Adopting Intraclass Correlation Principles to Estimate the Consistency of Egg Production of Quails Supplemented with Metabolic Enhancer

N Widyas, S Prastowo and A Ratriyanto

Department of Animal Science, Faculty of Agriculture, Sebelas Maret University, Surakarta, Indonesia

E-mail: nuzul.widyas@staff.uns.ac.id

Abstract. Betaine as metabolic enhancer is proven to improve eggs production in poultry. The consistency of the improvement, however, is not yet explored. This study aimed to explore the consistency of quails’ egg production under the influence of betaine supplementation utilizing intraclass correlation approach. In total 225 quails were used and allotted into three treatment groups: T0 (control), T1 (control + 0.06% betaine) and T2 (control + 0.12% betaine). Each treatment was replicated five times with 15 quails each. Egg production data was collected for 2 clutches (2 × 28 days) started after egg production reached 50%. The data was split and averaged into eight consecutive weeks. Linear model resulted in significant difference of egg production mean among treatments which were 66.08±18.39%, 70.55±15.11% and 75.46±14.88% for T0, T1 and T2 respectively (P<0.01). Intraclass correlation within each treatment was used as the measure of egg production consistency. Every replicate was recorded in eight consecutive weeks during the experiment. Results showed that T2 has the highest intraclass correlation (0.88), followed by T1 (0.86) and T0 (0.79). Our findings confirmed that betaine supplementation improve quails’ egg production. We further discover that the improvement obtained during experimental period due to betaine supplementation was more consistent compared to the quails without supplementation.

Keywords: betaine, quail, egg, interclass correlation principle.

1. Introduction
Egg production is the most important economic trait in laying quail. The Japanese quails (*Coturnix coturnix japonica*) starts to lay after reaching the sexual maturity at the age of 35-45 days [1]. In a good management practice, quail can produce 250 to 300 eggs per year. Although the egg production is genetically programmed, it is also influenced by environmental factors [2]. Egg production can be improved by a nutritional approach such as supplementation with a specific feed additive which influence nutrient digestion and metabolism [3]. A high egg production represents the high metabolic rate as a response to dietary modifications [4].
Betaine is a derivative of amino acid glycine which donates its methyl group in the protein and energy metabolism process [5]. Dietary inclusion of betaine has been shown to enhance egg production in poultry, including laying hens [3], quails [5,6], and ducks [7]. Betaine supplementation can be categorized as a temporary environmental factor contributing to the improved quails’ egg production. The aforementioned studies, however, mainly focused on the production rate, while the consistency of the improvements is not yet explored. Thus, this study aims to explore the consistency of quails’ egg production under the influence of betaine supplementation utilizing intraclass correlation (ICC) approach [8].

2. Methodology
In total 225 female quails, 21 days of age were used in the experiment as in Giri[9]. The newly incoming quails were given commercial feed and slowly adapted into the treatment diet until the age of 42 weeks. There were three treatment diets: basal diet (T0), basal diet + 0.06% betaine supplementation (T1) and basal diet with 0.12% betaine supplementation (T2). There were five replicates for every treatment and each replicate contained 15 quails. The nutrient composition of basal diet is presented in Table 1. Feed were given twice a day in the morning and afternoon and the water were provided ad libitum.

| Nutrient                          | Contents |
|----------------------------------|----------|
| Metabolizable energy (Kcal/kg)   | 2,800.10 |
| Crude Protein (%)                | 19.51    |
| Calcium (%)                      | 3.40     |
| Phosphorus (%)                   | 0.62     |
| Lysine (%)                       | 1.14     |
| Methionine (%)                   | 0.41     |

Data collection were started when the quails egg production reached 50% which was at the age of 63 weeks. Daily egg production was recorded as percentage of the number of eggs relative to the total number of birds in each replicate. The period of data collection was two clutches, or two times 28 days the data were then grouped into eight different weeks for further analysis.

Arithmetic means and standard deviations of weekly egg production were estimated as the summary statistics for all of the treatments. We later defined the consistency of egg production as the intraclass correlation (ICC) among weeks within each treatment group. The ICC estimator is within the ANOVA framework in term of one way random effect model [10–12] as followed:

\[ y_{ij} = \mu + \alpha_i + \epsilon_{ij} \]

where \( y_{ij} \) is the vector of observed variable (egg production) belonged to \( i^{th} \) groups (\( i = 1, \ldots, k \)) and \( j^{th} \) target (\( j = 1, \ldots, n \)); \( \mu \) is the general mean, \( \alpha_i \) is the random effect of group i and \( \epsilon_{ij} \) is random residual term. The required assumptions were \( \alpha_i \) and \( \epsilon_{ij} \sim iid (0,\sigma^2) \). The group effect in this study referred to different measurement weeks whereas the target referred to the replicates. This one-way ANOVA model gives the estimate of Between-target Mean Square (BMS) and Within-target Mean Square (WMS); hence ICC in this framework is defined as:

\[ ICC1 = \frac{BMS - WMS}{BMS + (k - 1)WMS} \]
3. Result and Discussions

We started to record the egg production data when the quails were at the age of 63 weeks or when the egg production reached a minimum value of 50%. The mean and standard deviation off weekly egg production for all of the treatment groups are presented in Table 1.

### Table 2. Mean of egg production (%) in eight consecutive weeks

| Week | Control      | Betaine 0.06% | Betaine 0.12% |
|------|--------------|---------------|---------------|
|      | Mean         | Sd\(^1\)      | mean          | Sd\(^1\)      | mean          | Sd\(^1\)      |
| 1    | 54.67        | 13.02         | 58.86         | 11.82         | 64.57         | 13.89         |
| 2    | 65.90        | 10.94         | 72.78         | 12.78         | 70.53         | 16.38         |
| 3    | 60.33        | 17.46         | 71.06         | 11.97         | 73.71         | 15.18         |
| 4    | 72.84        | 15.41         | 78.65         | 13.35         | 82.20         | 8.96          |
| 5    | 69.03        | 16.57         | 78.82         | 11.75         | 84.25         | 11.51         |
| 6    | 60.78        | 19.58         | 76.93         | 13.65         | 79.68         | 15.65         |
| 7    | 67.98        | 22.02         | 61.34         | 17.96         | 72.01         | 13.27         |
| 8    | 77.12        | 20.47         | 65.98         | 12.95         | 76.70         | 13.61         |
| Average | 66.08   | 70.55         | 75.46         |       |       |       |

\(^1\) Standard deviation; *ICC = Intraclass Correlation Coefficient

Betaine supplementation has proved its capability to improve the egg production in eight consecutive weeks of data collection in our study. This is in agreement with the earlier studies which showed that 0.1% and 0.15% betaine supplementation on laying hens was able to improve egg production up to 5.58%[13] and 19.66% [14] respectively. In quails, betaine supplementation of 0.06 and 0.12% were able to improve their egg production up to 14.5% compared to the quails without supplementation [15].

Although betaine supplementation was proven to increase egg production in poultry in general and specifically in quails, the consistency of the improvement is yet to be explored. In tropical climate as in Indonesia, feed supplement is necessary in order to reduce the effect of environmental stress (more specifically heat stress) for the birds to reach optimum production. Vitamin C supplementation, for example, was reported to be able to improve the quails’ egg production; the improvement, however, was not consistent as shown by low repeatability value [16]. In this paper we discussed the consistency of improvement in egg production when the quails’ diets were supplemented with betaine. We adopted the ICC principles to estimate the consistency of egg production. ICC has been mainly used to obtain the reliability index in test-retest, intra-rater and interrater types of data [11], to estimate genetic components using half-sib family analysis[10] and to obtain the repeatability estimate of traits with repeated measures in animal breeding studies[17].

We obtained the ICC estimates of 0.79 in our control group, 0.86 in the quails with 0.06% betaine supplementation and 0.88 in the group of quails with 0.12% betaine supplementation. ICC value between 0.70 – 0.90 is considered as having good reliability index. These high ICC values related to the low variability among the groups[11] which implied that the quails egg production was stable over the experimental period as the group in this study represented the mean of egg production in different weeks. Regarding the consistency of the improvement in egg production, we can offer the following postulates: 1) betaine supplementation induced the antibody formation thus increase the immunity which in the end will lead to better production [3,18,19]; 2) betaine functioned as methyl donor in the birds’ metabolism which ensure the availability of egg yolk precusor as the initiatiator of egg formation [14,20,21].
4. Conclusion

Our findings confirmed that betaine supplementation was able to improve the quails' egg production. Further our results deducted that the achieved improvement was constant over the experimental period of eight weeks.

References

[1] D. Narinc, E. Karaman, T. Aksoy and M.Z. Firat. 2013. Investigation of nonlinear models to describe long-term egg production in Japanese quail. Poult. Sci. 92:1676–1682.
[2] H. O. Pavlidis, S. E. Price and P. B. Siegel. 2002. Associations between egg production and clutch length in four selected lines of chickens. J. Appl. Poult. Res. 11:304–307.
[3] Y. A. Attia, A. E. E. Abd-El-Hamid, A. A. Abedalla, M. A. Berika, M. A. Al-Harthi, O. Kucuk, K. Sahin and B. M. Abou-Shehema. 2016. Laying performance, digestibility and plasma hormones in laying hens exposed to chronic heat stress as affected by betaine, vitamin C, and/or vitamin E supplementation. Springerplus 5:1619.
[4] J. Kaye, S. J. Luka, G. N. Akpa and I. A. Adeyinka. 2017. Egg production pattern of Japanese quail (Coturnix coturnix japonica ) in Northern Guinea Savannah Zone of Nigeria. Int. J. Innov. Res. Adv. Stud. 4:93–97.
[5] A. Ratriyanto and R. Mosenthin. 2018. Osmoregulatory function of betaine in alleviating heat stress in poultry. J. Anim. Physiol. Anim. Nutr. (Berl). 102:1634–1650.
[6] A. Ratriyanto, R. Indreswari and A. M. P. Nuhriawangsa. 2017. Effects of dietary protein level and betaine supplementation on nutrient digestibility and performance of Japanese quails. Rev. Bras. Cienc. Avic. 19:445–454.
[7] W. Ezzat, M. S. Shoeib, S. M. Mousa, A. M. A. Bealish and Z. A. Ibrahim. 2011. Impact of betaine, vitamin C and folic acid supplementations to the diet on productive and reproductive performance of matrouh poultry. Egypt. Poult. Sci. 31:521–537.
[8] A. Yakubu, D. Ib, A. Hs and O. Oia. 2017. Estimates of repeatability and heritability of egg number in sasso hens in a tropical environment. J. of Gen. and Gen. 1:2–5.
[9] M. S. Giri. 2016. Performa puyuh (Coturnix coturnix japonica) yang disuplementasi donor metil dalam ransum. Universitas Sebelas Maret.
[10] L. A. Swiger, W. R. Harvey, D. E. Everson and K. Gregory. 1964. The Variance Of Intraclass Correlation Involving Groups With One Observation. Biometrics : 818-816.
[11] T. K. Koo and M. Y. Li. 2016. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J. Chiropr. Med.15:155–163.
[12] P. E. Shrout and J. L. Fleiss. 1979. Intraclass correlations : uses in assessing rater reliability. Psychol. Bull. 86:420–428.
[13] W. Ezzat and M. S. Shoeib. 2011. Impact of betaine, vitamin c and folic acid supplementations to the diet on productive and reproductive performance of matrouh poultry. Poult. Sci. 31:521–537.
[14] S. P. Ralcheva, I. Yanchev, P. Moneva, E. Petkov and M. Ignatova. 2011. Effect of betaine on egg performance and some blood constituents in laying hens reared indoor under natural summer temperatures and varying levels of air ammonia. Bulg. J. Agric. Sci.17:859–866.
[15] A. Ratriyanto, R. Indreswari, A. Magna, P. Nuhriawangsa and A. Endah. 2015. Performance of japanese quails fed different protein levels and Supplemented with betaine. The 6th International Seminar on Tropical Animal Production Integrated Approach in Developing Sustainable Tropical Animal Production, October (Yogyakarta, Indonesia) :118-122.
[16] A. Ratriyanto, T. Nugroho, M. Masykur, B.F. Hidayat, S. Prastowo, S. Sunarto and N. Widyas. 2018. The consistency of quail’s egg production supplemented with vitamin c in the diet.
[17] W. Hardjosubroto. 1994. Aplikasi Pemuliaan Ternak di Lapangan. Jakarta: Gramedia Widiasarana Indonesia.
[18] M. Alahgholi, S. A. Tabeidian, M. Toghyani and S. S. A. Fosoul. 2014. Effect of betaine as an
osmolyte on broiler chickens exposed to different levels of water salinity. *Arch. Tierzucht* 57:1–12.

[19] M. T. Kidd, P. R. Ferket and J. D. Garlich. 1997. Nutritional and osmoregulatory functions of betaine. *Worlds. Poult. Sci. J.* 53:125–139.

[20] M. Eklund, E. Bauer, J. Wamatu and R. Mosenthin. 2005. Potential nutritional and physiological functions of betaine in livestock. *Nutr. Res. Rev.* 18:31–48.

[21] C. Bunchasak and T. Silapasorn. 2005. Effects of adding methionine in low-protein diet on production performance, reproductive organs and chemical liver composition of laying hens under tropical conditions. *Int. J. Poult. Sci.* 4:301–308.