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Research Article

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Effects of zinc oxide as forced-resting agent for layers on post-moult quality and nutritional value of eggs

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ABSTRACT

This study evaluated the effect of using zinc oxide to achieve moult in laying hens on post moult egg quality and mineral deposition. Two hundred Isa Brown laying hens of 75 weeks old were subjected to moult induction by supplementing their feed with varying amount of ZnO mineral. The birds were randomly assigned to 5 treatment groups with 40 layers per treatment and 10 layers in each replicate per treatment group following completely randomised design. The treatment groups were; T_0– 0 ppm (control), T_1– 5000 ppm, T_2– 10000 ppm, T_3– 15000 ppm and T_5– 20000 ppm ZnO mineral supplementation per kg diet. After 14days moult period, eggs production was monitored for 8 weeks period and eggs were collected daily from layers in each treatment group for determination of its quality and mineral contents. Egg weight, egg width and shell weight were not affected ($P > 0.05$) by dietary ZnO moulting treatment. However, egg length, egg shape index, shell thickness, albumen height, yolk weight and Haugh unit score qualities improved ($P < 0.01$) in moulted hens compared to non-moulted hens. The birds in the ZnO supplemented groups when compared with birds in the non-treated group (T_0) exhibited the greatest ($P < 0.01$) amount of zinc and calcium deposition in their eggs. From our findings, moulting with ZnO mineral enhances egg quality and also adds value to the nutritional content of the eggs thereby increasing its acceptability by humans.

Keywords: Trace minerals, calcium transfer, DNA, poultry, egg, gonadotropin

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INTRODUCTION

Moult induction is a common practise in most commercial egg industry as a means of rejuvenating a flock to undergo a second and third cycle of egg production [1]. In hen, moulting ceases egg production and allows the hen to enter a resting or non-reproductive stage which increases egg production and egg quality post moult [2]. Several documented methods have been applied in the moulting of laying hens in many commercial poultry farms in developed countries [2-4]. However, non-feed withdrawal method involving the manipulation of dietary minerals like zinc, sodium, calcium, aluminium, etc [2, 5, 6] has been recommended by researchers due to its reduced impact on the health and physiological wellbeing of the birds[3, 7]. A high dose of dietary zinc is efficient in causing regression of the reproductive tissue of moulted hen. Sundaresann et al. [7] suggested that a high dose of dietary zinc seems to induce reproductive regression via the upregulation of cytokines and chemokines, the suppression of feed intake, and the increase in serum corticosterone, resulting finally in the apoptosis of reproductive tissues. The entire physiological processes culminate in the increase in egg production and egg quality during post moult. In commercial egg production, the practice of moulting in laying hens could be applied as a means of adding value to egg by improving its mineral and other nutritional qualities making it more and better acceptable for consumers to improve their health status. There has been an increasing effort to improve nutritional value of egg lately and there is a renewed hope that health-conscious consumers may be willing to pay more for a value-added product like egg [8].

The beneficial effect of using zinc oxide (ZnO) mineral to achieve moult induction in laying hens has been reported. However, information on the impact of feeding zinc oxide mineral as moulting agent on post moult egg quality and nutritional value is inconclusive. This study evaluated the effect of using zinc oxide to achieve moult in laying hens on post moult egg quality and mineral deposition.

EXPERIMENTAL SECTION

Two hundred Isa Brown laying hens of 75 weeks old were subjected to moult induction by supplementing their feed with varying amount of ZnO mineral. The birds were randomly assigned to 5 treatment groups with 40 layers per treatment and 10 layers in each replicate per treatment group following completely randomised design. The treatment groups were; T_0 – 0 ppm (control), T_1 – 5000 ppm, T_2 – 10000 ppm, T_3 – 15000 ppm and T_5 – 20000 ppm ZnO mineral supplementation per kg diet. Birds in each treatment group were housed individually in cages. Also, the birds were fed the standard diet (Table 1) for two weeks prior to exposure to zinc oxide supplementation. Clean drinking water was provided to the birds *ad libitum* whereas egg production was also monitored during the same period. After the two weeks acclimatization period, the diet of birds was supplemented with ZnO mineral according to their treatment groups to induce mounting.

Table 1 Percentage and proximate composition of the experimental diet

Ingredients	Composition (Kg/100kg)	Nutrient	Proximate (%)
Maize	48	Crude protein	16.5
Wheat offal	12	Crude fibre	2.5
Soya bean meal	16	Moisture	5
Palm kernel cake	12	Ash	14.35
Fish meal	2	Ether extract	12.5
Bone meal	5	Nitrogen free extract	49.15
Limestone	4		
Lysine	0.25		
Methionine	0.25		
*Vitamin Mineral	0.25		
Salt	0.25		
Total	**100**		**100**

**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.*

After 14 days moult period, eggs production was monitored for 8 weeks period and eggs were collected daily from layers in each treatment group for determination of its quality and mineral contents. The egg qualities characteristics determined were: egg weight, egg length, egg shape index, shell weight, shell thickness, albumen height, yolk weight and Haugh unit. Egg weight was determined by weighing in an electronic scale while egg length and egg width were measured using a vernier callipers. Egg shape index was calculated using the formula, egg shape = (egg width / egg length) * 100 [9]. Shell weight was determined after drying the egg shell in normal room temperature (27 ^{o}C) for 24 hours and weighing using an electronic weighing scale. To determine egg shell thickness, three measurements of shell thickness including egg shell membranes were taken from the large end, equator and small end of each egg shell with a micrometer (Ames, Waltham, MA). Average of the three shell thickness measurements were recorded and used for analysis. For the determination of yolk weight, eggs were cracked and its content carefully emptied into a flat plate. The yolk was separated from the albumen using a Teflon spoon and the chalazae carefully removed before weighing. Also, yolk and albumen heights were determined using Ames tripod micrometer (Ames, Waltham, MA, USA) after emptying the content of the egg on a clean flat surface. The Haugh unit was also measured using Ames tripod micrometer. Zinc and calcium determination in egg was done by the method of Pearson [10]. All data were analyzed using the PROC ANOVA statement of SAS software [11]. Differences in mean of the parameters among treatment groups were compared at 5% level of significance ($P < 0.05$) using Duncan's multiple range tests.

RESULTS AND DISCUSSION

The effect of moulting using zinc oxide minerals on the egg quality characteristics are shown in Table 2. Moult induction with zinc oxide had no significant ($P > 0.05$) impact on the egg weight, egg width and shell weight. However, egg length, egg shape index, shell thickness, albumen height, yolk weight and Haugh unit score of eggs showed significant ($P < 0.05$) variations among treatment groups. Egg length was longer for hens in T_4 compared (6.36 ±0.12 cm; $P < 0.05$) to other treatments. There was a gradual increase in the egg length as the amount of dietary zinc oxide supplementation was increased from 5000 ppm to 20000 ppm/ kg of diet. Egg length of hens in T_0 and T_1 were similar but differed ($P < 0.05$) from those in T_2 and T_3. Egg shape index for hens in the control treatment group compared ($P > 0.05$) favourably with those of moulted hens in T_1, T_2, and T_3. However, their egg shape index values differed ($P < 0.05$) from those of hens in T_4. Eggs of moulted hens in T_1 and T_2 and the control groups (T_0) had higher shell thickness characteristics which differed ($P < 0.05$) from those of hens moulted using 15000 ppm (T_3) and 20000 ppm (T_4) zinc oxide per kg diet. Albumen height and Haugh unit of egg in the various treatment followed similar pattern. Both egg characteristics were higher for eggs of hens in T_2, T_3 and T_4 but differed highly ($P < 0.01$) from those of hens in T_0 and T_1. With the exception of T_4, the average weight of egg yolk was higher ($P < 0.01$) for T_3 and lower for hens in T_0, T_1 and T_3.

Table 2: Egg quality characteristics of Zinc-moulted and non-moulted hens

	Treatments					
Parameters	T_0	T_1	T_2	T_3	T_4	Prob.
Egg weight, g	64.83±1.06	64.11±1.81	63.22±0.64	64.31±0.71	63.12±2.29	0.62^{NS}
Egg length, cm	$5.95±0.08^c$	$5.98±0.70^c$	$6.05±0.09^b$	$6.02±0.06^b$	$6.36±0.12^a$	0.00**
Egg width, cm	4.86±0.07	5.04±0.10	4.91±0.07	4.95±0.08	4.98±0.07	0.58^{NS}
Shape Index	$0.85±0.90^a$	$0.84±0.4^a$	$0.84±0.78^a$	$0.82±1.30^{ab}$	$0.78±0.58^b$	0.05*
Shell weight, g	5.34±0.1	5.25±0.10	5.05±0.14	6.30±0.13	5.46±0.20	0.36^{NS}
Shell thickness, mm	$0.42±0.01^a$	$0.40±0.01^{ab}$	$0.42±0.02^a$	$0.38±0.01^b$	$0.38 ±0.01^b$	0.05*
Albumen height, mm	$7.64±0.60^b$	$8.35±0.60^b$	$9.75±0.35^a$	$10.56±0.22^a$	$9.63±0.38^a$	0.00**
Yolk weight, g	$16.11±0.30^b$	$16.36±0.34^b$	$15.70±0.25^b$	$17.70±0.40^a$	$16.70±0.38^{ab}$	0.01**
Haugh unit	$85.54±1.50^c$	$91.70±3.08^b$	$99.69±1.83^a$	$99.90±0.75^a$	$96.73±2.27^{ab}$	0.00**

*a, b, c, Means on the same row with different superscripts are significant at 5%, NS: not - significant; * = P<0.05; ** P < 0.01; Prob.- Probability*

Moulting with zinc oxide did not cause major changes in egg weight, egg width and shell weight characteristics of the birds. This is consistent with reports by El-Deek and Al-Harthi [12] who found no significant differences in these egg parameters. Aygun [13] reported no significant variation in egg weight between moulted and non-moulted hens. Although it has been reported that egg weight increased as the hens age [14], this was not the case in this study since the moulted hen and non-moulted hens were of the same age supporting our findings that the zinc mineral had no influence on egg weight. Other egg quality indices namely egg length, shape index, shell thickness, albumen height, yolk weight and Haugh unit score were influenced by the zinc oxide diet. This finding is in agreement with other reports in literature. For instance, Bar et al. [15] reported higher shell thickness in hens moulted with organic Zn compared to their non-moulted groups. The authors observed improvements in egg production; egg and egg shell quality for layers fed with organic Zn. Earlier report by Shippee et al. [16] showed no significant variation in shell thickness for groups of hens moulted with zinc acetate and zinc oxide during post moult period. A better and improved albumen quality as measured by increased albumen height and Haugh unit in the second laying cycle shown in this study is in agreement with the report of Sahin and Kucuk [17] and Tabatabaie et al. [18] who reported that Zn supplementation positively affected the Haugh unit. The Haugh unit is a measure of egg protein quality based on the height of its egg white (albumen).

Highly significant effect was shown in the zinc and calcium composition in the yolk, albumen and whole eggs of moulted and non-moulted hens (Table 3). Zinc and calcium compositions in yolk and whole egg of moulted hens in T_4 surpassed ($P < 0.01$) those of other treatment groups. Moulted hens in T_2 and T_3 had similar amount of Zn and Ca in the yolk and whole egg that were higher ($P < 0.01$) than those of T_1 and the control group (T_0). In the egg albumen, Zn and Ca contents of eggs for the moulted hens differed ($P < 0.01$) from those of the non-moulted hens. While zinc composition in albumen was higher in eggs of moulted hens in T_4 and least for the non-moulted groups of hens (control; T_0), their calcium contents was similar in eggs of moulted hens but differed ($P<0.01$) from eggs of the control groups of hens.

Table 3: Zinc and calcium composition in eggs of moulted and control hens

	Treatment					
	T_0	T_1	T_2	T_3	T_4	Prob.
Yolk (ppm)						
Zn	95.5±0.29^{d}	102.50±0.72^{c}	109.38±1.80^{b}	109.20±0.26^{b}	115.88±0.94^{a}	0.00**
Ca	48.0±4.62^{c}	72.25±0.14^{b}	72.25± 0.14^{b}	78.00±1.16^{b}	100.00±2.31^{a}	0.00**
Albumen (ppm)						
Zn	52.00±1.16^{d}	56.50±0.29^{c}	62.55±0.03^{b}	59.50±1.73^{bc}	82.50± 2.89^{a}	0.00**
Ca	16.25±0.14^{b}	24.25±0.14^{a}	20.00±2.31^{ab}	24.30±0.17^{a}	20.00±2.31^{ab}	0.01**
Whole Egg (ppm)						
Zn	147.50±1.44^{d}	159.00±0.43^{c}	171.93±1.78^{b}	168.70±1.47^{b}	198.38±3.83^{a}	0.00**
Ca	64.25±4.47^{d}	96.50±0.00^{bc}	96.25±2.17^{c}	102.30±1.33^{b}	120.00±0.00^{a}	0.00**

a, b, c, d Means on the same row with different superscripts are significant at 5%, = P < 0.05; ** P < 0.01; Prob.- Probability.*

Higher amount of zinc and calcium contents were found in egg yolk, egg albumen and whole egg of moulted hens compared to the non-moulted birds indicating an increase in the amount of zinc and calcium deposition in eggs of moulted hens. Therefore, inducing moult in hens using zinc had a profound effect on the zinc and calcium deposition in eggs. Our findings showed that egg contents of these minerals increased across treated groups with increasing level of zinc in the diets. Egg yolk from hens fed 20000 ppm Zn/kg diet contained about 30% more zinc whereas hens fed with 5000 ppm diet gave about 5% more zinc than egg yolk from non-moulted hen. These findings are in consonant with reports of previous studies [19, 20]. The observed increase in yolk zinc content may be linked probably to the production of vitellogenin. In poultry, Guo et al. [20] reported that vitellogenin may be increased when zinc concentration increases because of the transfer of zinc which is stored in the liver to the yolk of the egg. About 70% of the total zinc in the whole egg was deposited in the yolk while 30% was found in the albumen. This is not surprising because of the important role of zinc in the development of the embryo. Richards [21] reported that egg yolk is a major source of zinc in fertile eggs because they are required for the development of the embryo. Although higher amount of zinc compared to calcium was found in the yolk, albumen and whole eggs, both minerals plays crucial role in avian reproduction. Calcium plays an important role in gonadotropin secretion and reproduction in avian ovarian cells [22]. It is noteworthy that increasing levels of dietary zinc inclusion above a threshold may impair calcium uptake and causes calcium to fall below the critical level essential for gonadotropin production and release of LH [23], thus suggesting that moderate amount of zinc should be added in diets of poultry. Nutritionally, higher amount of these mineral depositions in egg of moulted hens compared to non-moulted hens is remarkable because the eggs can serve as a good source of these minerals for human consumption. This finding supports the view of Vilà [8] that supplementing hens diet with minerals like magnesium, manganese, zinc, iodine, and selenium, raises the levels of these minerals in the egg. For instance, NDMoPH[24] report showed that the egg can contribute 21%, 16% and 13% of the recommended levels of Thai Dietary Reference Intake for children age 4 to 5, 6 to 8 and 9 to 12 years, respectively. Zinc has been noted as being an important trace mineral for maintaining health of humans and other animals playing a ubiquitous role in cellular metabolism [8, 25]. It functions as a catalyst and contributes to the stabilization of the quaternary structure of metalloenzymes, RNA, DNA, and ribosome [25]. Research reports from experiments using zinc in animals [26, 27] have shown that the egg is a veritable choice for supplying extra zinc to human diet. Vilà [8] noted that eggs enriched with some minerals, vitamins, carotenes, fatty acids, and even specific antibodies or decreased cholesterol content, provides the vision of new eggs and egg products on the present and future markets. Then, eggs with superior biologic and nutritional value will be readily available for human consumption.

CONCLUSION

From our findings, moulting with ZnO mineral enhances egg quality and adds value to the nutritional content of the eggs thereby increasing its acceptability by humans and such eggs represent a good opportunity for supplying extra zinc to human diets

ETHICAL STANDARDS

Experimental procedures and management conditions complied with the ethical and scientific standards for carrying out biomedical research on human and animal subjects Medical and Scientific Ethics Committee, University of Nigeria, Nsukka, 2006).

Also, all authors of this manuscript gave their informed consent prior to their inclusion in the study and each contributed immensely to the final completion of the manuscript.

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REFERENCES

[1] SH Khan; A Rehman; A Jehanzeb. *Vet. World*, **2011**, 4 (9): 389-395.doi:10.5455/vetworld.2011.389-395.
[2] AB Webster. *Poult. Sci.*, **2003**, 82, 992-1002.
[3] K Keshavarz; FW Quimby. *J. Appl. Poult. Res*., **2002**, 11, 54-67.
[4] AA Salem; M Eman; NE Nofal. *Egypt J. Appl. Sci*., **2005**, 20, 12-31.
[5] RU Khan; Z Nikousefat; M Javdani; V Tufarelli; V Laudadio. *Worlds Poult. Sci. J.,***2011**, 67, 497-506.
[6] DD Bell. *Poult. Sci.*, **2003**, 82, 965-970
[7] NR Sundaresann; D Anish; KV Sastry; VK Saxena; K Nagarajan; J Subramani; MD Leo; N Shit; J Mohan; M Saxena; KA Ahmed.*Cell Tissue Res.*, **2008**, 332(3), 543-54.doi: 10.1007/s00441-008-0599-3.
[8] B Vilà. Improvement of biologic and nutritional value of eggs. In :Brufau J. (ed.), Tacon A. (ed.). Feed manufacturing in the Mediterranean region: Recent advances in research and technology. Zaragoza: CIHEAM, **1999**, 379-396 (Cahiers Options Méditerranéennes; n. 37).
[9] PC Panda; Shape and Texture. In Textbook on Egg and Poultry Technology. First Edition, New Delhi, India.**1996**
[10] D Pearson; Chemical analysis of food, 8th Edition. H Egan (Ed.) Elsevier Health Sciences Publishers, Edinburg, UK.**1980**.
[11] M Stokes; N Curtis. Statistical Enhancements in Release 6.12 of the SAS[â] System. SAS STAT Users Guide, SAS. Inst Inc., Cary, NC. **2001.**
[12] AA El-Deek; MA Al-Harthi. *Intern. J. Poult. Sci*., **2004**, 3 (7), 456-462.
[13] A. Aygun. *Revue Médical Véterinarian*, **2013**, 164 (2), 46-51.
[14] Y Akbas; O Altan; C Kocak. *Turk. J. Vet. Anim. Sci.*, **1996**, 20, 455-460.
[15] A Bar; V Razaphkovsky; D Shinder; E Vax. *Poult. Sci.*, **2003**, 82, 543–550.
[16] RL Shippee; PE Stake, U Koehn; JL Lambert; RW Simmons. *Poult. Sci.,***1979**, 58, 949–954.
[17] K Sahin, O Kucuk. *J. Nutrition*, **2003**, 133, 2808-2811.
[18] MM Tabatabaie; H Aliarabi; AA Saki; A Ahmadi; SA Hosseini-Siyar. *Pakistan J. Biol. Sci.*, **2007,** 10, 3476-3478. DOI:10.3923/pjbs.2007.3476.3478
[19] I Mabe; C Rapp; MM Bain; Y Nys. *Poult.Sci*, **2003**, 82, 1903-1913.
[20] YM Guo; R Yang; J Yuan; TL Ward; TM Fakler. Effect of Availa®Zn and zinc sulfate on egg zinc concentration, laying performance and egg quality. In: Program & Abstracts Bioavailability (2006): Optimizing Dietary Strategies for Better Health in Developing Countries. **2006**, 7-10 March. Chiang Mai, Thailand. 95
[21] MP Richards. *Poult. Sci.*, **1997**, 76, 152-164
[22] TG Taylor. Calcium-endocrine relationships in the laying hens, The Proceedings of the Nutrition Society, **1965**, 24, 49–54.
[23] WD Berry; J Brake. *Poult. Sci*., **1987,** 66, 218–226
[24] The Committees on Dietary Reference Intakes for Thais; NDMoPH. Dietary Reference Intakes for Thais 2003. 3rd Ed., Nonthaburi: Nutrition Division, Ministry of Public Health. **2003**, 347pp
[25]BL O'Dell. *Nutrition Rev.*, **1992**, 50(2), 48-50.
[26] JD Flinchum; CF Nockels; RE Moreng.*Poult. Sci.*,**1989**, 68(Suppl. 1):55(Abstr.).
[27] MT Kidd; NB Anthony; SR Lee.*Poult.Sci*.,**1992**, 71, 1201—1206.