Egg production patterns of quails given diets with different nutrient density

N Widyas, T Nugroho, B F Hidayat, A Masykur, S Prastowo and A Ratriyanto
Department of Animal Science, Sebelas Maret University, Surakarta INDONESIA
E-mail: ratriyanto@staff.uns.ac.id

Abstract. Energy and protein ratio in the diet plays an important role in laying quails production. High nutrient density could expose the quails into heat stress due to inefficient metabolic process and nutrient absorption. On the other hand, lower density possesses the risk of nutrient insufficiency. Both cases are potential in affecting the egg production. This study aimed to investigate the egg production patterns of quails fed different nutrient density with constant ratio of metabolizable energy (ME) and crude protein (CP). Egg production data was obtained from two hundred laying quails (Coturnix coturnix japonica) which were randomly assigned into two distinct experimental diets. Dietary treatments were given for eight weeks and replicated five times each with 20 quails. Two diets were formulated to contain High ME-CP (2,800 kcal/kg ME and 18.7% CP) and Low ME-CP (2,600 kcal/kg ME and 17.3% CP). The data were analysed using t-test and egg production patterns were plotted. Quails fed with different nutrient density yielded similar egg production values and patterns. We fit non-linear mathematical model into the datasets; similar trends and fitness were also observed (R² = 0.96). It is concluded that quail fed with different nutrient density exhibited minor difference in egg production pattern.

1. Introduction
Feed formulation for laying quails in Indonesia is still based on the nutrient requirements published by other countries with different climates, thus it is not necessarily ideal for tropical conditions in Indonesia. The nutrient requirement for quails during production period according to Nutrition Research Council [1] is 20% crude protein (CP) and 2,800 kcal/kg metabolisable energy (ME). This condition provides an opportunity to adjust the nutrient content to the hot climate regions to produce optimal performance [2]. It is well known that environment is a fundamental factor that limits poultry production in the tropics due to excessive metabolic heat production leads to heat stress [3].

Excessive content of protein and energy in the diet would not have a positive impact on improving the productivity, but rather reduce the performance of poultry in hot climates. This condition also causes inefficiency due to high undigested nutrients, thus, the diet has to be formulated precisely since egg production is affected by nutrient balance in the diet [4]. In feed formulation, the emphasis is placed on protein and energy content which holds 70% of feed costs [5]. A decrease in CP or ME in the diet can reduce feed costs [3,6] and minimize metabolic heat produced by protein and energy [7]. Therefore we need to provide a precise feed formulation for tropical regions with lower CP and ME content in accordance with local climate in Indonesia.

Poultry egg production follows specific pattern. Deviation from the pattern can indicate anomalies, thus the information on egg production pattern is very useful for control and evaluation mechanism [8–11]. The objective of this paper is to investigate the egg production patterns of quails fed different nutrient density with constant ratio of metabolizable energy (ME) and crude protein (CP).
2. Materials and Methods

2.1. Experimental design and diet formulation
Two diets with different nutrient densities were formulated: High ME-CP (2,800 kcal/kg ME and 18.7% CP) and Low ME-CP (2,600 kcal/kg ME and 17.3% CP) as in Table 1.

| Nutrient dalam pakan | Metabolizable Energy : Crude Protein |
|----------------------|-------------------------------------|
|                      | 2.800 : 18.7                       |
|                      | 2.600 : 17.3                       |
| Metabolisable energy (kcal/kg) | 2800 | 2601 |
| Crude protein (%)    | 18.70 | 17.30 |
| Calcium (%)          | 3.38  | 3.36  |
| Phosphorus (%)       | 0.49  | 0.49  |
| Lysine (%)           | 1.06  | 0.96  |
| Methionine (%)       | 0.40  | 0.41  |

The experiment was started with female quails at the age of 21 days. The quails were randomly allotted into two diets. Each diet was replicated five times with twenty quails per replication. The quails were then immediately adapted to the experimental diets from age 41 to 60 and the full experimental diets were fed from age 61. Quails started to lay eggs around 42 days of age and the daily egg production was recorded. The experiment lasted until 49 days after the experimental diets were given.

2.2. Data analyses
Egg production data were obtained as hen day average which is the percentage of daily eggs produced by each flock relative to the number of birds in the corresponding flock. All data analyses were performed using custom scripts of R program [12].

2.2.1. Comparing treatments
To observe the difference of eggs production between high and low-density diets, independent sample t-test was performed under 5% significance level. The test was done for both the adaptation (41-60 days) and treatment period (61-109 days). Later, we visualize the actual egg production data into a trend line plot.

2.2.2. Logistic regression
The production plot of real data contained fluctuation due to uncontrolled effect. To obtain the idealized sigmoid curve which is identical with eggs production pattern can be achieved by utilizing non-linear mathematical models. We employed logistic regression to build the hypothesized production pattern with the following formula:

\[ Y_t = \frac{\alpha}{1 + \beta \exp[kt]} \]

Where:
- \( Y_t \) = production at time-\( t \)
- \( \alpha \) = peak of production
- \( \beta \) = carrying capacity
- \( k \) = production rate
- \( t \) = time of production

The fitness of the models were then assessed through the coefficient of determination parameter.
3. Results and Discussion

3.1. Comparing experimental diets

The egg production of two diets with different nutrient densities were compared. The comparison results can be seen in Table 2.

| Diets            | Observation days | Min    | Max    | Mean±Sd     | p-value |
|------------------|------------------|--------|--------|-------------|---------|
| **Adaptation period** |                  |        |        |             |         |
| High             | 20               | 0.00   | 68.00  | 23.32±19.74| 0.54    |
| Low              | 20               | 0.00   | 72.00  | 21.64±18.99|         |
| **Treatment period** |                |        |        |             |         |
| High             | 49               | 28.00  | 92.00  | 64.44±11.33| 0.92    |
| Low              | 49               | 39.13  | 92.00  | 64.35±10.69|         |
| **Whole period**  |                  |        |        |             |         |
| High             | 69               | 0.00   | 92.00  | 52.52±23.50| 0.75    |
| Low              | 69               | 0.00   | 92.00  | 51.97±23.70|         |

Results showed that whether it is during the adaptation or treatment period, the egg production were relatively consistent. This finding means that there was no significant difference (p<0.05) of eggs production between different diets.

![Figure 1. Egg production pattern](image)

**Figure 1. Egg production pattern**

The results from t-test in Table 2 were supported by the eggs production pattern in Figure 1. Although the eggs productions were fluctuating among days, but the pattern for both diets were similar. The low-density diet which contained less nutrients (metabolizable energy and crude protein) stimulated the quails to eat more; and thus yielding in higher feed intake [13]. With this mechanism, the nutrients utilization is optimized while the metabolic heat production is minimized [14]. The positive side effect of high feed intake was that the intake of the other nutrients such as minerals, amino acids and vitamins were also higher and supporting the productivity.

3.2. Logistic Regression

We employ logistic regression to obtain the hypothesized pattern of eggs production for low diet (Figure 2) and high diet (Figure 3)
The patterns and the parameters estimate from logistic regression model were very similar for both diets. The peak production was slightly higher in low diet while the carrying capacity of the high diet was a bit higher. Logistic regression models fit well with the data showed with the coefficient determination ($R^2$) of 0.96 for both diets.

### Table 3. Parameter estimates of the logistic regression model

| Parameters          | High   | Low    |
|---------------------|--------|--------|
| Peak production     | 64.92  | 65.14  |
| Production rate     | 0.27   | 0.26   |
| Carrying capacity   | 46.10  | 35.21  |
| $R^2$               | 0.96   | 0.96   |

### 4. Conclusion

Diets with high and low protein density showed similar egg production and egg production pattern.

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