Application of logistic model to predict egg production pattern of quails given a low-energy diet supplemented with methionine

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Abstract. Tropical countries such as Indonesia face high temperatures, which impact the energy utilization in poultry. This study aims to predict the egg production pattern of quail supplemented with methionine in a low-energy diet. In total, 204 laying quails were divided into two treatments: Control (T0) and 0.12% methionine supplementation (T1). After three weeks adaptation period, daily egg production data were collected for two periods of four weeks each (treatment period week 4-11). The t-test was applied to analyze the egg production data. Egg production patterns were predicted using logistic regression. The egg production pattern of T1 showed a significant increase compared to T0 during the treatment period (p<0.01) and overall period (p<0.01). Peak production from T0 and T1 was 59.14% vs. 66.82%, with a production rate of 0.22 vs. 0.18 and prediction accuracy of 91% vs. 86%, respectively. In conclusion, methionine supplementation to a low-energy diet increased egg production of quails.

1. Introduction
The relatively high tropical air temperature with an annual average may lead to heat stress in poultry [1–3]. Heat stress affects the availability of dietary energy, which is used to maintain body homeostasis. According to Zhang et al. [4], ambient temperature above 26°C causes a decrease in production energy utilization, diverting to maintain body temperature. The negative impact of heat stress on poultry is reduced growth and production performance [5–7], which directly causes economic losses [8]. Manipulation of diet nutrients is an effective strategy to maintain adequate energy in poultry.

The availability of an energy diet needs to be adjusted to balance nutrients. Thus it is expected to produce optimal performance. The dietary methionine can assist the transmethylation process [9] and increase glucose and glycogen synthesis [10]. On the other hand, amino acids from the transmethylation cycle are useful in synthesizing proteins used in egg production [11]. Reda et al. [12] stated that 1.5 g/kg methionine supplementation increased the egg production of quails. A similar study by Ratriyanto et al. [13] revealed that 0.12% methionine supplementation in a low-energy diet (ME: 2,700 kcal/kg) increased egg production, egg weight, and feed efficiency of quails.

A nonlinear logistic regression model can evaluate egg production patterns to obtain actual and predicted data [13–16]. Research on utilizing logistic regression models to predict quail egg production patterns with 0.12% methionine supplemented on a low-energy diet has never been done. Based on the
description above, the purpose of this study was to predict the egg production pattern of quail supplemented with methionine in a low-energy diet.

2. Materials and methods

2.1. Materials and experimental design
204 25-day old laying quail (Coturnix coturnix japonica) were taken from the same local breeding farm. The research design used was a completely randomized design with two treatments. The treatments consisted of two levels of methionine supplementation, namely T0=control and T1=0.12% methionine supplementation. The basal diet was given in the first three weeks of production and continued with the treatment during weeks 4-11. The nutrient composition of the basal diet is presented in Table 1. Methionine was supplemented in the diet with the expense method, according to Ratriyanto et al. [18].

Table 1. Nutrient composition of the basal diet.

| Nutrients                  | Basal diet |
|---------------------------|------------|
| Metabolizable energy (kcal/kg) | 2,700      |
| Crude protein (%)         | 18.03      |
| Crude fat (%)             | 2.93       |
| Methionine (%)            | 0.40       |

2.2. Data collection and analysis
Quail egg production was collected daily during the adaptation period and two treatment periods of 4 weeks. The t-test was used to see the treatment effect in the three observation periods. The logistic regression model was used to show fluctuations in egg production patterns due to the treatment given [14,15,17] and compared the actual with the predicted data of quail egg production. Data analysis was performed using R software according to the R Core Team procedures [19].

3. Results and discussion

3.1. Treatments effect on quail egg production
The results of quail egg production analysis can be seen in table 2; figure 1. The non-significant effect was shown on quail egg production during the adaptation period (P>0.05). Due to the treatment given, variations in quail egg production only commenced being seen in the treatment period (P<0.01). Significant effects (P<0.01) could be seen in the whole period due to 0.12% methionine supplementation.

Table 2. Effect of 0.12% methionine supplementation on quail egg production

| Treatments | Egg production (%) | P-value |
|------------|--------------------|---------|
| Adaptation period |                      |         |
| T0         | 46.33±33.89        | 0.46    |
| T1         | 42.93±39.38        |         |
| Treatment period |                    |         |
| T0         | 58.98±7.25         | <0.01   |
| T1         | 65.57±15.49        |         |
| Whole period |                    |         |
| T0         | 41.04±35.76        | <0.01   |
| T1         | 58.98±13.56        |         |

Note: adaptation period (week 1–3), treatment period (week 4–8), whole period (week 0–11), T0=control, T1=0.12% methionine supplementation, P-value<0.01 in the same period showed a significant difference.
The similarity of treatment given in the adaptation period resulted in no significant effect on egg production (Table 2). The improvement in quail egg production was only seen during the treatment period due to methionine supplementation (T1). Methionine supplementation increased the formation of glucose and glycogen used for energy reserves [10] so that energy deficiency due to heat stress that occurred in T1 quail could be minimized. The energy sufficiency of T1 can be seen from the response of quail egg production in the treatment and the whole period are higher than quail egg production of treatment T0 [17,20].

3.2. Egg production pattern

Several nonlinear mathematical models can be used to see egg production patterns [14,16,21–24]. Logistic regression is one of them, and this model can be used to compare the actual data (Figure 1) with the predicted data (Figure 2). Egg production in the adaptation period showed a rapid increase. Production consistency began to appear when entering the middle of the treatment period. The logistic regression parameter showed that the peak production of quail eggs T0 and T1 was 59.14% vs. 66.82% (Table 3). The actual data conformity level with predictions using logistic regression showed 91% for T0 and 86% for T1, where these values were categorized as high [25]. Savegnago et al. [25] stated that when the fitness value is close to 100%, the actual data represented the realized data based on the predictions made.

| Parameter          | T0       | T1       |
|--------------------|----------|----------|
| Peak production    | 59.14    | 66.82    |
| Carrying capacity  | 11.33    | 10.24    |
| Production rate    | 0.22     | 0.18     |
| Fitness (%)        | 91       | 86       |

Note: T0=control; T1=0.12% methionine supplementation

Figure 1. Weekly quail egg production pattern

Figure 2. Logistic regression of quail egg production.
4. Conclusion

Based on the study results, it can be concluded that 0.12% methionine supplementation increased quail egg production at weeks 4–11 or weeks 0–11. Logistic regression has proven to evaluate quail egg production patterns with a high degree of accuracy.

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