Estimated the Requirements for Calcium and Phosphorus of Female Arab Chicken in Semi-Scavenging Systems in the Tropics

Syafwan[1,*] Yatno[2,*] Agus Budiansyah[3]

[123] *Animal Science Faculty of the University of Jambi.*
[*] *Corresponding author. Email: syafwan@unja.ac.id*

ABSTRACT
The ability of chickens to retain calcium and phosphorus at high temperatures is low, so a lot of calcium and phosphorus is wasted through feces. This study aimed to calculate the calcium and phosphorus requirements of female Arab chicken until the first age of laying eggs in a semi-scavenging system with a free choice feeding system in tropical climates. The research design was a completely randomized design with four treatments and each treatment was repeated 4 times and each replication consisted of 18-day old chick female Arab chickens. The treatments were (a) control feed, (b) high calcium high phosphorus feed and high calcium low phosphorus feed, (c) high calcium high phosphorus feed, high calcium low phosphorus feed and low calcium high phosphorus feed, and (d) high calcium high phosphorus, high calcium low phosphorus, low calcium high phosphorus, and control feed. The protein and energy content of all the feeds were based on the results of research by Adrizal et al (2017), while calcium and phosphorus were based on standards from Hy-line International in 2018. The data collected are feed consumption, calcium and phosphorus consumption, calcium, and phosphorus concentrations in the feed consumed. Data were analyzed by using ANOVA. This research has only been going on for 3 weeks. Consumption of feed was not different (P> 0.05) between treatments until week 3. Calcium intake was different (P<0.05) between treatments in weeks 2 and 3, Phosphorus intake was different (P< 0.05) between treatments in week 3. The calcium concentration of the feed consumed was significantly different (P <0.05) between treatments each week. Calcium concentration in control diets was significantly lower between treatments each week, except between T2 in week 3. Calcium concentration in T2 was lower than T3 in week 2, but it was similar to T3 dan T4 in week 3. The phosphorus concentration of T1 was lower than that of T3 and T4 in week 1 and of T2 and T3 in week 3. The body weight gain did not differ between treatments (P> 0.05) each week. It can be concluded that the concentration of calcium and phosphorus in the control diets was the limiting factor to support the growth of female Arab chicken as shown a numerically higher growth rate based on the free-choice feeding system.

Keywords: *calcium, phosphorus, free-choice, female Arab chicken, semi-scavenging, tropics.*

1. INTRODUCTION AND OBJECTIVES

Calcium is one of the most important compositions of eggshells, in addition to its role in maintaining bone health [1]. Calcium deficiency significantly reduces egg production, egg weight, feed consumption, bone density and strength, and shell quality [2], [3]. Eggs with low shell quality result in economic loss for producers. because eggshells are easy to break, often occurring in the final egg-laying period, possibly due to disorders related to calcium homeostasis [4].

The nutritional role of calcium is closely related to phosphorus and affects vitamin D. The metabolic function and structure of these two minerals in bone and egg formation are important in poultry production [5]. During egg formation, the blood phosphorus level is so high that the kidneys try to increase the removal of phosphate. During excretion, phosphate carries out H^+ ions, helps balance bicarbonate levels, consequently decreasing blood acidity [5].

The need for calcium and phosphorus in chickens at high temperatures can be higher than in chickens at low temperatures. This is reflected in the lower egg weight,

shell weight, plasma calcium, and phosphate ion concentrations in hens subjected to a temperature of 30 ° C than at 18 ° C [6]. Furthermore, the retention of several minerals including calcium and phosphorus is lower in chickens reared at high cyclic ambient temperatures (24-35 ° C) than at 24 ° C [6].

Many factors influence calcium needs, including chicken strain, phosphorus, feed energy, age of chickens, and temperature [4]. Calcium and phosphorus requirements in the NRC literature [7] or the HyLine Brown (Hyline International, Australia) management guidelines are generally aimed at chickens raised in seasonal areas and strains of commercial chickens. Thus, these standards may not match the needs of local Indonesian chickens, including Arab chickens raised in tropical climates. So far, research on Arab hens is still limited to determining protein and energy needs [8], [9]. Therefore, the correct determination of calcium and phosphorus requirements can reduce the consequences of heat stress by maintaining the acid-base balance of the blood and having a beneficial effect on growth and production performance. The objectives of this study were to measure the calcium and phosphorus intake and calculating calcium and phosphorus requirements from the age of 1 week to the first egg-laying age.

2. RESEARCH METHODS

A total of 288-day-old Arab chickens were used in this research. They were assigned to 16 sheltered pens with 18 chicks each. The pen dimension was 2 m inside the house and 3 m outside the house with similar wide (1.14 m) and high (2 m). The pen was separated with netted nylon. The pen's floor inside the house was covered with sand and the pen's floor outside the house was ground. The house was open-sided and the hens could access the yard freely.

Each diet was filled in separate feeders in each pen. Feeders' positions in each pen were changed every day randomly to avoid the habituation of chicks. One bell-shaped drinker was filled in when necessary. During the first two weeks, the pen inside the house was covered with black plastic. After two weeks of age, only half of the pen high inside the house was covered. The chicks were warmed with an electric bulb. Until 14 days of age, the light in the roofed pen was set for 23 hours. After 14 days of age, the light in the roofed pen was set to 18 hours light and 6 hours dark.

A completely randomized design with four treatments and four replicate (pens) of 18 chicks was used in this experiment. The treatments were (a) control feed, (b) high calcium low phosphorus feed and low calcium high phosphorus feed, (c) high calcium high phosphorus feed, high calcium low phosphorus feed and low calcium high phosphorus feed, and (d) high calcium high phosphorus, high calcium low phosphorus, low calcium high phosphorus, and control feed. The protein (19.80%) and energy (2996 kcal of ME/kg) content of all the feeds were based on the results of research by Adrizal et al [8], while calcium (1%) and phosphorus (0,45%) for control diet were based on feed standards from Hy-line International [10]. All the diets were offered in mash form with a free choice feeding system. These four diets differed from that of the control in the calcium (Ca) and phosphorus (P) contents, while the other nutrients were almost identical.

Data on feed intake Ca intake, P intake, concentrations of dietary Ca and P, and body weight gain were recorded weekly. Data were analyzed using ANOVA. A probability level of less than 5% was considered to be statistically significant. Means were compared by pairwise comparison using the Least Significant Difference when the main effects were significant.

3. RESULTS

This research has only been going on for 3 weeks. Consumption of feed was not different ($P > 0.05$) between treatments until week 3 (Figure). Consumption of calcium was different ($P < 0.05$) between treatments in weeks 2 and 3. The calcium consumption of T1 was lower than that of T2 and T3. The rest of the comparisons were not significantly different. Consumption of phosphorus was was different ($P < 0.05$) between treatments in week 3. Phosphorus consumptions of T1 and T4 were lower than of T3. The calcium concentration of the feed consumed was highly different ($P < 0.01$) between treatments each week (Figure). The calcium concentration of T1 was significantly lower than other treatments each week, except with T2 in week 3. The calcium concentration of T2 was lower ($P<0.05$) than of T3 in week 2, whereas it was similar ($P>0.05$) to T3 and T4 in week 3 (Figure). The phosphorus concentration of the feed consumed was significantly different in weeks 1 and 3, but not different ($P > 0.05$) in week 2(Figure). The phosphorus concentration of T1 was lower than that of T3 and T4 in week 1 and with T2 and T3 in week 3. The phosphorus concentration of T2 was lower ($P<0.05$) than that of T3 in week 1. The chicken body weight gain did not differ between treatments ($P > 0.05$) each week.

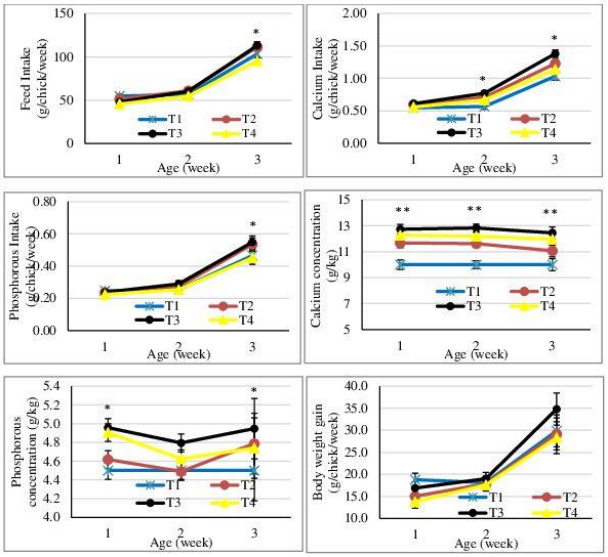

Figure. Performance data of female Arab chicken fed a control and choice diet from 1 to 3 weeks of age.

4. DISCUSSION

The number and quality of feeds offered in the choice feeding system influence the amount of feed consumption when the chick grows older. The choice-fed chicks in T4 (four diets) of the present study consumed a much lower amount of feed than T1 (8%), T2 (14.7%), and T3 (14.4%). The lower feed intake in T4 might be related to more time in selection from the four feeds offered to adjust the Ca and P requirements. This finding was not in agreement with the study reported by An et al [4] that there were no significant linear and quadratic trends of dietary Ca levels from 3.5 to 4.7% affecting feed intake in the aged laying hens.

Calcium and phosphorus intake were also influenced by the feeding system. The amount of Ca intake was lower in T1 in weeks 2 and 3, but phosphorus intake was lower in T4 in week 3. The shift in the amount of Ca and P intake reflected the ability of female Arab chicken chick to adjust the correct Ca and P ratio needed for growth. Interaction of Ca and NPP provide clear evidence that insufficient supply of one mineral interferes with the homeostasis of the other; therefore, the ratio of Ca-to-NPP may be more influential than individual mineral concentrations when formulating poultry diets. The reduction of broiler growth performance has been influenced by widening the Ca-to-NPP ratio in diets [11].

Ca concentrations in free choice treatments were significantly higher than the control diet (T1) each week, while P concentrations were significantly higher than the control diet in week 3 except with T4. This finding gave evidence that the Ca and P concentration in T1 was not enough to support the growth of the chicks. Therefore, the Ca to P ratio be a more important factor than the absolute dietary concentration of Ca or P [11]. Although the body weight gain in this tree weeks experiment did not statistically different, but numerically higher in the choice feeding system when the chick was able to compose an elegant compromise as in T2 and T3.

5. CONCLUSIONS

The concentrations of calcium and phosphorus in the control diets were the limiting factor to support the growth of female Arab chicken as shown a numerically higher growth rate based on the free-choice feeding system.

ACKNOWLEDGMENT

The authors would like to thank the Rector of Jambi University and the Head of Research and Community Services Institute of Jambi University for providing funds for this research.

AUTHORS' CONTRIBUTIONS

Syafwan conceived the presented idea and wrote the manuscript. After presenting the manuscript, Mr. Yatno and A. Budiansyah gave feedback to enhance the quality of the manuscript. All authors were involved in planning and supervised the work, data collected and analyzed the experimental data, drafted the manuscript.

REFERENCES

[1] O. Olgun and A. Aygun, Nutritional factors affecting the breaking strength of bone in laying hens, *Worlds. Poult. Sci. J.*, vol. 72, no. 04, 2016, pp. 821–832, DOI: 10.1017/s0043933916000696.

[2] W. Narváez-Solarte, H. S. Rostagno, P. R. Soares, L. F. Uribe-Velasquez, and M. A. Silva, Nutritional requirement of calcium in white laying hens from 46 to 62 wk of age, *Int. J. Poult. Sci.*, vol. 5, no. 2, 2006, pp. 181–184, doi: 10.3923/ijps.2006.181.184.

[3] N. M. Ahmed, K. A. A. Atti, K. M. Elamin, K. Y. Dafalla, H. E. E. Malik, and B. M. Dousa, Effect of dietary calcium sources on laying hens performance and egg quality, *J. Anim. Prod. Adv.*, vol. 3, 2013, pp. 226–31, DOI: 10.5455/Japa.20130718034818.

[4] S. H. An, D. W. Kim, and B. K. An, Effects of dietary calcium levels on productive performance, eggshell quality and overall calcium status in aged laying hens, *Asian-Australasian J. Anim. Sci.*, vol. 29, no. 10, 2016, pp. 1477–1482, DOI: 10.5713/ajas.15.0655.

[5] K. Pelicia *et al.*, Calcium and available phosphorus levels for laying hens in the second production cycle, *Brazilian J. Poult. Sci.*, vol. 11, no. 1, 2009, pp. 39–49, DOI: 10.1590/s1516-635x2009000100007.

[6] A. Mujahid, I. Hagimori, K. Takahashi, and A. Matsuda, Nutritional strategies to maintain efficiency and production of chickens under high environmental temperature, *J. Poult. Sci.*, vol. 48, no. 3, 2011, pp. 145–154, DOI: 10.2141/jpsa.010115.

[7] NRC, *Nutrient Requirements of Poultry*, 9th rev.ed., 1994. Washington, DC.: National Academy Press, 1994.

[8] A. Adrizal, S. Syafwan, N. Noferdiman, S. Zubaida, and T. M. Pasaribu, Energy and protein consumption and utilization of local female chicken reared under a semi-scavenging system in the tropics, 2017, 2017, [Online]. Available: http://www.wpsa.com/index.php/publications/wpsa-proceedings/2017/21st-european-symposium-on-poultry-nutrition/3224-energy-and-protein-consumption-and-utilization-of-local-female-chicken-reared-under-semi-scavenging-system-in-the-tropics/file.

[9] S. Syafwan and N. Noferdiman, Egg production and quality of local female chicken by dietary self-selection reared under a semi-scavenging system in the tropics, in *IOP Conference Series: Earth and Environmental Science (Vol. 287)*, 2019, 2019, pp. 1–6, [Online]. Available: https://iopscience.iop.org/article/10.1088/1755-1315/287/1/012008.

[10] Hy-Line, Management guide for Hy-Line Brown commercial layers, 2018, p. 32, [Online]. Available: https://www.hyline.com/filesimages/Hy-Line-Products/Hy-Line-Product-PDFs/Brown/BRNCOM ENG.pdf.

[11] A. E. Gautier, R. N. Dilger, and C. L. Walk, Influence of dietary calcium concentrations and the calcium-to-non-phytate phosphorus ratio, *Poult. Sci.*, vol. 96, no. 8, 2017, pp. 2795–2803, [Online]. Available: https://doi.org/10.3382/ps/pex096.