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Proper levels of dietary protein and metabolizable energy on production performance and carcass quality of Pradu Hang Dam × Hubbard JA 57 Ki crossbred native chicken during 6-10 weeks of age

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ABSTRACT: A total of healthy 1,440 crossbred native chickens (Pradu Hang Dam × Hubbard JA 57 Ki) at 5 weeks of age, composed of 720 males and 720 females were used in this study. Each sex of chickens was randomly allocated into 6 groups of 3 replicates containing 40 birds/replication. Chickens were raised in an open house with a 2 × 4 m area/pen during 6-10 weeks of age and fed with diets containing 19% vs 17% crude protein (CP). Each CP level contained 3 metabolizable energy (ME) levels (3.2 vs 2.9 vs 2.6 kcal/g) based on a 2 × 3 factorial in a randomized complete block design (RCBD) having sex as a block. The result revealed there was no statistically significant for interaction between CP and ME on for all parameters. Dietary CP level had no significant effects on body weight gain (BWG), average daily gain (ADG), feed intake (FI), feed conversion ratio (FCR), feed cost per kg BWG (FCG), and carcass composition ($P > 0.05$). Contrariwise, the highest ME diet (3.2 kcal ME/g) gave significantly higher BWG, ADG, and lower FI, resulted in better FCR and FCG than the lowest ME diet (2.6 kcal ME/g). In addition, the 3.2 and 2.9 kcal ME/g diet had significantly higher percentage of carcass, breast meat and abdominal fat, but lower percentage of liver, gizzard and whole intestine than the 2.6 kcal ME/g diet. Male had significantly higher BWG and FI with better FCR and FCG than female chicken. In addition, male also had significantly higher percentage of carcass, thigh, drumstick, but significantly lower percentage of wing, liver, heart, and whole intestine than females. The proper ration for Pradu Hang Dam × Hubbard JA 57 Ki during 6-10 weeks of age should contain 19% CP with 3.2 kcal ME/g.

Keywords: protein; metabolizable energy; crossbred native chicken (Pradu Hang Dam × Hubbard JA 57 Ki); production performance; carcass quality

Introduction

Crossbred native chickens gain favor from consumers due to their tight texture and better flavor than broilers. In addition, their meat seems to be healthier than broiler meat, due to the lower fat, cholesterol, and triglyceride content (Phianmongkhol et al., 2012). Therefore, it could be sold at a high price similar to native chickens (Prachyalak et al., 1998). Crossbred native chickens also adapt well to the local environment (Rajpura et al., 2010). Most of them were raised by small farmers, who often used other types of chicken feed, therefore it may cause slow growth with poor performance (Kridtayopas et al., 2019). It is well recognized that protein and

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energy levels need to be highly concern in formulating the diet. However, Information on crude protein (CP) and metabolizable energy (ME) requirements of indigenous and crossbred chickens is limited (Kingori et al., 2003). According to Jeerathamstien et al. (2017), content in the diet for optimal growth of Pradu Hang Dam native chicken were 19.45%, 19.36%, and 17.77% for starter (1-28 days of age, DOA), grower (29-56 DOA) and finisher periods (57-84 DOA), respectively. Pingmuang et al. (2001) found that the proper CP and ME levels for crossbred native chickens during 6-10 weeks of age (WOA) should be 17% CP with 2.9 kcal ME/g for males, while that for females was 17% CP with 2.6 kcal ME/g, respectively. In addition, Tangtaweewipat et al. (2000) reported that the proper dietary CP and ME levels for Pradu Hang Dam × RIR-BPR at 1-5, 6-10, and 11-13 WOA were 21% CP with 3.2 kcal ME/g, 17% CP with 2.9 kcal ME/g, and 15% CP with 2.6 kcal ME/g, respectively. The strain JA 57 Ki of Hubbard is a crossbred recessive female which allows its offspring to possess the male's phenotype such as high growth rate, good FCR, excellent viability and good meat yield at processing (Hubbard Premium, 2020). The female of JA 57 Ki strain achieves a bodyweight of 1.8-2.0 kg, while the male can reach 2.5-2.8 kg within 100 days (Hubbard, 2019). At present, this crossbred chicken gains popularity in many Asian countries, due to its high growth performance, and good quality of meat (Niyamcom, 2019). Although the breed has been improved, no data on the appropriate diet for this crossbred was reported, therefore it is necessary to investigate. The objective of this study was to determine the proper levels of dietary CP and ME on production performance and carcass quality of Pradu Hang Dam × Hubbard JA 57 Ki during 6-10 weeks of age.

Materials and methods

Birds and housing

All procedures used in this study were approved by the Animal and Aquatic Sciences' Graduate Committee of Chiang Mai University (CMU; Protocol No. CMU-Agri. 262/2563), Thailand and were performed in accordance with the guidelines for experimental animals of the CMU farm.

A total of healthy 1,440 crossbred native chicks (Pradu Hang Dam × Hubbard JA 57 Ki) at 5 weeks old with an average initial body weight (BW) of 0.45 kg/bird and being fed with diet containing 19% CP and 3.2 kcal ME/g during the first 5 weeks of age were used. They composed of 720 males with an average initial BW of 0.46 kg and 720 females with an average initial BW of 0.44 kg, as shown in the result. Each sex was randomly allocated into 6 treatments of 3 replicates, containing 40 birds/rep. The experiment was carried out during week 6-10 of birds' age. The chicks were fed with diets containing 2 levels of CP (19% vs 17%) and 3 levels of ME (3.2 vs 2.9 vs 2.6 kcal/g) based on a 2 × 3 Factorial in randomized complete block design (RCBD), while the sex of birds was considered as a block. They were raised in an open house with a 2 × 4 m area/pen of 40 birds, containing rice husk as a litter. Light was provided through the night while feed and water were freely accessed all the time.

Feed analysis and data record

At the onset and at the end of the experiment (day 36 and 70 of birds' age), all birds in each pen were weighed for the calculation of body weight gain (BWG). Feed of each treatment were sampled and determined for major chemical composition according to the Proximate Analysis (AOAC, 2005) in which DM, CP, EE, CF and ash were determined according to AOAC Official Method 934.01, AOAC Official Method 2001.11, AOAC Official Method

920.39, AOAC Official Method 962.09 and AOAC Official Method 942.05, respectively, while %NFE was calculated from %DM - %ash - %EE - %CP - %CF. Feed ration and chemical composition of the experimental diets are shown in **Table 1**. The amount of feed offer and feed left in each pen at the end of the experiment were recorded for the calculation of feed intake (FI). Feed conversion ratio (FCR) was calculated from FI/BWG. Feed cost per kg BWG (FCG) was calculated from feed intake × cost of feed (THB/kg)/BWG. Mortality and culling rates as well as abnormal symptoms were recorded immediately at the notice. The influences of sex on these parameters were also calculated.

Carcass composition

At the end of the experiment, 2 birds from each sex in each replicate, i.e. 6 birds/group were randomly selected for slaughtering after 12 hours of starving. The carcass quality (weight and percentage of carcass as well as percentage on hot carcass of breast, thigh, drumstick, wing, liver, gizzard, whole intestine, and abdominal fat) were recorded.

Statistical analysis

All the data were subjected to statistical analysis according to the factorial arrangement in RCBD using a software program SAS version 6.12.0.1 (SAS, 1996). Duncan's new multiple range test was performed when significant differences were found.

Table 1 Ingredients and composition of experimental diets for crossbred native chickens (Pradu Hang Dam × JA 57 Ki) during 6-10 weeks of age

Level of CP (%) in diet	19			17		
Level of ME (kcal/g) in diet	3.2	2.9	2.6	3.2	2.9	2.6
Ingredients:						
Yellow corn	61.03	54.97	25.03	64.24	54.78	27.02
Fine rice bran	0	11.99	45.05	0	16.93	48.03
Soybean meal, 44% CP	0	19.99	25.03	0	17.43	20.01
Full fat soybean (FFSB)	30.02	5	0	29.88	4.98	0
Meat meal, 50% CP	6	5	1	2.49	2.50	1
Monocalcium phosphate, 22% P	1.70	1.70	1.50	1.64	1.70	1.50
Limestone	0.70	0.80	1.80	1.03	1.10	1.80
DL-Methionine	0.10	0.10	0.15	0.19	0.14	0.17
Salt (NaCl)	0.20	0.20	0.20	0.24	0.20	0.20
Premix[1/]	0.25	0.25	0.25	0.24	0.24	0.25
Total	**100**	**100**	**100**	**100**	**100**	**100**
Calculated chemical composition *(% air dry basis)*						
CP	19.05	19.04	19.01	17.56	17.26	17.33
ME (kcal/kg)	3,201	2,929	2,652	3,200	2,922	2,688
Ca	0.95	0.94	1.10	0.90	0.92	1.09
Total P	0.71	0.85	1.21	0.70	0.90	1.22
P, available	0.43	0.44	0.46	0.42	0.45	0.46
Lysine	0.94	0.97	0.97	0.85	0.85	0.85
Methionine	0.42	0.41	0.44	0.49	0.43	0.44
Methionine + Cysteine	0.71	0.67	0.69	0.77	0.68	0.66
Threonine	0.71	0.70	0.66	0.66	0.63	0.59
Tryptophan	0.21	0.22	0.21	0.20	0.20	0.19
Linoleic acid	3.60	1.99	2.20	3.63	2.13	2.33
Feed cost of diet (THB/kg)	12.60	12.32	11.90	12.31	11.88	11.49
Chemical composition analysis [2/] (% DM basis)						
DM (%) [3/]	90.36	90.04	90.95	90.61	90.74	90.82
CP	22.01	21.57	21.46	18.87	18.79	18.80
EE	8.83	6.26	5.11	8.45	6.07	5.26
CF	3.25	4.90	10.21	2.77	5.38	9.74
Ash	7.87	9.75	10.56	7.73	8.38	11.61
NFE	58.04	57.52	52.67	62.18	61.38	54.59
GE (kcal/kg DM)	4,495	4,263	3,989	4,465	4,210	3,855

[1/] Premix: Each 1 kg contained 15,000 IU vitamin A, 3000 IU vitamin D_3, 25 IU vitamin E, 5 mg vitamin K_3, 2 mg vitamin B_1, 7 mg vitamin B_2, 4 mg vitamin B_6, 25 mg vitamin B_{12}, 11.4 mg pantothenic acid, 35 mg nicotinic acid, 1 mg folic acid, 15 µg biotin, 250 mg choline chloride, 1.6 mg Cu, 60 mg Mn, 45 mg Zn, 80 mg Fe, 0.4 mg I, and 0.15 mg Se

[2/] Analyzed at the Feed Lab., Dept. of Animal and Aquatic Sciences, Fac. of Agriculture, Chiang Mai University

[3/] DM from air dry or as fed basis, while % of absolute DM was 100

CP = crude protein; EE = ether extract; CF = crude fiber; NFE = nitrogen free extract; Ca = calcium; P = phosphorus; ME = metabolizable energy; GE = gross energy

Results

Chemical composition of diets

Crude protein (CP) levels of all diets **(Table 1)** are closed to the calculated values. The higher ME diet had higher concentration of ether extract (EE), due to the use of more corn and full fat soybean (FFSB) which contain high amount of fat and being considered as high energy ingredients. On the contrary, the lower ME diets had higher crude fiber (CF) content, due to the higher level of fine rice bran which is a low energy ingredient. At the same ME level, the higher CP diets contained higher amount of meat meal which is a good source of protein **(Table 1).**

Growth performance

The result of the performance is shown in **Table 2**. No significant interactions were found between the dietary CP and ME levels. In addition, no significant difference ($P > 0.05$) between the 2 dietary CP levels (19% vs 17%) on BWG, ADG, FI, FCR and FCG. On the contrary, dietary ME significantly affected all performances. Decreasing dietary energy from 3.2 or 2.9 to 2.6 kcal ME/g significantly decreased BWG and ADG. In addition, it also caused higher FI ($P < 0.05$), thus gave worse FCR and higher FCG, respectively. No mortality rate was found in this experiment.

Crude protein and metabolizable energy intake

The CP and ME intake are shown in **Table 3**. No interaction between these 2 dietary factors on both parameters ($P > 0.05$). Decreasing dietary CP level from 19% to 17% caused significantly lower CP intake ($P < 0.01$), while decreasing dietary ME from 3.2 to 2.9 and 2.6 kcal ME/g caused significantly higher CP intake ($P < 0.01$), respectively.

On the contrary, the lower dietary CP did not significantly affect ME intake ($P > 0.05$), whereas decreasing dietary ME level from 3.2 or 2.9 to 2.6 kcal ME/g gave higher ME intake ($P< 0.01$), respectively.

Table 2 Production performance of crossbred native chicken (Pradu Hang Dam × JA 57 Ki) fed diets containing varying levels of CP and ME during 6-10 weeks of age

Variables		Items					
		Initial BW (kg/bird)	BWG (kg/bird)	ADG (g/bird)	FI (kg/bird)	FCR	FCG (THB/kg BWG)
Mean of main effect:							
Level of CP in diet (%)							
19		0.45 ± 0.02	0.67 ± 0.12	19.03 ± 3.37	2.39 ± 0.35	3.69 ± 1.13	45.75 ± 12.67
17		0.44 ± 0.02	0.64 ± 0.11	18.36 ± 3.23	2.48 ± 0.37	3.71 ± 0.93	46.99 ± 9.54
Level of ME in diets (kcal/g)							
3.2		0.45 ± 0.02	0.70 ± 0.09^{x}	20.12 ± 2.70^{x}	2.15 ± 0.07^{z}	3.21 ± 0.03^{z}	38.48 ± 3.84^{y}
2.9		0.44 ± 0.03	0.68 ± 0.14^{x}	19.32 ± 4.01^{x}	2.29 ± 0.02^{y}	3.44 ± 0.55^{y}	41.96 ± 6.20^{y}
2.6		0.44 ± 0.02	0.58 ± 0.08^{y}	16.64 ± 2.14^{y}	2.87 ± 0.06^{x}	4.45 ± 0.62^{x}	58.67 ± 7.54^{x}
CP × ME							
19	3.2	0.45 ± 0.03	0.74 ± 0.11	21.25 ± 3.09	2.14 ± 0.16	3.05 ± 0.05	36.72 ± 4.58
	2.9	0.45 ± 0.04	0.69 ± 0.10	19.58 ± 2.93	2.19 ± 0.17	3.35 ± 0.18	39.78 ± 3.46
	2.6	0.46 ± 0.03	0.60 ± 0.09	16.26 ± 2.46	2.85 ± 0.09	4.68 ± 0.11	60.76 ± 9.65
17	3.2	0.46 ± 0.04	0.66 ± 0.05	18.99 ± 1.46	2.16 ± 0.10	3.37 ± 0.12	40.25 ± 3.34
	2.9	0.44 ± 0.03	0.67 ± 0.17	19.06 ± 4.73	2.40 ± 0.22	3.53 ± 0.07	44.14 ± 7.26
	2.6	0.43 ± 0.03	0.56 ± 0.09	17.02 ± 2.50	2.89 ± 0.13	4.23 ± 0.09	56.58 ± 7.65
Sex:							
Male		0.46 ± 0.09	0.74 ± 0.09^{A}	21.03 ± 2.47^{A}	2.51 ± 0.32^{A}	3.48 ± 0.80^{B}	46.86 ± 8.50^{B}
Female		0.44 ± 0.05	0.57 ± 0.06^{B}	16.36 ± 1.70^{B}	2.37 ± 0.39^{B}	4.24 ± 1.08^{A}	50.88 ± 11.46^{A}
P-value:							
CP		0.3832	0.2263	0.2263	0.0567	0.0736	0.3832
ME		0.8613	0.0006	0.0001	0.0004	0.0001	0.0004
CP × ME		0.2458	0.0960	0.0960	0.2004	0.0671	0.3470
Sex		0.2073	0.0001	0.0001	0.0034	0.0001	0.0001
SEM		0.05	0.02	0.54	0.06	0.17	1.82

$^{A-B,\ x-y-z}$ Values with no common superscript differ significantly (P < 0.05) when tested with Duncan's new multiple range test following the Analysis of variance

BW = body weight; BWG = body weight gain; ADG = average daily gain; FI = feed intake; FCR = feed conversion ratio; FCG= feed cost per gain; ME = metabolizable energy; CP = crude protein; SEM = standard error of the mean

Table 3 Effects of dietary crude protein (CP) and metabolizable energy (ME) levels on CP and ME intake of crossbred native chicken (Pradu Hang Dam × JA 57 Ki) during 6-10 weeks of age

Variables			Items	
			CP intake (g/bird)	ME intake (kcal/bird)
Mean of main effect:				
Level of CP in diet (%)				
	19		454.78 ± 69.87^{m}	6,870.50 ± 556.62
	17		421.95 ± 60.06^{n}	7,125.60 ± 465.13
Level of ME in diet (kcal/g)				
	3.2		387.22 ± 25.62^{z}	6,649.80 ± 213.94^{y}
	2.9		411.72 ± 33.51^{y}	6,886.10 ± 642.19^{y}
	2.6		516.15 ± 30.75^{x}	7,458.20 ± 151.98^{x}
CP × ME				
	19	3.2	406.63 ± 30.31	6,848.44 ± 510
		2.9	416.26 ± 33.10	6,353.42 ± 505
		2.6	541.46 ± 17.15	7,409.49 ± 234
	17	3.2	367.82 ± 16.88	6,923.66 ± 317
		2.9	407.19 ± 37.46	6,946.14 ± 638
		2.6	490.83 ± 22.57	7,506.88 ± 345
Sex:				
Male			451.02 ± 58.71^{A}	7,207.30 ± 345.98^{A}
Female			425.71 ± 72.83^{B}	6,788.70 ± 583.43^{B}
P-value:				
CP			0.0003	0.0596
ME			0.0001	0.0085
CP × ME			0.1105	0.2031
Sex			0.0037	0.0032
SEM			10.82	94.46

$^{A-B,\ m-n,\ x-y-z}$ Values with no common superscript differ significantly (P < 0.05) when tested with Duncan's new multiple range test following analysis of variance.

SEM = standard error of the mean

Carcass composition

Carcass composition as a percentage of hot carcass is shown in **Table 4**. No significant interactions were found between the dietary CP and ME levels. Dietary CP level did not have significant effect (P > 0.05) on all parameters, but different dietary ME level affected live weight and carcass composition. Even though decreasing dietary ME level from 3.2 to 2.9 kcal ME/g did not show significant effect except on the whole intestine, but further decreasing to 2.6 kcal ME/g caused significantly lower live weight, carcass percentage, breast and abdominal fat. In contrast, the groups fed the lowest ME diet gave significantly higher percentage of liver, gizzard and whole intestine than the higher ME diets.

Table 4 Effects of dietary CP and ME levels on carcass composition of crossbred native chicken (Pradu Hang Dam × JA 57 Ki) during 6-10 weeks of age

Variables	Items										
	Live weight[1/] (kg/bird)	Carcass (%)	Carcass composition (% on hot carcass)								
			Breast	Thigh[2/]	Drumstick[3/]	Wing	Liver	Gizzard	Heart	Whole intestine	Abdominal fat
***Mean of main effect:* Level of CP in diet** (%)											
19	1.12±0.15	69.94±2.09	18.59±0.74	18.59±0.20	16.19±0.55	15.17±0.36	3.25±0.41	5.16±3.37	0.72±0.09	7.58±1.45	1.91±0.52
17	1.11±0.13	70.74±1.32	18.41±0.61	18.41±0.68	19.34±0.65	15.1±0.39	3.17±0.62	5.04±3.23	0.66±0.14	7.46±1.55	1.79±0.74
Level of ME in diet (kcal/g)											
3.2	1.14±0.12^{x}	70.55±1.16^{x}	18.74±0.48^{x}	18.03±0.60	16.16±0.45	14.98±0.46	3.10±0.62^{y}	5.00±0.22^{y}	0.64±0.16	7.50±1.14^{y}	2.01±0.17^{x}
2.9	1.16±0.17^{x}	71.39±0.65^{x}	18.92±0.59^{x}	18.34±0.56	16.17±0.93	15.18±0.41	3.06±0.30^{y}	4.53±0.27^{y}	0.70±0.12	6.60±0.92^{z}	2.29±0.63^{x}
2.6	1.05±0.12^{y}	69.08±2.32^{y}	17.85±0.03^{y}	17.93±0.29	16.47±0.32	15.24±0.20	3.46±0.56^{x}	5.77±0.52^{x}	0.74±0.02	8.45±1.75^{x}	1.25±0.43^{y}
CP × ME											
19 3.2	1.16±0.14	70.17±1.49	18.50±0.27	17.99±1.03	16.30±0.87	15.18±0.62	3.40±0.66	5.15±0.73	0.69±0.13	7.71±1.31	2.13±0.74
2.9	1.16±0.13	71.43±1.99	19.43±0.21	18.07±0.87	15.90±0.91	15.00±0.91	3.12±0.51	4.43±0.39	0.73±0.16	6.67±1.31	2.28±0.78
2.6	1.03±0.15	68.23±4.52	17.83±0.58	17.93±0.96	16.37±0.90	15.34±1.00	3.23±0.84	5.90±1.08	0.74±0.09	8.36±2.19	1.31±1.45
17 3.2	1.11±0.14	70.93±1.86	18.97±0.84	18.08±1.17	16.02±0.65	14.77±0.88	3.23±0.84	4.86±1.05	0.58±0.29	7.30±1.67	1.88±0.83
2.9	1.16±0.20	71.34±1.21	18.40±0.27	18.62±0.99	16.43±1.18	15.37±1.25	2.80±1.01	4.63±0.80	0.66±0.10	6.53±1.26	2.30±1.25
2.6	1.08±0.14	69.94±2.54	17.86±0.42	17.92±0.96	16.56±0.83	15.14±0.59	3.01±0.32	5.65±0.90	0.74±0.12	8.54±2.33	1.18±1.37
Sex:											
Male	1.23±0.08^{A}	71.41±0.66^{A}	18.57±0.72	18.40±0.48^{A}	16.68±0.44^{A}	14.92±0.38^{B}	2.85±0.35^{B}	4.91±0.47	0.63±0.12^{B}	6.43±0.52^{B}	1.83±0.80
Female	1.00±0.05^{B}	69.27±1.82^{B}	18.43±0.63	17.80±0.28^{B}	15.85±0.38^{B}	15.35±0.16^{A}	3.57±0.34^{A}	5.30±0.74	0.76±0.06^{A}	8.61±1.19^{A}	1.86±0.44
P-value:											
CP	0.8945	0.1420	0.1278	0.0567	0.4472	0.7066	0.6003	0.5628	0.0900	0.6939	0.3642
ME	0.0009	0.0030	0.0001	0.0004	0.3241	0.5424	0.0539	0.0001	0.0713	0.0001	0.0093
CP × ME	0.1634	0.4019	0.1001	0.5555	0.2156	0.2752	0.1147	0.5353	0.5121	0.7426	0.9973
Sex	0.0001	0.0002	0.2207	0.0100	0.0001	0.0378	0.0001	0.0525	0.0004	0.0001	0.8947
SEM	0.02	0.31	0.09	0.11	0.11	1.82	0.09	0.12	0.20	0.22	0.15

$^{A-B,\ x-y-z}$ Values with no common superscript differ significantly ($P < 0.05$) when tested with Duncan's new multiple range test following analysis of variance

[1/] Averaged from 6 birds/group

[2/, 3/] Meat including skin and bone of both legs

ME = metabolizable energy; CP = crude protein; SEM = standard error of the mean

Sexual effects

Male showed significantly (P < 0.05) better performances than female in nearly all parameters, i.e. higher BWG, ADG, FI, FCR and FCG as shown in **Table 5**. The higher FI of male than female caused significantly higher CP and ME intake as shown in **Table 3**. In the case of carcass quality, male had significantly higher percentage of carcass, thigh and drumstick but lower percentage of wing, liver, heart and whole intestine (**Table 4**). No significant difference between the 2 sexes was noticed on breast, gizzard and abdominal fat.

Table 5 Sexual effects on performance of crossbred native chicken (Pradu Hang Dam × Hubbard JA 57 Ki) fed diets containing varying levels of CP and ME during 6–10 weeks of age

Treatment No.	1	2	3	4	5	6	***Mean of sex***
Level of CP in diet (%)	19	19	19	17	17	17	
Level of ME in diet (kcal/g)	3.2	2.9	2.6	3.2	2.9	2.6	
Initial BW (kg/bird)							
Male	0.46±0.03	0.47±0.03	0.48±0.01	0.48±0.01	0.45±0.03	0.44±0.01	0.46±0.09
Female	0.43±0.02	0.42±0.03	0.44±0.02	0.43±0.04	0.44±0.03	0.42±0.04	0.44±0.05
Mean of Tr	0.45±0.03	0.45±0.04	0.46±0.03	0.46±0.04	0.44±0.03	0.43±0.03	
BWG (kg/bird)							
Male	0.84±0.04	0.77±0.04	0.62±0.06	0.70±0.03	0.81±0.05	0.67±0.03	0.74±0.09^{A}
Female	0.65±0.03	0.69±0.04	0.52±0.09	0.63±0.04	0.52±0.04	0.52±0.02	0.57±0.06^{B}
Mean of Tr	0.74±0.11	0.69±0.10	0.60±0.09	0.66±0.05	0.67±0.17	0.56±0.09	
ADG (g/bird)							
Male	23.96±1.16	22.10±1.17	17.64±1.62	20.04±0.98	23.25±1.39	19.19±0.98	21.03±2.47^{A}
Female	18.55±0.77	17.06±1.05	14.89±2.16	17.95±1.05	14.86±1.08	14.85±0.71	16.36±1.70^{B}
Mean of Tr	21.25±3.09	19.58±2.93	16.26±2.46	18.99±1.46	19.06±4.73	17.02±2.50	
FI (kg/bird)							
Male	2.22±0.15	2.32±0.16	2.81±0.09	2.17±0.14	2.58±0.01	2.94±0.11	2.51±0.32^{A}
Female	2.06±0.15	2.06±0.03	2.89±0.10	2.16±0.07	2.21±0.12	2.83±0.15	2.37±0.39^{B}
Mean of Tr	2.14±0.16	2.19±0.17	2.85±0.09	2.16±0.10	2.40±0.22	2.89±0.13	
FCR							
Male	2.65±0.12	3.00±0.06	4.58±0.39	3.09±0.05	3.18±0.18	4.39±0.37	3.48±0.80^{B}
Female	3.18±0.32	3.46±0.19	5.63±0.81	3.45±0.30	4.25±0.22	5.46±0.36	4.24±1.08^{A}
Mean of Tr	3.05±0.05	3.35±0.18	4.68±0.11	3.37±0.12	3.53±0.07	4.23±0.09	
FCG (THB/kg BWG)							
Male	33.36±1.57	36.95±0.74	54.50±4.60	38.09±0.66	37.81±2.13	50.48±4.22	46.86±8.50^{B}
Female	40.07±4.02	42.61±2.31	67.03±9.69	42.41±3.67	50.48±2.60	62.68±4.11	50.88±11.46^{A}
Mean of Tr	36.72±4.58	39.78±3.46	60.76±9.65	40.25±3.34	44.14±7.26	56.58±7.65	

$^{A-B}$ Values with no common superscript differ significantly (P < 0.05) when tested with Duncan's new multiple range test following analysis of variance

BW = body weight; BWG = body weight gain; ADG = average daily gain; FI = feed intake; FCR = feed conversion ratio; FCG= feed cost per gain; Mean of Tr = Mean of the treatments

Discussion

The lower dietary CP level from 19% to 17%, averaged from all 3 ME levels, in the present experiment did not show significant effect on any production performances (**Table 2**). It might be due to the level of methionine and lysine which are considered as the first and second limiting amino acids for chicken as well as the other nutrients in both CP levels were sufficient for the requirement of chicken in this age (**Table 1**). This result agreed with Sompie et al. (2015) who investigated 2 CP (18 vs 20%) and 3 ME levels (2,800 vs 3,000, vs 3,200 kcal ME/kg) being fed to native chicken for 60 days of age. They found no interactions between dietary energy and protein level. In addition, there were no significant differences ($P > 0.05$) of dietary CP levels on any parameters measured, whereas different dietary ME level has significant ($P < 0.05$) influence on feed efficiency. Phaitong (2017) also found no significant differences on BWG, FI, FCR, and mortality rate of Black bone chicken fed diet containing 17% or 19% CP during 6-10 weeks of age.

On the contrary, decreasing dietary energy from 3.2 or 2.9 to 2.6 kcal ME/g significantly decreased BWG and ADG even though the birds consumed more feed, thus had higher CP and ME intake. This result might be due to the lower ME diet had lower nutritive quality as being noticed by the lower percentage of FFSB and meat meal (**Table 1**). In addition, the lower ME diet also contained high fiber ingredient such as rice bran which inhibited digestibility and utilization efficiency of feed. The effect of high dietary CF on digestibility and performances was shown by Ginindza et al. (2016) who fed slow-growing indigenous Venda chickens of Indonesia with isocaloric and isonitrogenous diets containing different CF levels (2-8%). They found that 3.4%, 4.0% and 3.0% CF in starter period optimized growth rate, FCR, and live weight of the unsexed chickens. Dietary CF at 6.5%, 4.3%, 3.2%, and 4.4% in finishing period optimized FI, growth rate, nitrogen retention, and live weight of male chickens, respectively. The higher dietary CF levels caused low FI, poor FCR and nutrient digestibility ($P < 0.05$). Their results also indicated that different CF levels optimized production parameters, and dietary CF levels for optimal productivity increased as chickens grew older.

In the present experiment, the higher FI of the groups fed lower ME diets was due to the fact that chicken try to consume more diet in order to meet their energy requirement. This result agreed with Tangtaweewipat et al. (2000) who found that crossbred Thai native chicken fed with lower ME diet during 1-13 weeks of age consumed more feed than the groups fed higher ME diet. In addition, the higher FI of the lower ME diet (2.6 and 2.9 kcal ME/g) in the present experiment caused worse FCR and higher FCG as compared to the 3.2 kcal ME/g diet. This result is partially agreed with Araújo et al. (2005) who evaluated the performance and carcass yield of broilers at 55 days of age fed diets with different levels of energy (3,200 to 3,400 and 3,600 kcal ME/kg) and lysine (0.95%; 1.05% and 1.15%). They found that increasing levels of dietary ME improved BWG and FCR, while overall performance was not affected by lysine levels. In addition, Rajpura et al. (2010) investigated the effect of varying levels of energy and protein on the performance of colored crossbred broilers. They found that crossbreds fed the diet containing high energy (2,900 kcal ME/kg), irrespective of protein content had the highest body weight, weight gain and better FCR. On the contrary, the group fed 2,400 kcal ME/kg diet with 16% protein had the lowest body weight, weight gain and poor FCR.

No significant influence of ME level between 3.2 and 2.9 kcal/g on most of the carcass compositions of this experiment, except the percentage of whole intestine which is lower in the groups fed 2.9 kcal ME/g. The result indicated that ME level at 2.9 kcal/g is sufficient for the chicken at this age. It is similar to Phaitong (2017) who found no significant difference on dressing percentage and carcass composition between Royal Project Black bone chicken at 16 weeks of age fed with diets containing 3.2 vs 2.9 kcal ME/g. However, these 2 high levels of dietary ME in the present study significantly gave higher percentage of carcass and breast meat than the 2.6 kcal ME/g diet. This result agreed with Van Nguyen et al. (2010) who found dietary energy contents of 3,000 and 3,200 kcal ME/kg did not alter the growth performance of Betong chicks, while higher energy (3,200 kcal ME/kg) increased abdominal fat yield from 0.39% to 0.57% ($P < 0.05$). In their conclusion, protein levels in the diets at 19% CP and energy contents between 3,000-3,200 kcal ME/kg were appropriated for growth performance and carcass quality. The significantly heavier gizzard (% on hot carcass weight) of the group fed the lowest ME diet (2.6 kcal/g) in this present experiment might be due to the increasing of necessary muscle for digesting more fiber. Widjastuti et al. (2019) also found significant higher gizzard weight and intestinal length with lower carcass weight of native Indonesian chicken breed fed diets containing 10 and 12% compared to those fed 6-8% CF during 2–12 WOA. They stated that if the rough fiber in the ration is too high it will caused the gizzard, which serves to grind feed ingredients into small particles, to work harder which in turns the gizzard thicken and enlarged. In addition the high CF diet also caused the ration rate in the digestive tract to be slow, resulted in increasing the length of the intestine.

In the case of sexual effects, the significant production performances of male comparing to female chicken found in the present experiment should be due to the effect of androgens, such as testosterone which promote protein synthesis and thus the growth of tissues as well as stimulate the development, growth, and activity of reproductive parts (IML, 2021).

The higher FI of male is also the main factor in causing the higher CP and ME intake (**Table 3**), thus led to the higher BWG with better FCR and FCG (**Table 2**). The result agreed with many researchers such as Tananchai et al. (2001) who found that the growth rate of male was faster than female. Tangtaweewipat et al. (2000) also reported that male crossbred native chicken gained higher BW, consumed more feed and had better FCR in all experimental dietary groups. In addition, Benyi et al. (2015), who study the effects of genotype and sex on growth performance and carcass characteristics of broiler chickens, found that male broilers consumed more feed, utilized the feed more efficiently, gained more BW, and were heavier than females at all stages of growth (1-49 days of age). Phaitong (2017) investigated the optimum CP and ME levels in Royal Project Black bone chicken during growing period and found that male had higher BW with higher percentage of heart and drumstick meat than female, while female had higher percentage of visceral organ, abdominal fat, gizzard, breast meat and fillet. However, no significant difference in abdominal fat between sexes in the present experiment was noticed. The result is in contrast with many researchers, such as Tangtaweewipat et al. (2000) who found the significant higher percentage of abdominal fat in female than male chicken. The reason might be due to the slaughter age of the chicken in this experiment at only 10 weeks of age which is too early for puberty age of this crossbred chicken to show the effect of female sex hormone on fat accumulation.

Conclusion

No significant effect of dietary CP level (19% vs 17%) was noticed on any production performances and carcass quality in this study. On the contrary, the higher ME diets gave significantly better production performances on all parameters including FCG than the lower ME diets. In addition, the higher energy diets (3.2 vs 2.6 kcal ME/g) gave significantly higher percentage of carcass, breast meat and abdominal fat but lower percentage of liver, gizzard, and whole intestine. Male had significantly higher BWG and FI with better FCR and FCG than female chicken. The proper diet for crossbred native chicken (Pradu Hang Dam × JA 57 Ki) during 6-10 weeks of age should contain 19% CP with 3.2 kcal ME/g because it gave the highest BWG, ADG and FCR with the lowest FCG.

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