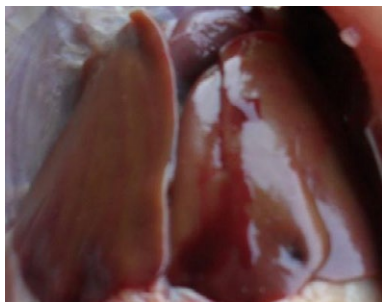


Figure 2: Liver of hens on T₁.

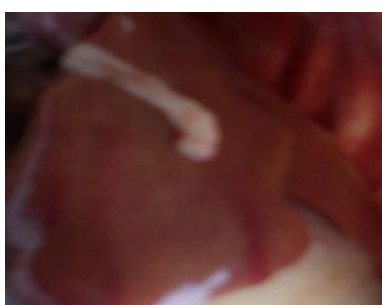


Figure 3: Liver of hens on T₂.

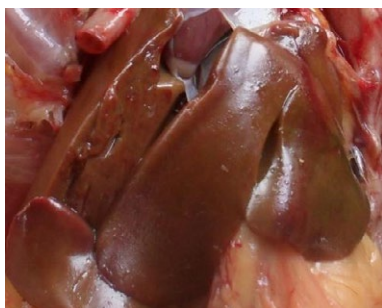


Figure 4: Liver of hens on T₃.



Figure 5: Liver of hens T₄.

Discussion

The result of this study showed the effectiveness of using ZnO as a moulting agent in laying hens. Inducing moult in hens by the application of ZnO caused a significant decline in the body weight and feed intake

of the birds. The rate of decline in these variables was dependent on the amount of ZnO salt used as moulting agent. For instance, moulted hens fed 2.0% ZnO supplementation lost the greatest amount in body weight (15%). Losses in body weight of about 25-30% have been reported in hens moulted using various amounts and types of zinc salt [2,11]. The decline in body weights in the moulted hens is not unconnected with decreases in feed consumption of the hens during the moulting process, and to the decrease in organ weights (especially the reproductive organs and liver), which occur simultaneously during with body weight loss during moulting [11,12]. Park et al. [12] reported about 65-70% reduction in feed intake in hens moulted using zinc salt (zinc acetate or zinc propionate). Incorporation of Zinc salts (ZnO) in the diet of the hens above a certain amount is capable of decreasing the palatability of the diet, and has the potential of causing anorexia in the birds [13], thus, accounting for the decrease in feed intake in the moulted birds. Although the non-moulted hens continued egg production throughout the duration of the study, egg production by the moulted hens ceased few days after ZnO exposure, in accordance with the quantity of the salts added to the diets. This suggests that higher consumption of dietary ZnO increases the rate of reproductive quiescence in moulted hens. This result is in agreement with reports by Park et al. [12] and Johnson and Brake [14]. Reports by Johnson and Brake [14] indicated that zinc cation (Zn²⁺) has the ability to induce follicular atresia and halting egg production. Therefore, using zinc as a moulting agent interferes with the physiological processes of reproduction in hens, probably by the inhibition of the hypothalamic-pituitary-gonadal axis. According to McDowell [15], zinc is physiologically involved in production, storage and secretion of sex hormones, and also affects the receptor sites of these hormones.

During post moulting period, significantly higher percentage body weight gain, feed intake, feed conversion ratio, and hen-day production was observed in the moulted hens, compared to the non-moulted hens. Higher gain in body weight in moulted hens during the recovery period may be ascribed to compensatory growth, as earlier mentioned. Reports by Summers [16] have shown that animals restricted in growth due to low nutrient intake, resulting from a low quality diet or environmental or disease stress, usually exhibit an increased rate of gain and enhanced feed utilization, when the stress(es) are eliminated. As evidenced in this study, it is probable that moulted hens consumed higher amount of the normal diet during post moult, to compensate for the loss in appetite that occurred during moulting. El-Gendi et al. [17] indicated an increase in feed consumption of birds during the first 4 to 6 weeks after moulting. Also, higher feed intake witnessed in the moulted hens during the same period suggests that feed intake of the hens returned to normal, irrespective of the quantity of dietary ZnO supplementation used in the study. The aim of a viable moulting programme is to enhance feed efficiency, and increase egg production and quality during birds moulted with 1.5% and 2.0% ZnO supplementation. This greenish moult. Results showed that moulted hens with ZnO salt significantly decreased feed conversion ratio and increased egg production of the birds. This result agrees with reports by Durmus et al. [18], Salem et al. [19], who observed improvement in egg production and feed efficiency in hens moulted using zinc salts. According to McDaniel and Aske [20], increase in egg production can relate to profit for the egg industry, depending on bird and feed prices and demand for egg. Increased egg production witnessed in the Zn treated birds may be attributed to the role of zinc in increasing blood plasma sex hormone concentration [18], and its interaction in metabolic processes in the animal like in protein synthesis, carbohydrate metabolism, reproduction, enzyme activation and growth [21]. In addition, increased post moult egg production in

moulted hens may be accounted for by the decline in the production of shell-less egg during the same period [12]. In consonance with reports by Khan et al. [8] and Khan et al. [11], that moulted hens that lost higher percentage in body weight exhibited greatest improvement in post moult egg production, our study showed that moulted hens fed 1.0%, 1.5% and 2.0% ZnO supplementation which lost higher amount in body weight, had maximum egg production during post moult. In the moulted hens, post moult resumption of egg production increased progressively as the amount of dietary ZnO supplementation increased across treatment. Birds exposed to higher amount of dietary ZnO resumed egg production much later, compared with those exposed to lower amount of Zn mineral, implying that higher consumption of dietary Zn by laying hens, effectively increases the rate of involution of their reproductive organs. This agrees with the findings of Berry [2] that hens return to egg production in proportion to the amount of Zn added to their diet and the duration of dietary exposure.

Results of these studies showed that inducing moult in hens using ZnO had a profound effect on the relative weights of the ovary, liver and gizzard of the birds. Our findings revealed an increase in the weight of these organs in moulted birds, in contrast to the non-moulted hens. Reports by Park et al. [12], Khan et al. [11] revealed that the moulting process causes a decrease in the weights of the ovary, and liver, especially during the moulting period. During the recovery period (post moulting period), when the moulting agent (ZnO) has been withdrawn, the rate of growth of these organs may have increased to compensate for decrease in their growth caused by the moulting process. This may account for the increased growth of these organs, as observed in our study, in contrast to the findings of Park et al. [12], Khan et al. [11], that moulting process caused a significant decline in the relative weights of the ovary and liver. It may be inferred that increase in the weight of the liver of moulted hens during the recovery period was because of the re-instatement of liver energy resources like glycogen and lipids, and estrogen-dependent egg component synthesis, which were lost during the moulting period [12]. Also, the liver may have been actively involved in the process of detoxification of the excess Zn mineral used in inducing moult. A greenish colouration was observed on the liver of birds moulted with 1.5% and 2.0% ZnO supplementation. This greenish colouration was very prominent in the latter birds. The cause of this colour change in the liver of these birds is unclear. However, it may be suggested that it was caused by an increased bile accumulation in the liver, as a result of the high dietary Zn mineral intake by the birds. The increase in the weight of kidney in the moulted hens may be credited to the increased physiological functions of the kidney in processing and removing metabolic waste and excess ions (detoxified ZnO) from the blood, and by so doing, regulating the acid-base or electrolyte balance in the body of the birds [22]. The amount of dietary ZnO used for moulting of the hens had no adverse effect on the relative weights of heart, lungs, and gizzards.

In conclusion, these results demonstrate that in order to achieve good post moult performance of laying hens in the humid tropics, farmers should practice the use of 1.0% ZnO supplementation per kg diet, as an effective method to achieve induced moulting because higher percentage inclusion levels of ZnO may be detrimental to the overall physiology of the birds.

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