Feed efficiency of diets with different energy and protein concentrations supplemented with methionine in laying quails

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Abstract. The study was conducted to evaluate the feed efficiency of quail diets containing different concentrations of metabolizable energy (ME) and crude protein (CP) with constant ratio and supplemented with methionine. Four hundred laying quails (Coturnix coturnix japonica) were randomly assigned to four experimental diets in a 2×2 factorial arrangement. Each dietary treatment used 5 replicates of 20 quails. Two basal diets were formulated to contain 2,800 kcal kg⁻¹ ME and 18.7% CP (High ME-CP) and 2,600 kcal kg⁻¹ ME and 17.3% CP (Low ME-CP). Each basal diet was supplemented with 0 and 0.12% methionine. The High ME-CP diets generated lower feed consumption but higher egg mass and feed efficiency (P<0.01) compared with the Low ME-CP. Furthermore, supplementation of methionine increased egg mass, feed efficiency, energy efficiency ratio and protein efficiency ratio (P<0.01). The High ME-CP supplemented with methionine resulted the highest feed efficiency followed by the Low ME-CP supplemented with methionine, while both High ME-CP and Low ME-CP without methionine supplementation resulted the lowest feed efficiency (P<0.05). In addition, ME and CP consumption of the birds were not influenced by the treatments. Thus, feeding High ME-CP supplemented with 0.12% methionine provided benefit to improve the feed efficiency in laying quails.

1. Introduction
Energy and protein concentrations in the diet play an important role in livestock productivity and are critical in the evaluation of poultry performance [1]. It is generally accepted that the poultry diet should be formulated precisely to obtain an optimal performance [2]. The nutrient concentration is important both in the nutritional aspect and practical application in terms of its economics, thus, feed formulation with lower protein or energy concentration enables the decrease of feed cost [3].

Feed consumption in poultry is regulated among others by nutrient density in the diet [4] and more specifically poultry consume the feed to fulfill the requirement of energy and protein [5]. The too high nutrients content in quail’s diet may induce heat stress as a result of metabolic processes [2] and leading to inefficiency [6]. Therefore, feeding quails with low energy and protein diet is expected to minimize the heat production, especially in tropical climates [7]. However, the quail’s performance may decrease if the energy and protein are provided below the requirement. In addition, adjustment of energy and protein concentration in the diet is necessary to avoid excessive feed consumption and fat deposition in laying poultry [8]. The recommendation for crude protein (CP) content is 20% and metabolizable energy (ME) is 2,900 kcal kg⁻¹ for laying quail raised at the temperature 21ºC [9]. However, in higher temperature condition, some researchers evaluated the nutrient requirement for laying quails to be 18% CP and 2,700 kcal kg⁻¹ ME [10].
The requirement of energy and protein is correlated with the methionine level in the diet. Methionine requirement increases as ME level increases [11]. Methionine lessened the energy excretion, thus, the energy absorbed and digested by the animals can be improved [12]. Methionine supplementation also improved the immunity in chickens fed diet containing low ME [13], and may raise the laying performance [14]. Moreover, methionine serves as a methyl group donor which plays an important function in metabolism of energy and protein [15]. Thus, this study evaluated the effects of ME and CP concentrations with constant ratio and methionine supplementation to the diet on feed efficiency of quails.

2. Methods
In total, 400 twenty-five-days laying quails (Coturnix coturnix japonica) with average body weight of 80.83 ± 2.47 g were randomly assigned to four experimental diets in a 2 × 2 factorial arrangement. Two basal diets were formulated to contain 2,800 kcal kg⁻¹ ME and 18.7% CP (High ME-CP) and 2,600 kcal kg⁻¹ ME and 17.3% CP (Low ME-CP). Each basal diet was supplemented with 0 and 0.12% methionine. Each dietary treatment used 5 replicates of 20 quails. Nutrient composition of the basal diets is presented in Table 1. The experimental diets were obtained by supplementing 0.12% methionine to the basal diets in the expense of rice bran [16].

Table 1. Nutrient composition of the basal diets

| Nutrients                  | High ME-CP | Low ME-CP |
|----------------------------|------------|-----------|
| Metabolizable energy (kcal/kg) | 2,800      | 2,600     |
| Crude protein (%)           | 18.70      | 17.30     |
| Calcium (%)                 | 3.30       | 3.30      |
| Nonphytate phosphorus (%)   | 0.43       | 0.43      |
| Lysine (%)                  | 1.18       | 1.18      |
| Methionine (%)              | 0.40       | 0.40      |

The birds were randomly distributed to 20 pens with the size 120 × 30 × 25 cm. During experiment, water and feed were provided ad libitum. Commercial grower diet was fed during pre-experimental period in growing phase. Then, the quails were fed a basal diet containing 2,800 kcal kg⁻¹ ME and 18.7% CP from the age of 42 days. The experimental diets were fed for 2 periods of 28 days after egg production reached 50%. The observed data included the feed, ME and CP consumption, egg mass, feed efficiency as well as energy and protein efficiency ratio (EER and PER). The EER was calculated as grams of egg mass per 100 kcal kg⁻¹ ME consumption, and PER was calculated as grams of egg mass per gram of CP consumption [17].

The obtained data were submitted to analysis of variance using R statistic to determine the effect of treatment and it was continued to Duncan’s test if the treatment indicated significant effect [18].

3. Results and Discussion

3.1. Nutrient consumption
There was no interaction between dietary ME-CP concentration and methionine supplementation on feed, energy and protein consumption (Table 2). This indicated that the quails consumed the same amount of energy and protein both fed Low ME-CP and High ME-CP with or without methionine supplementation. Furthermore, feed consumption in quails fed Low ME-CP was higher (P<0.01) than quails fed High ME-CP resulting in the equal amount of ME and CP consumption. This phenomenon confirms glucostatic and amino static theories which described that the birds consume the feed to meet the requirement of energy and protein/amino acids [5]. In agreement with this finding, other authors observed in quails that feeding 2,700 kcal kg⁻¹ ME generated higher feed consumption than feeding 2,900 kcal kg⁻¹ [19]. However, feeding 16.5 to 19.5% CP for laying quails did not affect feed consumption [17].
Supplementation of methionine did not affect feed, ME and CP consumption of the quails (Table 2). Feed consumption is affected by amino acids concentration in the blood [5]. It is hypothesized that methionine supplementation did not alter amino acid profiles in the blood since the basal diets contained adequate total sulphur amino acids. In support with this observation, methionine supplementation did not affect feed consumption in broiler chickens [20].

| Treatments                  | Feed Consumption (g day⁻¹) | Metabolizable Energy Consumption (g day⁻¹) | Crude Protein Consumption (g day⁻¹) |
|-----------------------------|----------------------------|-------------------------------------------|-------------------------------------|
| Interaction ME-CP × methionine |                            |                                           |                                     |
| High ME-CP 0.00%            | 24.04                      | 67.32                                     | 4.50                                |
| High ME-CP 0.12%            | 24.36                      | 68.20                                     | 4.55                                |
| Low ME-CP 0.00%             | 25.57                      | 66.49                                     | 4.42                                |
| Low ME-CP 0.12%             | 25.93                      | 67.41                                     | 4.49                                |
| Significance                | NS                         | NS                                        | NS                                  |

**Effect of ME-CP**

|                      |                            |                                           |                                     |
|----------------------|----------------------------|-------------------------------------------|                                     |
| High ME-CP           | 24.20ᵇ                     | 67.76                                     | 4.53                                |
| Low ME-CP            | 25.75ᵃ                     | 66.95                                     | 4.45                                |
| Significance         | **                         | NS                                        | NS                                  |

**Effect of methionine**

|                      |                            |                                           |                                     |
|----------------------|----------------------------|-------------------------------------------|                                     |
| 0.00%                | 24.81                      | 66.90                                     | 4.46                                |
| 0.12%                | 25.14                      | 67.81                                     | 4.52                                |
| Significance         | NS                         | NS                                        | NS                                  |

ᵃᵇ Means within a treatment and column with different superscripts differ significantly (P<0.01)
NS: Not significant
** P<0.01

3.2. Feed and nutrient efficiency

An interaction was observed between ME-CP concentration and methionine supplementation on feed efficiency of quails (Table 3). Methionine supplementation, independently ME-CP concentration, increased feed efficiency, with the highest feed efficiency was observed for feeding High ME-CP supplemented with methionine (P<0.05). This finding may be attributed to the combined effects of improvement in feed efficiency of feeding High ME-CP and methionine supplemented diets. Similar result was also observed in previous study in quails [21].

Feeding High ME-CP improved (P<0.01) egg mass and feed efficiency by 1.9 and 8.9%, respectively, compared with feeding Low ME-CP (Table 3) which is in accordance with previous observations in laying quails [17, 21]. Feed efficiency is affected among others by feed consumption. Since the quails fed High ME-CP consumed less feed but generated higher egg mass than the quails fed High ME-CP, the feed efficiency was higher for feeding High ME-CP. Furthermore, energy and protein efficiency ratio were not affected by ME-CP concentration, which was in accordance with the ME and CP consumption in this study.

Methionine supplementation enhanced (P<0.01) egg mass by 15.7% and feed efficiency, energy and protein efficiency ratio by 14.4, 14.4, and 14.6%, respectively (Table 3). The improvement in feed efficiency obtained with the dietary methionine supplementation may be attributed to its role as a methyl group donor [16, 22]. Its suggests that methionine as a methyl group donor is used in protein and energy metabolisms, thus the higher egg mass and feed efficiency can be obtained due to methionine supplementation [21]. Previous observation indicated that dietary methionine increased
egg mass and feed efficiency in quails [23]. Similar to this finding, supplementation of betaine, other methyl group donor, improved energy and protein efficiency ratio in quails [17].

Table 3. Egg mass, feed efficiency, energy, and protein efficiency ratio in quails fed diets containing different ME and CP concentration and supplemented with methionine

| Treatments                        | Egg Mass (g d−1) | Feed Efficiency (%) | Energy Efficiency Ratio | Protein Efficiency Ratio |
|-----------------------------------|------------------|---------------------|-------------------------|-------------------------|
| Interaction ME-CP × methionine     |                   |                     |                         |                         |
| High ME-CP 0.00%                  | 6.38             | 26.53c              | 9.48                    | 1.42                    |
| High ME-CP 0.12%                  | 7.62             | 31.30a              | 11.18                   | 1.67                    |
| Low ME-CP 0.00%                   | 6.47             | 25.30c              | 9.73                    | 1.46                    |
| Low ME-CP 0.12%                   | 7.26             | 28.01b              | 10.77                   | 1.62                    |
| Significance                      | NS               | *                   | NS                      | NS                      |
| Effect of ME-CP                   |                   |                     |                         |                         |
| High ME-CP                         | 7.00a            | 28.92a              | 10.33                   | 1.55                    |
| Low ME-CP                          | 6.87b            | 26.66b              | 10.25                   | 1.54                    |
| Significance                       | **               | **                  | NS                      | NS                      |
| Effect of methionine               |                   |                     |                         |                         |
| 0.00%                             | 6.43b            | 25.92b              | 9.60b                   | 1.44b                   |
| 0.12%                             | 7.44a            | 29.66a              | 10.98a                  | 1.65a                   |
| Significance                       | **               | **                  | **                      | **                      |

**Means within a treatment and column with different superscripts differ significantly (P<0.05) NS: Not significant * P<0.05 ** P<0.01

4. Conclusion
Dietary methionine supplementation independently metabolizable energy and crude protein concentration improved feed efficiency in quails. Feeding quails with 2,800 kcal kg−1 metabolizable energy and 18.7% crude protein generated higher feed consumption, egg mass, and feed efficiency than feeding 2,600 kcal kg−1 metabolizable energy and 17.3% crude protein. Moreover, supplementation of methionine enhanced egg mass, feed efficiency, energy and protein efficiency ratio in quails.

References
[1] Dairo F A S, Adesehinwa A O K, Oluwasola T A and Oluyemi J A 2010 High and low dietary energy and protein levels for broiler chickens Afr. J. Agric. Res. 5 2030–8
[2] Li Y X, Wang Y Q, Pang Y Z, Li J X, Xie X H, Guo T J and Li W Q 2011 The effect of crude protein level in diets on laying performance, nutrient digestibility of yellow quails Int. J. Poult. Sci. 10 110–2
[3] Kamran Z, Sarwar M, Nisa M, Nadeem M A, Mahmood S, Babar M E and Ahmed S 2008 Effect of low-protein diets having constant energy-to-protein ratio on performance and carcass characteristics of broiler chickens from one to thirty-five days of age Poult. Sci. 87 468–74
[4] Moura G de S, Barreto S L de T and Lanna E A T 2010 Efeito da redução da densidade energética de dietas sobre as características do ovo de codorna japonesa Rev. Bras. Zootec. 39 1266–71
[5] Ferket P R and Gernat A G 2006 Factors that affect feed intake of meat birds: A review. Int. J.
Poult. Sci. 5 905–11

[6] De Faria Filho D E, Campos D M B, Alfonso-Torres K A, Vieira B S, Rosa P S, Vaz A M, Macari M and Furlan R L 2007 Protein levels for heat-exposed broilers: Performance, nutrients digestibility, and energy and protein metabolism Int. J. Poult. Sci. 6 187–94

[7] Furlan R L, Faria Filho D E de, Rosa P S and Macari M 2004 Does low-protein diet improve broiler performance under heat stress conditions? Braz. J. Poult. Sci. 6 71–9

[8] Kiiskinen T and Helander E 1998 Effects of restricted methionine and energy intake on egg weight and shell quality Agric. Food Sci. Finl. 7 513–21

[9] Nutrition Research Council 1994 Nutrient Requirements of Poultry (Washington DC: National Academic Press)

[10] Ghazvinian K, Irani M, Jamshidi R and Mirzaei-aghshagahi A 2011 The effect of energy to protein ratio on production performance and characteristics of Japanese quail eggs 2 122–8

[11] Harms R H, Russell G B, Harlow H and Ivey F J 1998 The influence of methionine on commercial laying hens J. Appl. Poult. Res. 7 45–52

[12] Pliang G W and Djojosoebagio S 2006 Fisiologi Nutrisi (Bogor: Percetakan Institut Pertanian Bogor)

[13] Mirzaaghtagabar F, Saki A A, Zamani P, Aliarabi H and Matin H R H 2011 Effect of different levels of diet methionine and metabolisable energy on broiler performance and immune system Food Agric. Immunol. 22 93–103

[14] Koreleski J and Świątkiewic S 2010 Effect of methionine and energy level in high protein Ann. Anim. Sci. 10 83–91

[15] Ratriyanto A, Mosenthin R, Bauer E and Eklund M 2009 Metabolic, osmoregulatory and nutritional functions of betaine in monogastric animals Asian-Australasian J. Anim. Sci. 22 1461–76

[16] Ratriyanto A, Mosenthin R, Jezierny D, Sauer N and Eklund M 2009 Betaine, organic acids and inulin do not affect ileal and total tract nutrient digestibility or microbial fermentation in piglets J. Anim. Feed Sci. 18 453–64

[17] Ratriyanto A, Indreswari R, Nuhriawangsa A, Ratriyanto A, Indreswari R and Nuhriawangsa A 2017 Effects of dietary protein level and betaine supplementation on nutrient digestibility and performance of Japanese quails Rev. Bras. Ciênc. Avic. 19 445–54

[18] R Core Team 2015 R: A Language and Environment for Statistical Computing (Vienna: R Foundation for Statistical Computing)

[19] Ghesari A, Halaji H A, Maghsoudinegad G and Toghyani M 2011 Effect of different dietary levels of energy and protein on performance of Japanese quails (Coturnix coturnix japonica) Proc. 2nd Int. Conf. on Agricultural and Animal Science IPCBEE vol 22 (Singapore: IACSIT Press) pp 156–9

[20] Ratriyanto A, Indreswari R and Sunarto 2014 Effects of protein levels and supplementation of methyl group donor on nutrient digestibility and performance of broiler chickens in the tropics Int. J. Poult. Sci. 13 575–81

[21] Ratriyanto A, Indreswari R, Nuhriawangsa A M P and Arifin A A 2017 Dietary metabolizable energy and methionine affect performance of quails Proceeding of the 1st International Conference on Tropical Agriculture (Cham: Springer International Publishing) pp 329–35

[22] Ezzat W and Shoeib M S 2011 Impact of betaine, vitamin c and folic acid supplementations to the diet on productive and reproductive performance of Matrouh poultry Egypt. Poult. Sci. 521–37

[23] Khairani K, Sumiati S and Wiryawan K G 2015 Egg production and quality of quails fed diets with varying levels of methionine and choline chloride Med. Pet. 39 34–9