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Requirements of Energy and Protein for Arabic Chicken Hens During Late Egg Production Period

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ABSTRACT

The present study aimed to estimate the metabolizable energy (ME) and protein (CP) requirements of Arabic chicken hens during the late egg production period reared under a semi-scavenging system with free-choice feeding. A total of 112 sixty-two-week-old Arabic chicken hens were used. The treatments were control and the choice diet consisted of 6 replicate pens. Control hens received a control diet (2750 kcal of ME/kg and 14.1% of CP) complying with the Hy-line Brown Commercial Management Guide 2011, whereas the choice hens offered control and three other diets (high energy-high protein [3006 and 17.3], high energy-low protein [3089 and 12.7], and low energy-high protein [2656 and 17.0] kcal of ME/kg and % of CP, respectively). Feed, ME, and CP intake, the concentration of dietary ME and CP, and egg production were recorded weekly. Data were analyzed using Proc Mixed of SAS. The feeding method influenced feed intake, CP concentration, and ME concentration but had no significant effect on CP intake, ME intake, and egg production. Weekly feed intake of choice hens was lower than that of control hens (514.03 vs. 551.18 g /hen/week; $P<0.03$). Dietary concentrations of ME and CP in the choice hens were higher than those in the control hens (2957 vs. 2750 kcal of ME/kg; $P<0.001$ and 150.6 vs. 14.1 g of CP/kg; $P<0.001$). Egg production of the choice hens was not significantly higher than that of the control hens (51.17% vs. 46.82%; $P>0.05$). Feed intake, CP intake, and ME intake decreased significantly at week 66 onward, while egg production decreased at week 65 onward. It can be concluded that Arabic chicken hens in the late egg production period were able to adjust their energy and protein requirements by consuming more from high dietary energy than from a high dietary protein. Based on the choice feeding, ME and CP requirements for Arabic chicken hens during the late egg production period in the semi-scavenging system were 2957 kcal/kg and 151 g/kg and higher than ME and CP contain in the control diet of 2750 kcal/kg and 141 g/kg to maintain egg production. The egg mass and feed conversion ratio were better in the choice hens group.

Key words: Arabic chicken, Choice feeding, Egg production, ME and CP requirements

Introduction

Arabic chicken as an Indonesian local chicken strain has claimed that has been producing more egg (Husmaini and Sabrina, 2006; Hartawan and Dharmayanti, 2016) and will contribute to meet the demand for poultry egg in the future and to increase the contribution to national egg production. Therefore, the potential of Arabic chicken hens especially in the tropics area like Indonesia to produce more eggs should be improved. However, there are two important factors influencing egg production in the tropics, including temperature and nutrient requirements.

Laying hens' diets must contain sufficient quantities of all nutrients needed, particularly crude protein (CP) and metabolizable energy (ME). It is generally believed that feeding with a high dietary CP level to animals causes a low-protein utilization and high-heat production while limiting protein consumption and adding synthetic DL-methionine and L-lysine can improve the efficiency of protein utilization and productive performance of the hens (Poosuwan *et al.*, 2010). On the other hand, reducing the dietary CP resulted in lowering egg production as compared with the hens fed the normal-CP diets although lowered the NH_3 emission from laying-hen manure as a result of lowering the manure pH (Roberts *et al.*, 2007). However, different dietary levels of CP and amino acid contents had significantly improved feed conversion and a better protein utilization if the broiler fed with a high energy level at an ambient temperature ranging from 21.1℃ to 35℃ (Syafwan *et al.*, 2011).

Many farmers in tropical and subtropical countries raise laying hens in an open-housed system and the temperature inside the house is high most of the day in the yearly round. The hens exposed to high environmental temperature reduced feed intake, egg production, egg mass, and eggshell quality to maintain body homeostasis (Deng *et al.*, 2012). Syafwan *et al.*(2012) also demonstrated that high environmental temperatures decreased feed intake and growth of broiler. Thus, the high ambient temperature in the poultry house brings economic loss from production. Therefore, the nutrient requirements studied for commercial egg-laying hens in the temperate environment may not be matched to the nutrient requirements of egg-laying hens in tropical regions. One way to get an appropriate requirement of ME and CP for Arabic chicken hens is to allow the hens to select from the various quality of feed. To be effective in choice by the hens, the feeds need to be nutritionally distinct (Fanatico *et al.*, 2016). Free-choice feeding is an alternative feeding method that allows the hens to adjust intake as a function of nutrient requirements such as energy, protein, minerals, or other nutrients (Syafwan *et al.*, 2012; Fanatico *et al.*, 2013). Offering choices of the diet with various quality of ME (2638 to 3133 kcal/kg) and CP (14.6 to 23.4%) in Arabic chicken hens during early egg production resulted in a high ME and CP concentration in the diet consumed and produced more eggs than the control diet (Syafwan and Noferdiman, 2020). However, they use five feeds in the choice feeding group including an energy-protein poor diet. Thus, the hens need more time in choosing to balance the ME and CP needs. We do not know what kind of diet the Arabic chicken hens during late lay production would select without an energy-protein poor diet to compose their CP and ME requirements that are suitable for their egg production capacity in the late egg production period.

The objectives of the present study were (1) to determine Arabic chicken hens aged at late egg production period can compose an adequate ration from different diets that varying in energy and protein contents with a choice feeding; (2) to calculate the CP and ME requirements of Arabic chicken hens in the age of late egg production period, and (3) to compare the egg production of Arabic chicken hens when given a free choice diet with a standard layer ration.

Materials and Methods

Animal care, birds, and housing

All experiments were approved by the Animal Science Faculty Ethical Clearance Committee number 002/UN21.7/ECC/2021. A total of 112 sixty-two-week-old silver Arabic chicken hens were used in this research. This chicken is a specific breed of native chicken for layer purposes (Hartawan and Dharmayanti, 2016). They were assigned to 12 pens with 9 to10 hens each. The pen dimension was 2 m inside the house and 3 m outside the house with similar wide (1.75 m) and high (2 Am). The pen was separated with netted nylon. The pen floor inside the house was covered with sand and the pen floor outside the house was ground. The house was open-sided and the hens could access the yard freely.

Each diet was served in separate feeders in each pen. Feeders' positions in each pen were changed every day randomly to avoid the habituation of the hens. One bell-shaped drinker was filled in when necessary and the wooden perch with rounded angles was fixed about 1 m above the floor in each pen. The nest was provided in each pen on the floor.

The temperature and humidity cycle were recorded 3 times daily (07:00 am, 12:00, and 5:00 pm) by using a maximum-minimum thermo-hygrometer. An emergency light was placed for every two pens to guarantee 16-hour light and 8-hour dark every day when the electricity went off.

Experimental design and treatments

The experiment was conducted as a completely randomized design with two treatments and six replicate pens. The no-choice hens received a control diet containing 2750 kcal of ME/kg and 14.10% of CP for the late laying period [>-60 weeks of age] as recommended by Hyline Brown Commercial Management Guide (HyLine, 2011). The choice hens were fed with a control diet [ME: 2750 kcal/kg and CP: 14.10%]; high energy-high protein diet, **HMEHCP** [ME: 3006 kcal/kg and CP: 17%], high energy-low protein diet, **HMELCP** [ME: 3089 kcal/kg and CP: 12.70%], and low energy-high protein diet, **LMEHCP** [ME: 2656 kcal/kg and CP: 17%]. Each diet was supplied as a mash form and adapted for one week. Rice bran, yellow corn, and palm oil were energy sources, and soybean meal and fish meal were protein sources. Dietary compositions of the diets are presented in Table 1, and the nutrients contents of the diets are presented in Table 2. The only big differences in the nutrient content of dietary treatments were protein and energy. The other nutrients' contents such as Ca, NPP, and Na were almost identical. Thereby, the hens are directed only to meet the protein and energy requirements.

Traits measured

Feed intake (FI) per pen was recorded by weighing the feed offered and feed residues weekly (g/bird/week). Energy and protein intake were calculated from the intake of each of the four diets times the content of ME and CP in each diet then divided by 1000 (g/kg). The concentrations of ME and CP in the diet intake were calculated from the ME and CP intake divided by FI times 1000 (g/kg) (Syafwan *et al.*, 2012; Syafwan and Noferdiman, 2020).

Data of FI, ME intake, CP intake, the concentration of dietary ME and CP were recorded weekly. Egg productions were recorded daily. The percentage of hen day egg production (% HDP) was calculated from the total number of eggs laid divided by the total number of live hens

Table 1. The ingredients (%) composition of dietary treatments

Ingredients	Control (> 60 weeks)	High energy-high protein diet (HMEHCP)	High energy- low protein diet (HMELCP)	Low energy-High protein diet (LMEHCP)
Rice bran	12.05	5.54	7.23	15.32
Maize	52.64	38.52	52.00	41.19
Soybean meal	19.19	28.90	14.00	27.00
Fish meal	0.00	1.00	3.00	0.50
Salt	0.37	0.38	0.33	0.37
Top Mix[1]	1.30	1.30	1.30	1.33
Dicalcium phosphate	0.99	0.83	0.63	0.83
Calcium carbonate	9.35	9.47	9.42	9.40
DL-Methionine	0.11	0.06	0.09	0.06
Palm oil	4.00	14.00	12.00	4.00
Total	100.00	100.00	100.00	100.00

[1]Composition of 1 kg Top Mix: vitamin A (retinyl acetate), 12,000 IU; vitamin D_3 (cholecalciferol), 2,000 IU; vitamin E (dl-α-tocopherol), 8.0 mg; vitamin K, 2.0 mg; vitamin B_1 (thiamin), 2.0 mg; vitamin B_2 (riboflavin), 5.0 mg; vitamin B_6 (pyridoxine-HCl), 0.5 mg, vitamin B_{12} (cyanocobalamin), 12 mg; vitamin C, 25 mg; niacin, 40 mg; vitamin B_5 (d-pantothenic acid), 6.0 mg; choline chloride, 10 mg; methionine, 30 mg; lysine, 30 mg; iron, 20 mg; copper, 4 mg; manganese, 120 mg; zinc, 100 mg; cobalt, 0.2 mg; iodine, 0.2; and santoquin (antioxidant), 10 mg.

Table 2. Calculated nutrients content (/kg) of dietary treatments

Calculated nutrients content	Control diet (> 60 weeks)*	High energy-high protein diet (HMEHCP)	High energy- low protein diet (HMELCP)	Low energy-High protein diet (LMEHCP)
Dry matter (%)	87.69	78.37	80.53	87.65
Energy (Kcal ME/Kg)[1]	2750.00	3006.00	3089.00	2656.00
Crude protein (%)	14.10	17.00	12.70	17.00
Crude fat (%)	9.75	17.80	16.86	9.85
Crude fiber (%)	8.76	5.92	6.50	8.56
Lysine (%)	0.73	0.99	0.71	0.96
Methionine (%)	0.35	0.35	0.35	0.35
Met+Cys (%)	0.50	0.58	0.49	0.59
Ca (%)	4.40	4.40	4.41	4.40
Total P (%)	0.51	0.50	0.46	0.54
NPP (%)	0.33	0.33	0.33	0.33
Na (%)	0.17	0.17	0.17	0.17

*Recommended by Hyline Brown Commercial Management Guide, Australia (2011).

[1]Metabolizable energy was calculated by determining (combustion) gross energy of the entire diet multiplied with a ME to GE-conversion factor (0.725).

per day (Khawajaa *et al.*, 2012; Syafwan and Noferdiman, 2020). Egg mass (EM) was calculated from average egg weight multiplied with egg production percentage, and FC ratio by dividing FI by EM (Bigge *et al.*, 2018).

Statistical analysis

Data were analyzed according to the method described (Syafwan *et al.,* 2012; Syafwan and Noferdiman, 2020) by using PROC MIXED in SAS. The completely randomized design was used to analyze data for a mixed model, with dietary treatment as the main effect and week as a repeated measurement. Since the data were taken repeatedly every week on the same animals, a mixed model was used to determine the covariance structure among repeated observations (Littell *et al.*, 1998; Wang and Goonewardene, 2004; Walter *et al.*, 2018) with Mixed Procedure in SAS. In the analysis, the week was used as the time factor, and the pen was considered as an additional random effect.

A probability level of ≤ 5% was considered to be statistically significant. Means were compared by pairwise comparison using the Least Significant Difference when the main effects or their interactions were significant. Means of significant effects were separated using the PDIFF option with PDMIX800 SAS macro at the p<0.05 level (Syafwan *et al.*, 2012; Naseem and King, 2020; Syafwan and Noferdiman, 2020). The Kenward-Roger method was used for computing the denominator df for the tests of main effects. The best covariance structure was based on the corrected Akaike Information Criteria (AICC). The autoregressive covariance structure [AR(1)] was the best fit for FI, CP intake, and ME concentration. The heterogeneous autoregressive covariance structure [ARH(1)] was the best fit for ME intake. The first-order ante-dependence covariance structure [ANTE(1)] was the best fit for CP concentration. The unstructured covariance structure [UN] was the best fit for egg production.

Results and Discussion

Environmental condition

Ambient temperature (Ta) and relative humidity (RH) are given as the average ± SD for each time recorded. During the period of this experiment, the average Ta and RH in the morning (07.00) were 25.0±1.0°C and 84±12%. On the day (12.00), the average Ta and RH were 32.2±0.9°C and 66±7.0%. In the afternoon (17.00), the average Ta and RH were 31.0±1.6°C and 69±9%. In the night (22.00), the average Ta and RH were 26.6±1.2°C and 86±6%.

The house used in this experiment was open-sided and there was no effort to control the Ta and RH. Therefore, the changes of Ta and RH both in the roofed pen and in the yard relayed on the natural conditions. The increasing and decreasing of Ta in the house were followed by decreasing and increasing of RH.

The cyclical temperature and relative humidity in the house during the experiment were dependent on the environmental climate conditions. When the temperature outside the house rose, then the temperature inside the house also rose because there was no effort made to control the house temperature. When the temperature inside the house rose, the relative humidity fell, and vise versa. The hens were changing their behavior and panting when the temperature rose above 28°C and generally happens between 12:00 to 17:00 h. Panting activity is an indicator of heat stress (Sugiharto *et al.*, 2017; Wang *et al.*, 2018) and it helps to release the extra heat to the environment. Therefore, the environmental temperature conditions indicate that the birds experienced heat stress during the time hot period of the day. The birds spent more time panting and drinking and less time walking and feeding during heat stress (He *et al.*, 2018). High ambient temperature harms body weight and feed intake of laying hens (He *et al.*, 2018) and broilers (Syafwan *et al.*, 2011; Syafwan *et al.*, 2012; Wang *et al.*, 2018).

Hens performance

The results showed that there was an effect of treatments on FI of the hens (P<0.03; Table 3). Overall, FI was lower in choice-fed hens than that in control-fed hens (Table 3), although it was similar between treatments each week (Table 4). The treatments did not affect protein and energy intake (P>0.05; Table 3). Feed intake, protein intake, and energy intake were affected by week (P<0.01; Table 3) and they decreased from 66th to 68th week of age and then did not increase significantly until the 70th week of age (Figure 1, 2 and 3). There were no interaction effects between dietary treatments and week on FI, protein intake, and energy intake (P>0.05; Table 3). CP and ME concentrations and crude fat intake were affected by dietary treatments (P<0.001; Table 3). CP and ME concentrations and crude fat intake were significantly higher in choice-fed hens than control-fed hens every week (P<0.001; Table 4). However, CP and ME concentrations were not affected by week and there were no interaction effects between dietary treatments and week on CP and ME concentrations (P>0.05; Table 3). Crude fat intake was affected by week (P<0.001; Table 3) and decreased from 65th to 68th week of age and then did not increase significantly until the 70th week of age (Figure 4). There was no interaction effect between dietary treatments and week on crude fat intake (P>0.05).

The choice-fed hens in the present study consumed a much lower amount of feed than the control-fed hens and overall they consumed about 6.74% lower of feed than the control-fed hens. The lower feed intake in choice-fed hens might be related to a higher concentration of CP and ME in the feed consumed (Table 4). This is in agreement with another study in Arabic chicken during the growing period that feed intake decreased with increased protein and energy concentration in the diet consumed (Syafwan *et al.*, 2021). Increasing protein concentrations in the diet reduced feed intake (Liu *et al.*, 2016) to avoid the increase in body temperature due to higher heat increment from protein metabolism (Syafwan *et al.*, 2011) and high environmental temperature.

Table 3. Probability values of main effects and interaction between dietary treatments[1] and week for different traits

Main Effect	No Choice	Choice	Feed	Week	Feed*Week
Feed intake (g/bird/wk)	551.18	514.03	**0.033**	**0.003**	0.979
CP intake (g/bird /wk)	77.72	77.41	0.898	**0.007**	0.965
ME intake (kcal/kg/bird/wk)	1515.75	1519.82	0.929	**0.003**	0.976
CP concentration (g/kg)	141.00	150.57	**<0.001**	0.371	0.371
ME concentration (Kcal/kg)	2750.00	2957.24	**<0.001**	0.430	0.430
Egg production (%)	46.82	51.17	0.349	**0.043**	0.969
Crude fat Intake (g/bird /wk)	53.74	78.85	**<0.001**	0.001	0.761
Egg mass (g/wk)	21.28	23.47	**0.01**	**<0.001**	0.999
FCR	3.90	3.33	**<0.001**	**0.01**	0.962

[1]No-choice: control diet [ME: 2750 kcal/kg and CP: 14.1%]; Choice: a) control diet [ME: 2750 kcal/kg and CP: 14.1%]. b) high energy-high protein diet. HMEHCP [ME:3006 kcal/kg and CP:17.0%]. c) high energy-low protein diet. HMELCP [ME:3089 kcal/kg and CP:12.7%]. and d) low energy-high protein diet. LMEHCP [ME:2656 kcal/kg and CP:17.0%].

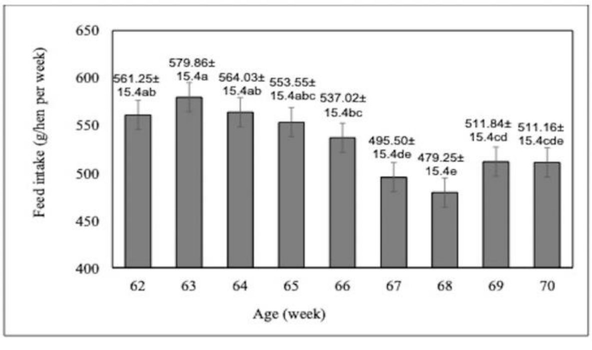

Figure 1. Least square means for feed intake that effected by week in the late laying period. Means without a common letter (a-e) differ significantly (P<0.05).

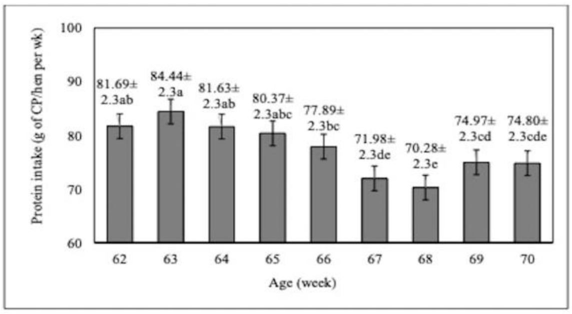

Figure 2. Least square means for protein intake that effected by week in the late laying period. Means without a common letter (a-e) differ significantly (P<0.05).

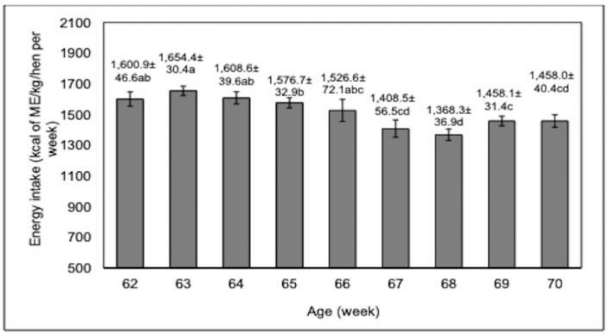

Figure 3. Least square means for energy intake that effected by week in the late laying period. Means without a common letter (a-d) differ significantly (P<0.05).

Furthermore, intraluminal infusion with lipids causes gastrointestinal delays in gastric emptying by lowering the gastric cycle frequency, increasing duodenogastric refluxes, and elongating the migrating myoelectric complex. Therefore, higher lipid concentration reduces feed intake (Khoddami *et al.*, 2018).

The average energy and protein consumption in the hens offered the free-choice diet were similar to those provided by the standard diet (1520 vs. 1516 kcal of ME/hens/week and 77.41 vs. 77.72 g/hens/week; P>0.05; Tabel 3). To meet the ME and CP requirements during this experiment, the hens in the choice group consumed HMEHCP, HMELCP, Control, and LMEHCP diets about 41.17%, 30.07%, 19.45%, and 7.31%, respectively (Figure 5). This distinct preference suggests that Arabic chicken hens during the late egg production period can fine-tune their energy and protein requirements from different diet contents independently. The shifted preference to a high-energy diet was also observed in Arabic chicken hens during the early egg production period (Syafwan and Noferdiman, 2020).

Based on these choices (Figure 5), energy and protein concentrations in the diet consumed were significantly higher in the choice group (Table 3). These preferences show that hens were capable of choosing a diet that contains nutrients for their needs. The capability of Arabic chicken hens to adjust their energy and protein requirements by selecting several diets during the early egg production period has been

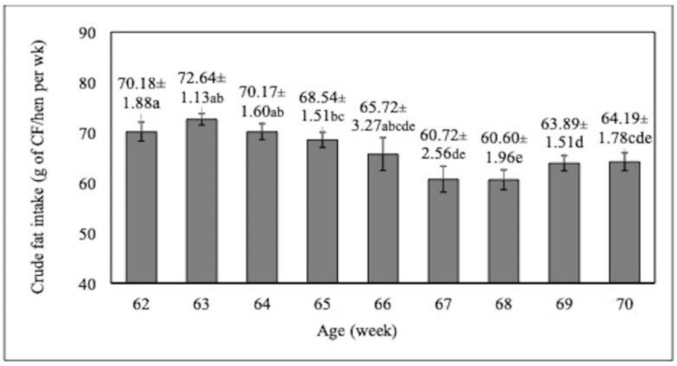

Figure 4. Least square means for crude fat intake that effected by week in the late laying period. Means without a common letter (a-e) differ significantly (P<0.05).

Table 4. Least square means of performance parameter in Arabian hens as affected by dietary treatments[1]

Parameters	Week									
	62	63	64	65	66	67	68	69	70	Average
Feed Intake (g/bird/week)										
No Choice	573.88	595.91	590.12	573.13	550.28	521.29	501.41	522.77	531.86	551.18
Choice	548.61	563.80	537.95	533.96	523.77	469.72	457.09	500.92	490.45	514.03
SEM	21.75	21.75	21.75	21.75	21.75	21.75	21.75	21.75	21.75	11.31
Probability	0.41	0.30	0.10	0.21	0.39	0.10	0.16	0.48	0.18	**0.03**
Crude Protein Intake (g/bird/week)										
No Choice	80.92	84.02	83.21	80.81	77.59	73.50	70.70	73.71	74.99	77.72
Choice	82.47	84.85	80.04	79.93	78.20	70.45	69.87	76.24	74.62	77.41
SEM	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	3.26	1.68
Probability	0.74	0.86	0.49	0.85	0.90	0.51	0.86	0.58	0.94	0.90
Energy Intake (kcal of ME/kg/bird/week)										
No Choice	1578.17	1638.75	1622.83	1576.11	1513.26	1433.54	1378.87	1437.61	1462.62	1516
Choice	1623.60	1669.99	1594.42	1577.22	1539.92	1383.42	1357.80	1478.67	1453.39	1520
SEM	65.86	42.98	56.06	46.66	101.94	79.98	52.22	44.40	57.18	36.10
Probability	0.63	0.62	0.73	0.99	0.86	0.67	0.78	0.52	0.91	0.94
Crude fat Intake (g/kg)										
No Choice	55.95	58.10	57.54	55.88	53.65	50.83	48.89	50.97	51.86	53.74
Choice	84.41	87.18	82.80	81.20	77.79	70.62	72.31	76.81	76.52	78.85
SEM	2.67	1.60	2.26	2.14	4.63	3.62	2.78	2.14	2.51	1.69
Probability	<0.001	<0.001	<0.001	<0.001	0.005	0.003	<0.001	<0.001	<0.001	<0.001
CP concentration (g/kg)										
No Choice	141.00	141.00	141.00	141.00	141.00	141.00	141.00	141.00	141.00	141.00
Choice	150.25	150.50	148.78	149.63	149.34	149.77	152.60	152.17	152.12	150.57
SEM	0.62	0.91	1.29	0.78	0.87	0.85	0.78	0.61	1.13	0.37
Probability	**<0.001**	**<0.001**	**0.002**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
ME Concentration (kcal/kg)										
No Choice	2750.00	2750.00	2750.00	2750.00	2750.00	2750.00	2750.00	2750.00	2750.00	2750.00
Choice	2959.71	2962.72	2964.57	2954.72	2941.94	2945.82	2970.68	2952.14	2962.87	2957.24
SEM	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41	3.40
Probability	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Egg Production (%)										
No Choice	58.0	54.8	53.4	50.1	46.0	41.3	39.9	37.1	40.8	46.8
Choice	59.4	59.8	57.2	56.0	49.8	46.1	44.7	42.7	44.7	51.2
SEM	4.44	3.19	3.90	4.33	3.63	3.60	3.47	3.44	4.66	3.13
Probability	0.82	0.29	0.50	0.35	0.48	0.37	0.35	0.27	0.57	0.35
Egg mass (g/wk)										
No Choice	26.50	24.46	24.62	22.57	20.95	18.75	18.42	16.81	18.48	21.28
Choice	27.17	27.48	26.35	25.50	23.22	21.00	20.39	19.63	20.45	23.47
SEM	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	1.86	0.62
Probability	0.80	0.25	0.51	0.27	0.39	0.39	0.45	0.28	0.45	**0.01**
FCR										
No Choice	3.30	3.42	3.46	3.68	3.85	4.12	4.08	4.65	4.53	3.90
Choice	3.02	2.99	2.95	3.09	3.36	3.20	3.39	4.42	3.54	3.33
SEM	0.22	0.17	0.22	0.25	0.24	0.27	0.27	0.44	0.52	0.10
Probability	0.38	0.11	0.14	0.12	0.18	**0.04**	0.10	0.72	0.20	**<0.001**

[1]No-choice: control diet [ME: 2750 kcal/kg and CP: 14.1%]; Choice: a) control diet [ME: 2750 kcal/kg and CP: 14.1%]. b) high energy-high protein diet. HMEHCP [ME:3006 kcal/kg and CP:17.0%]. c) high energy-low protein diet. HMELCP [ME:3089 kcal/kg and CP:12.7%]. and d) low energy-high protein diet. LMEHCP [ME:2656 kcal/kg and CP:17.0%].

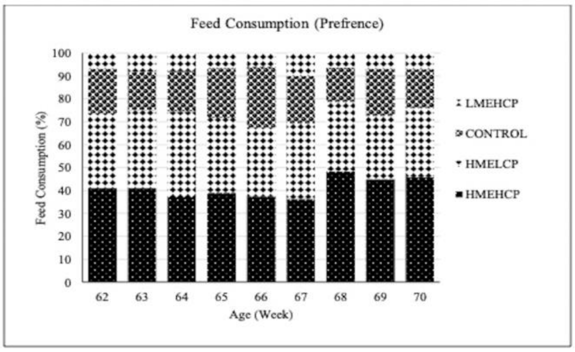

Figure 5. Intake of high energy-high protein diet (**HMEHCP),** high energy-low protein diet (**HMELCP**), control diet, and low energy-high protein diet (**LMEHCP)** as a proportion of total feed intake of dietary treament[1].

[1] a) control diet [ME: 2750 kcal/kg and CP: 14.1%]. b) high energy-high protein diet. HMEHCP [ME:3006 kcal/kg and CP:17.0%]. c) high energy-low protein diet. HMELCP [ME:3089 kcal/kg and CP:12.7%]. and d) low energy-high protein diet. LMEHCP [ME:2656 kcal/kg and CP:17.0%].

reported by Syafwan and Noferdiman (2020). These results suggested that energy and protein needs for Arabic chicken hens during the late egg production phase are higher than the energy and protein in the control diet. The higher energy requirement of Arabic chicken hens in this study was more likely due to the hens need more energy to walk in and out to the scavenging area and to release body heat to the environment. Behura *et al.* (2016) reported that

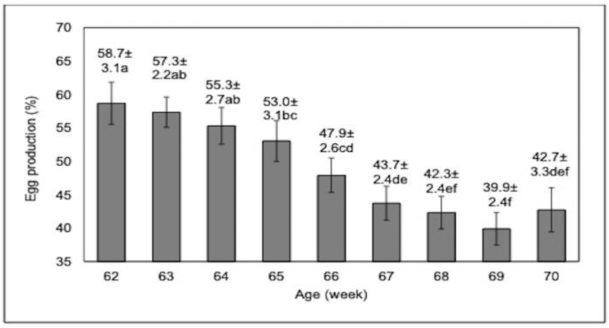

Figure 6. Least square means for egg production that effected by week in the late laying period. Means without a common letter (a-f) differ significantly (P<0.05).

the coefficient correlation between a climatic variable and ME requirement for maintenance (MEm) for broiler breeder pullet was positive and MEm increased when the temperature-humidity index increased in the hot and humid climatic condition during summertime. This higher energy concentration under high temperature reflects the higher demand for energy to release the heat load due to birds showing panting activity during summertime (Behura *et al.*, 2016). Panting is the common way for the bird to release body heat at high temperatures. On the other hand, an energy-rich diet may be favorable for the hens than a protein-rich diet under high environmental temperature because protein produces more heat load per kilojoules than do fat and carbohydrate (Syafwan *et al.*, 2011).

There was no effect of treatments on egg production of the hens (P>0.05; Table 3). Egg production was influenced by week (Table 3) and egg production decreased significantly from the 65th week of age onward (Table 4, Figure 6). Egg mass and feed conversion ratio were affected by treatments and week (Table 3). Egg mass decreased significantly from the 66th week of age onward (Figure 7) and feed conversion ratio increased significantly after 68th week of age (Figure 8).

The increasing CP concentration in the choice hens compared with the control hens (150.57 vs. 141.00 g/kg, P<0.001; Table 3) did not increase egg production significantly in this experiment. Torki *et al.*(2014) reported that the egg production of Lohmann Selected Leghorn (LSL-Lite) laying hens did not increase by

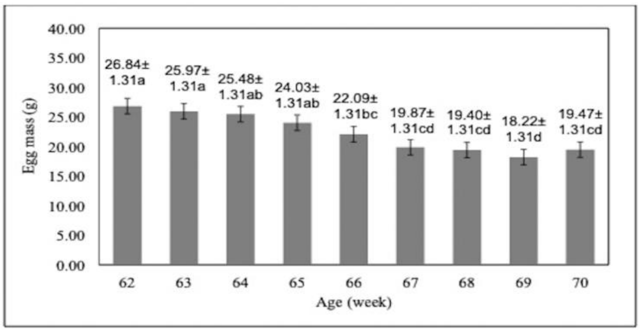

Figure 7. Least square means for egg mass that effected by week in the late laying period. Means without a common letter (a-d) differ significantly (P<0.05).

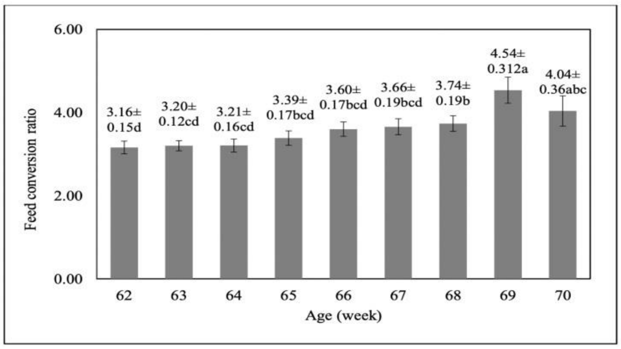

Figure 8. Least square means for feed conversion ratio that affected by week in the late laying period. Means without a common letter (a-df) differ significantly (P<0.05)

increasing CP level in the diet from 12.0 to 16.5% at an ambient temperature of 30.5±2.14°C and RH of 46.5±1.88% during 52 to 60 week of age. Limited information is available regarding the response of laying hens-fed diets with choice feeding under high-temperature conditions. In our previous study showed that egg production during the early egg production period was higher in the choice-fed hens with higher CP (2.87%; P<0.001) and ME (8.38%; P<0.001) dietary concentration in the diet consumed than the control diet (Syafwan and Noferdiman, 2020). The non-significant higher egg production in this experiment might be contributed by the ME concentration in the diet consumed by the choice hens (7.01% higher ME concentration than control diet; P<0.001) used more to release the heat load due to accumulation of heat in the body coming from protein metabolism (6.36% higher CP concentration than control diet; P<0.001) and environment and consequently less available of ME to increase egg production significantly. The Arabic chicken hens were probably more important to fulfill the nutrient requirements to balance the heat production rather than to increase egg production when they have a choice during the late egg production age under high temperatures. In normal environmental conditions (22°C), the commercial laying hens fed with a high protein diet showed a higher body weight gain, FI, and hen day egg production than that with medium and low protein diet for every phase of egg production (Shim *et al.*, 2013).

Feed intake was significantly lower and the egg mass was significantly higher and leading to a significantly lower feed conversion ratio in the choice hens group (3.33; Table 3) compared to the control group (3,90; Table 3). The feed cost for the control diet (14,1% of CP and 2750 of kcal ME/kg) was about IDR. 8,464/kg and the feed cost for the amount of CP and ME consumed in the choice hens group (15,1% of CP and 2975 of kcal ME/kg) was about IDR. 9,063/kg. By assuming the egg price was IDR. 40,000/kg, the income over feed cost was 21% and 32% for the control hens and choice hens group respectively.

Conclusions

Arabic chicken hens in the late egg production period were able to adjust their energy and protein requirements by consuming more from high dietary energy than from high dietary protein. Based on the choice feeding, ME and CP requirements for Arabic chicken hens during the late egg production period in the semi-scavenging system were 2957 kcal/kg and 151 g/kg and higher than ME and CP contain in the control diet of 2750 kcal/kg and 141 g/kg to maintain egg production. The egg mass and feed conversion ratio were better in the choice hens group.

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