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Research Article

Performance and Quality in Old Laying Hens Fed Dietary Silicon Extracted from Rice Hull Ash

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Abstract

Background and Objective: Normally, old laying hens must be provided with proper diet supplementation to maintain their optimum egg production and egg quality. As a silicon is an essential trace mineral which plays an important role in normal bone and associates with calcium in the early stages of biocalcification. Therefore, the current study was conducted to investigate the effects of dietary silicon extracted from rice hull ash (SERA) on the egg performance and egg quality of old laying hens. **Materials and Methods:** At 75 weeks of age, a total of 80 laying hens (Lohmann Brown Classic) were divided into 4 dietary groups of 20 birds each as follows: Each group was fed the basal diet (CP, 18%; ME, 2,850 kcal kg⁻¹) supplemented with 0.00, 0.50, 0.75 or 1.00% SERA, respectively. Data on egg performance and egg quality was collected for 8 weeks and analyzed using one-way analysis of variance followed by Duncan's multiple range test. **Results:** No significant differences were observed when feeding all levels of dietary SERA on hen-day egg production, average egg weight, feed intake, egg mass and feed conversion ratio. Significant differences in egg shell thickness and egg shell strength ($p < 0.05$) were detected in hens fed dietary 0.75% SERA when compared to the 0.00% SERA group. However, feeding all level of dietary SERA did not affect egg shell ratio, yolk ratio, albumen ratio, albumen height, yolk color and Haugh units. **Conclusion:** The current study concludes that SERA can be used as rich source of silicon in basal diets up to 0.75% to improve the egg shell quality of old laying hens without negative effects on egg performance.

Key words: Dietary silicon, egg quality, old laying hens, performance, rice hull

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Worldwide consumption of poultry products, especially eggs, has consistently increased since last few years and this trend is expected to be continued in near future. Nowadays, skeletal abnormalities, bone deformities, egg breakage and fracture are major issues in laying hens. They cause significant loss in the performance of laying hens and their egg quality^{1,2}. Generally, number of factors like genetics, feed quality, environment, level of feed conversion and age are involved to maintain optimum egg production, egg quality, bones and skeleton². Amongst all, age is considered to be predominant factor. Egg production and egg quality is more severely influenced particularly in aged laying hens compared to younger ones. Old laying hens must be provided proper diet supplementation to maintain their optimum egg production and egg quality.

Currently, silicon is an essential trace mineral which plays an important role in normal bone and cartilage development³. It is also considered as significant component which takes part in bone and skeletal formation^{4,5}. In addition, it seems that silicon is associated with calcium in the early stages of biocalcification⁶. Jugdaohsingh⁷ reported that silicon intake also has positive effect on human bone mineral density.

Bae *et al.*⁸ described that drinking water supplemented with silicon improved bone mineral density of tibia and femur as well as enhancing the femoral bone mineral content in aged rats⁹. In addition, ovariectomized rats fed with dietary silicon showed an increasing bone mass and reducing bone turnover¹⁰. Although multiple studies have been conducted on silicon application in poultry feeding experiments and reported that silicon plays vital role in bones and skeleton formation in broilers, quails and turkeys^{5,11-13}. In Thailand, the major rice mill by-product is rice hull ash, which can be used as a valuable raw material for silicon production.

Recently, Incharoen *et al.*⁵ published that dietary silicon extracted from rice hull ash (SERA) can be used as a mineral additive to improve the meat and bone quality in broilers, particularly silicon at a level of 0.75% in broiler diets. These studies suggested that dietary SERA may also have impact on eggs production and eggs quality in old laying hens. However, study on SERA and their influence on the old layer performance is very much exceptional and had never been studied. Therefore, current study was planned to especially focus on the effect of dietary SERA on performance and eggs quality of old laying hens for 8 weeks feeding periods.

MATERIALS AND METHODS

Geographical location of study: The current study was carried out from February-May, 2017 at the Poultry Research Station, Naresuan University, Phitsanulok, Thailand. The experiment was conducted following the guidelines verified and approved by the Naresuan University Animal Care and Use Committee (NU-AQ570503). This study was proposed in order to check the influence of dietary SERA on the performance and egg quality of old laying hens in the vicinity of Phitsanulok, Thailand.

SERA extraction: Rice hulls were obtained from the commercial milling process in Phitsanulok, Thailand and converted into rice hull ash by placing the rice hulls in the muffle furnace on the temperature of 700°C for 24 h. Resultant ash content was transferred to a flask and solution of sodium hydroxide (3.0 N) was poured. Flask was covered and contents of flask were boiled on the temperature of 100°C for 3 h and constantly stirred. Boiled contents were filtered using filter paper and boiling water was poured to wash the residues. Residues and washing solution were left for few minutes for to be cooled down to room temperature. As residues and washings achieved room temperature at that time they were titrated with 5.0 N H₂SO₄ by constantly stirring until pH 2. This step resulted solution to be precipitated. NH₄OH was added till solution achieved pH 8. By using filter paper, precipitated material was filtered and residues were dried in hot air oven on the temperature of 120°C for 18 h to give rise silicon. Then, dried residues were ground and resultant product was stored for to be used for feeding trials. However, the SERA product is mainly comprised of 96.50% SiO₂, 0.90% Na₂O and 0.60% K₂O.

Experimental design and data collections: At 75 weeks of age, old laying hens (Lohmann Brown Classic) were selected for the current study. During selection, percent hen-day production of each hen was key point to consider. A total of 80 selected hens were transferred to the experimental station and divided into 4 dietary groups of 20 birds each as follows: each treatment group was fed the basal diet (CP, 18%; ME, 2,850 kcal kg⁻¹) supplemented with 0.00, 0.50, 0.75 or 1.00% SERA, respectively. Data were collected during the study period of 8 weeks to determine the egg performance and egg quality of old laying hens on different dietary SERA levels. Eggs were collected daily and counted to obtain data on egg performance and feed intake for each replicate was recorded weekly for the entire study. Eggs from each group were collected weekly to measure egg quality. A total of 80

randomly selected eggs (20 from each group) were brought weekly to laboratory during the study period of 8 weeks to evaluate egg quality of old laying hens on different SERA levels. At first, egg weight was recorded by using an electronic digital balance. The shell-breaking strength was measured using a Texture Analyzer model QTS25 (Brookfield Engineering Labs., Inc. Middleboro, MA 02346 USA). Each eggs were placed vertically and compressed at a constant speed of 10 mm min⁻¹ and breaking strength was determined at the moment when eggshell broken up. Next step, each individual egg was conducted to measure internal properties (Haugh units, albumen height and yolk color) using an Egg Multi Tester (Model EMT-7300, Robomotion Co., Ltd., Tokyo, Japan). Then, the weights of the egg yolk, albumen and shell were measured using an electronic digital balance. Shell thickness was measured at three locations on the egg (the large, equator and small end) using a micrometer. The values of the shell ratio, albumen ratio and yolk ratio were calculated according to Incharoen and Yamauchi¹⁴.

Statistical analysis: Data were analyzed using one-way analysis of variance (ANOVA) followed by Duncan's multiple range test. Differences between means were considered to be significant at $p < 0.05$. All data were expressed in the form of Mean $\pm$ SE.

RESULTS AND DISCUSSION

Results regarding hen-day egg production, average egg weight, feed intake, egg mass and feed conversion ratio of old

laying hens fed dietary SERA are shown in Table 1. No significant differences results were observed among the dietary SERA groups. This indicated that the old laying performance was not affected by dietary silicon, which is partially in agreement with some researchers who studied dietary silicon-based in laying hens^{15,16}, broilers⁵ and swine¹⁷⁻¹⁹. From these data, authors can confirm that dietary SERA had no adverse impacts on eggs performance of old laying hens. On the other hand, Machacek *et al.*²⁰ reported that addition of 2% silicon-based clinoptilolite (62% SiO₂) to laying diet showed a highly significant increase in egg weight. Similar findings has also been reported by Moghaddam *et al.*²¹, who described that inclusion of the silicon-based zeolite in diet had a positive effect on egg performance and egg quality of laying hens fed varying levels of calcium and non-phytate phosphorous. Furthermore, Onderci *et al.*²² also demonstrated that dietary arginine silicate inositol complex has positive influence on the quail in term of improving feed intake and egg production.

Data on the egg shell thickness, egg shell strength, egg shell ratio, yolk ratio, albumen ratio, albumen height, yolk color and Haugh units of old laying hens fed dietary SERA are shown in Table 2. No significant differences results in egg shell ratio, yolk ratio, albumen ratio, albumen height, yolk color and Haugh units were observed among the dietary SERA groups. However, egg shell thickness and egg shell strength showed the highest value ($p < 0.05$) within the group supplemented with 0.75% SERA when compared to the 0.00% SERA group. These finding are also in agreement with Moghaddam *et al.*²¹, who reported the silicon-based zeolite in diet had a positive effect on egg shell thickness of laying hens

Table 1: Effects of dietary silicon extracted from rice hull ash (SERA) on egg performance of old laying hens (Mean $\pm$ SE)

Items	Dietary SERA (%)			
	0.00	0.50	0.75	1.00
Hen-day egg production (%)	84.26 $\pm$ 1.95	85.16 $\pm$ 2.82	83.62 $\pm$ 3.24	82.16 $\pm$ 2.75
Average egg weight (g)	60.86 $\pm$ 0.69	61.84 $\pm$ 1.10	61.94 $\pm$ 0.70	61.15 $\pm$ 0.87
Feed intake (g/hen/day)	100.40 $\pm$ 2.47	102.60 $\pm$ 2.36	101.84 $\pm$ 2.74	102.58 $\pm$ 2.47
Egg mass (g/hen/day)	51.25 $\pm$ 1.24	52.42 $\pm$ 1.52	50.54 $\pm$ 2.09	50.49 $\pm$ 1.99
Feed conversion ratio	1.96 $\pm$ 0.04	1.95 $\pm$ 0.07	2.01 $\pm$ 0.08	2.03 $\pm$ 0.13

Table 2: Effects of dietary silicon extracted from rice hull ash (SERA) on egg quality of old laying hens (Mean $\pm$ SE)

Parameter	Dietary SERA (%)			
	0.00	0.50	0.75	1.00
Egg shell thickness (mm)	0.34 $\pm$ 0.02 ^b	0.34 $\pm$ 0.01 ^{ab}	0.35 $\pm$ 0.01 ^a	0.33 $\pm$ 0.02 ^b
Egg shell strength (g cm ⁻²)	3904.00 $\pm$ 90.76 ^{bc}	4069.00 $\pm$ 80.35 ^{ab}	4215.00 $\pm$ 101.87 ^a	3785.00 $\pm$ 89.28 ^c
Egg shell ratio (%)	10.75 $\pm$ 0.22	11.17 $\pm$ 0.34	11.09 $\pm$ 0.20	10.86 $\pm$ 0.43
Yolk ratio (%)	27.83 $\pm$ 0.53	27.93 $\pm$ 0.76	27.01 $\pm$ 0.82	28.49 $\pm$ 0.65
Albumen ratio (%)	61.42 $\pm$ 0.60	60.90 $\pm$ 0.86	61.90 $\pm$ 0.87	60.65 $\pm$ 0.91
Albumen height (mm)	6.08 $\pm$ 0.14	5.94 $\pm$ 0.21	5.70 $\pm$ 0.15	6.06 $\pm$ 0.20
Yolk color	7.39 $\pm$ 0.12	7.42 $\pm$ 0.13	7.58 $\pm$ 0.11	7.35 $\pm$ 0.17
Haugh unit	76.56 $\pm$ 0.91	74.75 $\pm$ 1.51	72.21 $\pm$ 1.60	74.76 $\pm$ 1.60

^{a-c}Mean values within row with different superscripts are significantly different ($p < 0.05$).

fed varying levels of calcium and non-phytate phosphorous. Furthermore, the inclusion of the silicon-based clinoptilolites in laying diets had a significant ($p < 0.05$) effect on egg shell strength²³. Herzig *et al.*²⁴ demonstrated that a concentrated mixture of more than 60% SiO₂ was found to have an improvement in the content of crude protein, calcium and magnesium in egg shell. These beneficial impacts may be associates to the dietary silicon because it has been shown to affect calcium metabolism^{25,26}. In agreement with some testimonies indicated that silicon relate to the formation and/or stabilization of extra cellular matrix as well as the Ca metabolism^{7,27}. The current data are similar to Incharoen *et al.*⁵, who demonstrated that silicon derived from rice hull ash can be used as a mineral supplement to enhance the bone and meat quality of broiler chickens, especially dietary 0.75% silicon. Likewise, Short *et al.*²⁸ published the dietary silicon had an advantage function to reduce lameness in broilers. Thus, it seems that the dietary silicon is benefit for both bone and egg shall characteristic. Another advantage role of silicon also presented by Safaei *et al.*²⁹, who described that silicon-based supplement can enhance the litter quality in broiler production, as well as decreasing the conversion of NH₄⁺ to NH₃ in turkey production³⁰. Lastly, this study discover the positive effect of dietary SERA that can be beneficial for egg quality such as egg shell thickness and shell strength.

SIGNIFICANCE STATEMENT

The present data will help the researcher to uncover the critical area of the improvement in eggshell quality that many researchers were not able to explore. Therefore, a new theory on the SERA application in old laying hen diet may be arrived at.

CONCLUSION

The current study concluded that SERA can be used as rich source of silicon for old laying hens. Especially, SERA on the level of 0.75% along with basal diet appears to improve the egg quality of old laying hens without any negative effects on egg production.

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REFERENCES

1. Ehtesham, A. and S.D. Chowdhury, 2002. Responses of laying chickens to diets formulated by following different feeding standards. Pak. J. Nutr., 1: 127-131.
2. Almeida Paz, I.C.L., A.A. Mendes, A. Balog, L.C. Vulcano and A.W. Ballarin *et al.*, 2008. Study on the bone mineral density of broilers suffering femoral joint degenerative lesions. Braz. J. Poult. Sci., 10: 103-108.
3. Pietak, A.M., J.W. Reid, M.J. Stott and M. Sayer, 2007. Silicon substitution in the calcium phosphate bioceramics. Biomaterials, 28: 4023-4032.
4. Schwarz, K. and D.B. Milne, 1972. Growth-promoting effects of silicon in rats. Nature, 239: 333-334.
5. Incharoen, T., W. Tartrakoon, S. Nakhon and S. Treetan, 2016. Effects of dietary silicon derived from rice hull ash on the meat quality and bone breaking strength of broiler chickens. Asian J. Anim. Vet. Adv., 11: 417-422.
6. Matsko, N.B., N. Znidarsic, L. Letofsky-Papst, M. Dittrich, W. Grogger, J. Strus and F. Hofer, 2011. Silicon: The key element in early stages of biocalcification. J. Struct. Biol., 174: 180-186.
7. Jugdaohsingh, R., 2007. Silicon and bone health. J. Nutr. Health Aging, 11: 99-110.
8. Bae, Y.J., J.Y. Kim, M.K. Choi, Y.S. Chung and M.H. Kim, 2008. Short-term administration of water-soluble silicon improves mineral density of the femur and tibia in ovariectomized rats. Biol. Trace Element Res., 124: 157-163.
9. Calomme, M., P. Geusens, N. Demeester, G.J. Behets and P. D'Haese *et al.*, 2006. Partial prevention of long-term femoral bone loss in aged ovariectomized rats supplemented with choline-stabilized orthosilicic acid. Calcified Tissue Int., 78: 227-232.
10. Rico, H., J.L. Gallego-Lago, E.R. Hernandez, L.F. Villa, A. Sanchez-Atrio, C. Seco and J.J. Gervas, 2000. Effect of silicon supplement on osteopenia induced by ovariectomy in rats. Calcified Tissue Int., 66: 53-55.
11. Carlisle, E.M., 1982. The nutritional essentiality of silicon. Nutr. Rev., 40: 193-198.
12. Elliot, M.A. and H.M. Edwards, Jr., 1991. Comparison of the effects of synthetic and natural zeolite on laying hen and broiler chicken performance. Poul. Sci., 70: 2115-2130.
13. Sahin, K., M. Onderci, N. Sahin, T.A. Balci, M.F. Gursu, V. Juturu and O. Kucuk, 2006. Dietary arginine silicate inositol complex improves bone mineralization in quail. Poult. Sci., 85: 486-492.
14. Incharoen, T. and K. Yamauchi, 2009. Production performance, egg quality and intestinal histology in laying hens fed dietary dried fermented ginger. Int. J. Poult. Sci., 8: 1078-1085.

15. Ozturk, E., G. Erener and M. Sarica, 1998. Influence of natural zeolite on performance of laying hens and egg quality. *Turk J. Agric. For.*, 22: 623-628.
16. Gezen, S.S., M. Eren, F. Balci, G. Deniz, H. Biricik and B. Bozan, 2009. The effect of clinoptilolite in low calcium diets on performance and eggshell quality parameters of aged hens. *Asian-Aust. J. Anim. Sci.*, 22: 1296-1302.
17. Chen, Y.J., O.S. Kwon, B.J. Min, K.S. Son, J.H. Cho, J.W. Hong and I.H. Kim, 2005. The effects of dietary biotite V supplementation as an alternative substance to antibiotics in growing pigs. *Asian Aust. J. Anim. Sci.*, 18: 1642-1645.
18. Chen, Y.J., O.S. Kwon, B.J. Min, K.S. Shon, J.H. Cho and I.H. Kim, 2005. The effects of dietary biotite V supplementation on growth performance, nutrients digestibility and fecal noxious gas content in finishing pigs. *Asian Austr. J. Anim. Sci.*, 18: 1147-1152.
19. Yan, L., D.L. Han, Q.W. Meng, J.H. Lee, C.J. Park and I.H. Kim, 2010. Effects of anion supplementation on growth performance, nutrient digestibility, meat quality and fecal noxious gas content in growing-finishing pigs. *Asian Austr. J. Anim. Sci.*, 23: 1073-1079.
20. Machacek, M., V. Vecerek, N. Mas, P. Suchy, E. Strakova, V. Serman and I. Herzig, 2010. Effect of the feed additive clinoptilolite (ZeoFeed) on nutrient metabolism and production performance of laying hens. *Acta Vet. Brno*, 79: 29-34.
21. Moghaddam, H.N., R. Jahanian, H.J. Najafabadi and M.M. Madaeni, 2008. Influence of dietary zeolite supplementation on the performance and egg quality of laying hens fed varying levels of calcium and nonphytate phosphorus. *J. Boil. Sci.*, 8: 328-334.
22. Onderci, M., N. Sahin, K. Sahin, T.A. Balci, M.F. Gursu, V. Juturu and O. Kucuk, 2006. Dietary arginine silicate inositol complex during the late laying period of quail at different environmental temperatures. *Br. Poult. Sci.*, 47: 209-215.
23. Fendri, I., L. Khannous, Z. Mallek, A.I. Traore, N. Gharsallah and R. Gdoura, 2012. Influence of zeolite on fatty acid composition and egg quality in tunisian laying hens. *Lipids Health Dis.*, Vol. 11. 10.1186/1476-511X-11-71.
24. Herzig, I., E. Strakova and P. Suchy, 2008. Long-term application of clinoptilolite via the feed of layers and its impact on the chemical composition of long bones of pelvic limb (*femur* and *tibiotarsus*) and eggshell. *Vet. Med. Czech.*, 53: 550-554.
25. Roland, Sr., D.A., 1988. Further studies of effects of sodium aluminosilicate on egg shell quality. *Poult. Sci.*, 67: 577-584.
26. Roland, Sr., D.A., H.W. Rabon, Jr., K.S. Rao, R.C. Smith, J.W. Miller, D.G. Barnes and S.M. Laurent, 1993. Evidence for absorption of silicon and aluminium by hens fed sodium zeolite A. *Poult. Sci.*, 72: 447-455.
27. Reffitt, D.M., N. Ogston, R. Jugdaohsingh, H.F.J. Cheung and B.A.J. Evans *et al.*, 2003. Orthosilicic acid stimulates collagen type 1 synthesis and osteoblastic differentiation in human osteoblast-like cells *in vitro*. *Bone*, 32: 127-135.
28. Short, F., E. Burton, D. Belton, G. Mann and C. Perry, 2011. Efficacy of a novel form of dietary silicon supplement in reducing lameness in poultry. *Br. Poult. Abst.*, 7: 1-2.
29. Safaei, M., Y. Jafariahangari, M.S.A. Mutalib and R. Rezaei, 2014. Evaluation usage of kaolin and zeolite in broiler diet on litter quality. *Asian J. Anim. Vet. Adv.*, 9: 64-70.
30. Tran, S.T., M.E. Bowman and T.K. Smith, 2015. Effects of a silica-based feed supplement on performance, health and litter quality of growing turkeys. *Poult. Sci.*, 94: 1902-1908.