Volume 58, January-December 2024, ISSN: 2079-3480

Animal Science

Cuban Journal of Agricultural Science

Journal site: https://cjascience.com Cu-ID: https://cu-id.com/1996/v58e13

Effect of micronized zeolite as an additive on production and egg quality in laying hens

Efecto de la zeolita micronizada como aditivo para la producción y calidad del huevo de gallinas ponedoras

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The effect of micronized zeolite as an additive for the production and egg quality in 89-week-old laying hens is determined. 240 White Leghorns L-$_{33}$ hens were used for 10 weeks, distributed in four treatments, according to a completely randomized design, with 10 replications and six hens each. The treatments consisted of adding micronized zeolite to a control diet (corn-soybean) in the following proportions: T1) control diet without addition of zeolite, T2) control diet + 1 % addition of zeolite, T3) control diet + 1.5 % addition of zeolite and T4) control diet + 2 % addition of zeolite. Body weight, laying intensity, eggs per hen per week and feed conversion did not differ among treatments. However, with 2 % micronized zeolite, mass conversion was better than in the control (1.70 vs 1.86) and is closely related to the increase in egg weight (68.95 vs 66.89 g) compared to the diet without zeolite. Zeolite also had a positive effect on breaking strength compared to the control (37.92 vs 34.26 N), with no changes in color, albumen height and Haugh units. The results suggest using 2 % micronized zeolite as a dietary additive for 89-week-old laying hens, allowing for higher egg weight, better mass conversion, and resistance to breakage.

Keywords: *birds, clipnotilolite, feed, minerals*

Se determina el efecto de la zeolita micronizada como aditivo para la producción y calidad del huevo de gallinas ponedoras de 89 semanas de edad. Se utilizaron durante 10 semanas 240 gallinas White Leghorns L-33, distribuidas en cuatro tratamientos, según diseño completamente aleatorizado, con 10 repeticiones y seis gallinas cada una. Los tratamientos consistieron en adicionar zeolita micronizada a una dieta control (maíz-soya) en las proporciones siguientes: T1) dieta control sin adición de zeolita, T2) dieta control + 1 % de adición de zeolita, T3) dieta control + 1.5 % de adición de zeolita y T4) dieta control + 2 % de adición de zeolita. El peso vivo, la intensidad de puesta, los huevos por ave por semana y la conversión alimentaria no difirieron entre tratamientos. En tanto, con 2 % de zeolita micronizada, la conversión masal fue mejor que en el control (1.70 vs 1.86) y está muy relacionada con el incremento del peso del huevo (68.95 vs 66.89 g) respecto a la dieta sin zeolita. La zeolita además, tuvo efecto positivo en la resistencia a la ruptura respecto al control (37.92 vs 34.26 N), sin modificaciones en el color, la altura del albumen y las unidades Haugh. Los resultados sugieren utilizar 2 % de zeolita micronizada como aditivo en la dieta para gallinas ponedoras de 89 semanas de edad, al permitir mayor peso del huevo, mejor conversión masal y resistencia a la ruptura.

Palabras clave: *alimentación, aves, clipnotilolita, minerales*

Introduction

At the Institute of Animal Science (ICA), the evaluation of natural zeolites for the feeding of avian species began in the 1980s. The aim of this research was to evaluate and further study substances that could potentially be used as diluents for the concentration of nutrients in feed for broilers and laying hens, and thus reduce feed costs (Acosta *et al*. 2005). The work carried out on monogastrics (Lon-Wo *et al*. 1987, Castro 2014, and Llanes *et al*. 2022) considered the particle size provided by the mineral, commercially known as ZOAD, with ground particles less than 1 mm. The results achieved in laying hens suggested the use of this mineral between 1 and 10 % in diets (Berrios *et al.* 1983, Lon-Wo and Cárdenas 1996 and Lon-Wo *et al.* 2010), allowing improvements in productive behavior, health, and hygienic-sanitary conditions of agricultural facilities.

Received: April 02, 2024
Accepted: June 28, 2024
Conflict of interest: The authors declare that there is no conflict of interest.
CRediT authorship contribution statement: Bárbara Rodríguez Sánchez: **Conceptualization, Investigation, Data curation, Formal analysis, Writing - original draft.** M. Valera: **Conceptualization, Investigation.** M. Castro: **Conceptualization, Investigation**

Recently, the Cuban Mining Company of the West has been micronizing natural zeolite with smaller particles (0.045 mm), to achieve higher quality and biosecurity for its use in different products. In animal production, the fact that it has a smaller particle size could modify the productive results (Pérez-Bonilla *et al.* 2011). The reduction of the particle size can facilitate the contact between nutrients and endogenous enzymes, thus improving the digestibility of nutrients (Parsons *et al.* 2006). However, fine particles often have a negative impact on the development of the gizzard and gastrointestinal tract, which could affect productive performance (González-Alvarado *et al.* 2007). Hence, the importance of evaluating zeolite in its new form.

In poultry farming, there is a tendency to keep laying hens for more than 100 weeks, given the cost of layer replacements and the technological flow that allows eggs to be kept on the market (Martínez *et al*. 2021). It is known that, at this stage, the egg tends to reach a larger size (Hervo *et al.* 2022) and with it, the quality of the shell decreases (Wistedt *et al*. 2019). Previous studies reported improvements in eggshell quality when feeding laying hens with natural zeolite (Roland *et al.* 1985 and Keshavarz and McCormick 1991). However, contradictory results are known in this regard, thus the present work aims to determine the effect of micronized zeolite as an additive for the production and egg quality in laying hens at 89 weeks old.

Materials and methods

The study was carried out in the poultry unit of the Institute of Animal Science. 240 White Leghorn L_{33} hens were used, distributed in four treatments, according to a completely randomized design, with 10 replications and six hens each, for 10 weeks.

The birds were housed in metal cages of 40 x 40 cm, with two nipples/cage for the *ad libitum* water supply and a linear feeder to supply the feed in a restricted manner, at a rate of 110 g/bird/day. The treatments consisted of adding zeolite to the control diet (corn-soybean) (table 1) in the following proportions: T1) control diet without addition of micronized zeolite, T2) control diet + 1 % addition of micronized zeolite, T3) control diet + 1.5 % addition of micronized zeolite and T4) control diet + 2 % addition of micronized zeolite. Micronized zeolite, with the commercial name ZEOBLANK, is processed in the Empresa Minera de Occidente with an average particle size of 6.68 µm, from the San Ignacio deposit, Mayabeque province, Cuba.

The evaluation of the effect of micronized zeolite on growth performance of laying hens was determined by the following indicators: final body weight, feed and mass conversion, number of eggs per bird and laying intensity. For egg quality, in the morning, 15 eggs per treatment were randomly selected at week 96 old. Using two automatic devices, Egg Force Reader and EggAnalyzer® (ORKA brand), the eggshell breaking strength, yolk color, egg weight, albumen height and Hauhg units were determined.

Table 1. Experimental control diet for feeding laying hens

Ingredients, %	Control
Cornmeal	62.30
Soymeal (45 % PB)	25.00
Vegetable oil	0.89
Monocalcium phosphate	1.16
Calcium carbonate	9.80
Common salt	0.30
DL methionine	0.12
Choline	0.10
Vitamin and mineral premix1	0.30
Calculated contributions, %	
Crude protein	15.99
Metabolizable energy, MJ/kg of DM-1	11.50
Crude fiber	2.40
Total calcium	4.00
Available phosphorus	0.35
Methionine + digestible cystine	0.62
Digestible lysine	0.80

[1]Mineral premix per kg of feed: selenium (0.1 mg), iron (40 mg), copper (12 mg), zinc (120 mg), magnesium (100 mg), iodine (2.5 mg), and cobalt (0.75 mg), and Vitamin premix per kg of feed: vitamin A (10,000 IU), vitamin D3 (2,000 IU), vitamin E (10 mg), vitamin K3 (2 mg), vitamin B1 (thiamine, 1 mg), vitamin B2 (riboflavin, 5 mg), vitamin B6 (pyridoxine, 2 mg), vitamin B12 (15.4 mg), nicotinic acid (125 mg), calcium pantothenate (10 mg), folic acid (0.25 mg) and biotin (0.02 mg)

For statistical processing of the data, variance analysis was performed according to a completely randomized design for the indicators egg weight, feed conversion, mass conversion, breaking strength and albumen height. The comparison between the means was performed using the Duncan (1955) test. The theoretical assumptions of the analysis of variance, normality of errors by the Shapiro and Wilk test (1965) and homogeneity of variance by Levene (1960) were tested for the variables laying intensity, eggs per bird per week, yolk color, and Hauhg units. These variables did not meet these assumptions, thus a nonparametric simple classification analysis of variance by Kruskal and Wallis (1952) was performed, and the Conover test (1999) was applied for $p<0.05$. The statistical packages Infostat (Di Rienzo *et al*. 2012) and StatSoft (2003) were applied.

Results and Discussion

The addition of micronized zeolite in the diet did not modify the body weight of the hens, the feed conversion and the albumen height (table 2). The mass conversion was better with 2 % and is closely related to the increase in egg weight at this level, thus the hen used less feed to produce a kilogram of egg. Similar results were reported by Elsherbeni *et al.* (2024), when adding 20 g/kg of zeolite in the diet for Silver Montazah hens.

Previous studies have shown that Cuban zeolite is capable of increasing the efficiency of nutrient utilization (Berrios *et al.* 1983, Lon Wo *et al.* 1987 and Acosta *et al.* 2005). According to Macháček *et al.* (2010), this improvement can be attributed to zeolite due to its positive effect on the intestinal microflora and the digestion mechanism (Prasai *et al.* 2016). This is supported by the properties of this mineral, which participates in biochemical processes that include high cation exchange capacity, absorption, catalysis and rehydration-dehydration processes. The works of Emam *et al.* (2019) and Elsherbeni *et al.* (2024) also reported improved egg weight and mass conversion with the inclusion of zeolite in the diet.

The breaking strength of the egg (table 2), regardless of the level of zeolite used, increased by 1.13 times compared to the control. In this regard, Roland *et al.* (1985) stated that the beneficial effect of zeolite on eggshell quality corresponds to the high affinity with calcium and ion exchange capacity. Similarly, Watkins and Southern (1991) support that it may be associated with the content of elements such as silicon (Si), aluminum (Al), and sodium (Na) in the zeolite, which intervene in calcium metabolism. In a recent work, Yglesia *et al.* (2022) indicated that the micronized zeolite used in this study is of the calcium-sodium type, with a $Si0_2/Al_20_3$ molar ratio ranging between 6.0 and 8.0 %, a characteristic aspect of these silica-rich minerals with a cation exchange capacity of 126.31 meq/ 100 g. These characteristics could favor calcium absorption in hens, an aspect that should be further investigated in subsequent studies due to its importance in egg quality and production.

The laying intensity, eggs per bird per week, yolk color, and Haugh units (table 3) were not modified with the addition of micronized zeolite. However, with 2 % of this mineral, a numerical increase was found in the laying intensity and the number of eggs per bird per week (5.9 % compared to the control). Similarly, Amad (2021) did not find modifications in these indicators when using natural zeolite at levels of 0.5 and 1 %. According to Vieira *et al.* (2023), the contradictions in the results obtained when using zeolite in the diet of laying hens are related to some factors such as the type and origin of the mineral, breed, age, technological level in the breeding systems, among others. According to Kermanshahi *et al.* (2011), the expected effect of zeolite in animal experiments may vary, due to the source, concentration, particle size, aluminum and silicon content in the zeolite, as well as the calcium and phosphorus content in the diet.

Conclusions

It is concluded that the micronized zeolite did not affect animal performance, thus it is suggested to use 2 % micronized zeolite as an additive in the diet of 89-week-old laying hens, allowing for higher egg weight and better mass conversion. It is necessary to delve deeper into aspects related to the internal and external egg quality, as well as blood biochemistry and nutrient digestibility, thus that the results can be confirmed and the possible mechanisms of action established.

Table 2. Effect on productive and egg quality in 89-week-old laying hens with the addition of micronized zeolite to the diet

Productive indicators	Micronized Zeolite, %				SE ±	p-value
	0	1	1.5	2		
Initial body weight, g/bird	1714	1719	1731	1711	13.04	0.7288
Final body weight, g/bird	1777	1785	1792	1789	11.57	0.7963
Feed conversion, kg/kg	1.35	1.36	1.33	1.26	0.03	0.0874
Mass conversion, kg/kg	1.86[a]	1.89[a]	1.84[a]	1.70[b]	0.04	0.0223
Egg weight, g	66.89[a]	67.15[a]	68.56[ab]	68.95[b]	0.57	0.0343
Breaking strength, N*	34.26[a]	37.99[b]	38.78[b]	37.92[b]	0.86	0.0022
Albumen height, mm	5.36	5.47	5.69	5.61	0.19	0.6165

[a,b]Different letters in the row differ for $p \leq 0.05$ *Newton

Table 3. Effect on laying intensity, eggs per bird, Haugh units and egg yolk color of 89-week-old laying hens with the addition of micronized zeolite in the diet

Productive indicators	Micronized Zeolite, %				p-value
	0	1	1.5	2	
Laying intensity, %	19.20 (82.10) SD =8.39	15.45 (80.90) SD =4.14	19.10 (82.74) SD =4.49	28,25 (87.26) SD =4.36	0.0881
Eggs/bird/week, u	19,20 (5.75) SD =0.59	15.45 (5.66) SD =0.29	19.10 (5.79) SD =0.31	28.25 (6.11) SD =0.31	0.0881
Yolk color	36.50 (3.53) SD =0.52	24.50 (3.13) SD =0.35	34.50 (3.47) SD =0.52	26.50 (3.20) SD =0.41	0.0533
Haugh units	26.67 (73.92) SD =8.50	28.20 (73.93) SD =5.19	33.00 (75.13) SD =4.21	34.13 (75.37) SD =4.41	0.5850

() Means of original data without transformation SD: desviación estándar

Acknowledgements

We would like to thank the technician Yoslaidy Arbelo and Mirella Pérez and Idalmis Rodríguez for their contribution to the development of the research in the poultry unit of the Institute of Animal Science. We also thank Magaly Herrera PhD, and the specialist Yolaine Medina for their collaboration in the statistical processing of the results.

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