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Productive Performance of Mexican Creole Pullets and Immature Males Fed Different Levels of Metabolizable Energy and Crude Protein

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Abstract: Mexican Creole birds are a poorly researched genetic resource whose nutritional requirements are unknown. The objective was to evaluate the productive performance and nutrient use efficiency of Mexican Creole birds, using four diets with different concentrations of metabolizable energy (EM, MJ/kg) and crude protein (PC, g/kg). The experimental diets with constant ME/CP ratios equal to 0.06, were: 12.55/200, 11.92/190, 11.30/180 and 10.67/170. One hundred and ninety-two 12-week-old creole birds (96 males and 96 females) were randomly distributed amongst the diets (24 males and 24 females each). Due to the diet × sex interaction, males fed the 10.67/170 diet had higher feed intake, and males under 10.67/170, 11.92/190 and 11.30/180 had higher final body weight and weight gain than the other birds. Feed conversion ratio was lower in birds with diets 12.55/200 and 11.92/190. Total body fat retention was higher in females with the diet 12.55/200, 11.92/190 and 11.30/180. In conclusion, males with the 10.67/170 (lowest ME and CP) diet showed a high productive performance, without compromising carcase yield and body composition, while females with all diets did not show differences in productive performance, carcass yield and body composition.

Keywords: Mexican Creole birds; metabolizable energy; crude protein; feed efficiency; carcass yield; abdominal fat; digestive organ size; nutrient utilization efficiency

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1. Introduction

Creole chickens (*Gallus gallus domesticus*) of Mexico (CCMX) are birds with a lower growth rate compared to industrial broilers [1]. Despite having a lower growth rate, they are still an important source of animal protein for families in rural areas [1,2]. Thus, to increase their productivity, additional information on the nutritional requirements is needed to efficiently utilise their genetic potential [3].

The ingredients most commonly used for poultry feed (corn and soybean meal) are expensive [4] and difficult to acquire in rural regions of Mexico [5], and they represent approximately 90% of the total cost of poultry feed [6]. Slow-growing breeds like CCMX do not appear to require similar concentrations of metabolizable energy (ME) and crude protein (CP) as demanded by commercial broilers [7]. However, despite the National Research Council [8] recommends ME and CP levels for broilers, there are no reports of requirements for slow-growing breeds, such as CCMX.

Matus-Aragón et al. [9], showed that a diet with 10.67 MJ ME/kg and 170 g CP/kg offered from birth to 12 weeks of age, was sufficient to satisfy the ME and CP requirements of CCMX. However, the ME and CP requirements of CCMX from 13 to 20 weeks of age are unknown. We hypothesized that diets with less than 12.55 MJ ME/kg and 200 g/kg CP with a constant ratio of 0.06 (MJ ME/g CP) maintain or improve the productive performance of CCMX, at the indicated ages. The aim of this research was to study Mexican Creole pullets and immature males from 13 to 20 weeks of age. Four diets with different concentrations of ME and CP were used, all with a constant ME/CP ratio of 0.06 MJ/g. The response variables were productive performance, carcass yield, relative measures of digestive organs, whole body composition and nutrient retention efficiency.

2. Materials and Methods

2.1. Period and Place

The experiment was carried out from October to December 2019, in an open poultry house of natural environment at the experimental unit of the Postgraduate College, Campus Montecillo, located in Texcoco, State of Mexico, Mexico, coordinates 19°29′ N, 98°54′ W, altitude of 2247 m and average temperature of 16 °C.

2.2. Birds and Management

One hundred and ninety-two 12-weeks-old Mexican Creole immature birds (96 males and 96 females) were randomly assigned to four experimental diets. Each diet was evaluated with 48 birds (24 males and 24 females). Birds were housed individually in metal cages with dimensions of 60 × 60 × 60 cm, with a bed of wood shavings. A 16 h light:8 h dark illumination regime was provided and an average room temperature was maintained at 23 °C. Water and feed were provided ad libitum throughout the experimental period. Birds were handled following the regulations established by the Animal Welfare Committee of the Postgraduate College, Montecillo Campus, State of Mexico, Mexico. The experiment was carried out with the methodology previously reported by Matus-Aragón et al. [9] and described in detail next.

2.3. Experimental Diets

The ingredients used for diet formulation were analysed in triplicate with a near infrared equipment (NIRS™ from Foss model DS2500, Hillerød, Denmark). Four diets with different concentrations of ME and CP were used, maintaining a constant ME/CP ratio of 0.06: 12.55/200, 11.92/190, 11.30/180 and 10.67/170 MJ/g. Diets were supplemented with essential amino acids, calcium and phosphorus to meet the NRC [8] recommendations for broilers (Table 1).

Table 1. Composition (%) of the experimental diets.

Ingredients (g/kg)	ME [1]/CP [2] Concentrations of Diets			
	12.55/200	11.92/190	11.30/180	10.67/170
Maize	556.82	567.43	521.19	495.13
Soybean meal	240.37	198.27	148.99	141.54
Yellow corn DDGS [3]	60.00	60.00	60.00	57.01
Canola meal	60.00	60.00	60.00	57.01
Soybean oil	29.44	10.01	5.02	4.76
Wheat bran	20.00	68.94	167.36	158.98
Calcium carbonate	13.17	13.28	13.32	12.64
Dicalcium phosphate	9.10	9.13	9.07	8.61
Mineral-vitamin premix [4]	5.02	5.02	5.02	4.76
Sodium chloride	3.07	2.63	2.11	2.00
DL-Methionine	1.17	1.39	1.65	1.57
L-Lysine	0.69	1.73	2.88	2.74
Sodium bicarbonate	0.63	1.22	1.92	1.84
L-Threonine	0.52	0.95	1.47	1.41
Oat straw [5]	0.000	0.000	0.000	50.00

Table 1. *Cont.*

Ingredients (g/kg)	ME [1]/CP [2] Concentrations of Diets			
	12.55/200	**11.92/190**	**11.30/180**	**10.67/170**
Calculated nutrient composition (g/kg)				
Metabolizable energy (MJ/kg)	12.55	11.92	11.30	10.67
Crude protein	200	190	180	170
Energy: protein ratio	0.06	0.06	0.06	0.06
Dry matter	888	886	886	888
Crude fiber	32	37	45	62
Calcium	10	10	10	11
Available phosphorus	4.5	4.5	4.5	4.4
Lysine	10.8	10.5	10.5	10.5
Methionine	4.7	4.0	4.0	4.1
Methionine + Cystine	8.0	8.2	8.0	8.0
Threonine	7.5	7.8	7.5	7.5
Tryptophan	2.8	2.8	2.8	1.9

[1] ME = metabolizable energy; [2] CP = crude protein; [3] DDGS = dried distillery grains with solubles; [4] provided the following per kilogram of diet: vitamin A, 12,000 UI; vitamin D3, 1000 UI; vitamin E, 60 UI; vitamin K, 5.0 mg; vitamin B_2, 8.0 mg; vitamin B_{12}, 0.030 mg; pantothenic acid, 15 mg; niacin, 50 mg; folic acid, 1.5 mg; choline, 300 mg; biotin, 0.150 mg; thiamine, 3.0 mg. Fe, 50.0 mg; Zn, 110 mg; Mn, 100 mg; Cu, 12.0 mg; Se, 0.3 mg; I, 1.0 mg. [5] Oat straw was used as an inert filler in diet.

2.4. Productive Performance

The productive performance variables were calculated each week: feed intake (FI; g/bird), body weight gain (BWG; g/bird) and feed conversion ratio (FCR; g/g). At the end of the experimental period, the final body weight (FBW; g) of each bird was determined.

2.5. Carcass Yield

Body weight, carcass weight and yield were determined according to Van Harn et al. [10]. At 20 weeks of age, sixteen birds (eight females and eight males) per diet were randomly selected and slaughtered according to the Official Mexican Standard NOM-033-SAG/ZOO-2014 [11]. Birds were slaughtered with a stunning knife (model VS-200, input power 120 V–1 A, output power 50 V–0.1 A, Midwest Processing Systems, Minneapolis, MN, USA.) followed by the bleeding.

2.6. Digestive Organs and Abdominal Fat

The following variables were recorded in the slaughtered birds, according to Mera-Zúñiga et al. [12]: relative empty weight of crop, proventriculus, gizzard, small intestine and cecum; relative weights of liver, pancreas and abdominal fat, and relative length of the small intestine and cecum. The relative variables were expressed as percentage of body weight.

2.7. Whole Body Composition

In addition, the following variables were determined: whole body composition (moisture, dry matter [DM], CP, fat, ash and gross energy [GE]); nutrient retention (CP, fat and GE); retention efficiency of GE and CP; and excretion of N, following the methodology described by Aletor et al. [13] and Kamran et al. [14].

2.8. Nutrient Utilisation

For determining nutrient utilisation, sixteen birds of 20-week of age were randomly selected and slaughtered after 12 h of fasting. Immediately, they were desensitized with a stunning knife and cervically dislocated to avoid blood loss. The whole body of the birds was frozen at −20 °C. Subsequently, the bodies were thawed and placed in an autoclave for 5 h at 110 °C and a pressure of 1 atm. Finally, each body was individually placed in a blender for 10 min and 400 g of this product was lyophilized for the compositional analysis in order to estimate nutrient retention values as well as GE and CP retention efficiency. All compositional analyses were performed in triplicate, according to the AOAC [15]. The gross energy or heat of combustion was determined using an isoperibol calorimeter (No. 1266, Parr instruments, Moline, IL, USA). All the analyses described above were also performed in sixteen 12-weeks old birds to determine the initial whole body chemical composition.

The nutrient retentions were calculated as follows:

Crude protein retention

$$\text{CP retention (g)} = \text{CP}_{\text{wbb\_20weeks\_age}} - \text{CP}_{\text{wbb\_12weeks\_age}}$$

Fat retention

$$\text{Fat retention (g)} = \text{Fat}_{\text{wbb\_20weeks\_age}} - \text{Fat}_{\text{wbb\_12weeks\_age}}$$

GE retention

$$\text{GE retention (kcal)} = \text{GE}_{\text{wbb\_20\_weeks\_age}} - \text{GE}_{\text{wbb\_12\_weeks\_age}}$$

were wbb stands for whole body of the bird.

The retention efficiency for GE and CP were calculated using the following formula:

$$\text{GE retention efficiency (\%)} = \frac{\text{GE retention (kcal)}}{\text{GE consumption (kcal)}} \times 100$$

$$\text{CP retention efficiency (\%)} = \frac{\text{CP retention (g)}}{\text{CP consumption (g)}} \times 100$$

The nitrogen excretion was calculated as follows:

$$\text{N excretion (g)} = \text{N}_{\text{intake from 13 to 20 weeks}} - \text{N}_{\text{retention}}$$

where:

$$\text{N retention (g)} = \text{N}_{\text{wbb\_20weeks\_age}} - \text{N}_{\text{wbb\_12weeks\_age}}$$

2.9. Statistical Analysis

All variables were analysed using PROC GLIMMIX in SAS® (SAS version 9.4, SAS Institute, Cary, NC, USA [16]) using a repeated measures model with a 4 × 2 factorial arrangement (diet × sex), considering each bird as an experimental unit. The covariance structure that better fit the data was an AR (1). The Kenward-Roger [17] adjustment was used to correct the error degrees of freedom for the presence of multiple random effects in the model. Pairwise comparisons of means were conducted using the LSD method at the 5% significance level.

3. Results

3.1. Productive Performance

The FCR was significantly lower with 12.55/200 and 11.92/190, than with the other diets (Table 2). The diet × sex interactions were significant on FI, final body weight (FBW) and BWG. Male birds that received the diet 10.67/170 were those that consumed more feed, followed by males under the diets 11.30/180 and 11.92/190 (Figure 1A). In most diets, male birds were heavier than females. Both FBW and BWG were significantly higher in males under the diets 10.67/170, 11.30/180. No significant differences were found between male and female birds fed the diets 12.55/200 and 10.67/170 (Figure 1B,C).

Table 2. Cumulative productive performance of Mexican Creole pullets and immature males from 13 to 20 weeks of age fed diets with different concentrations of ME and CP.

Variable	Diet of [1] ME/ [2] CP				SEM	Sex		SEM	*p*-Value		
	12.55/200	**11.92/190**	**11.30/180**	**10.67/170**		**Female**	**Male**		**Diet**	**Sex**	**Diet × Sex**
Initial body weight (g/bird)	1172.8	1172.0	1193.7	1167.6	29.8	1167.0	1186.1	22.3	0.4972	0.5198	0.1211
Feed intake (g/bird)	5262.7	5400.9	5744.7	6085.7	155.1	5124.8	6122.1	149.7	<0.0001	<0.0001	<0.0001
Final body weight (g/bird)	1896.9	1925.5	1943.1	1924.8	29.8	1868.7	1976.5	24.1	0.4972	0.0001	0.0037
Body weight gain (g/bird)	724.1	753.5	749.4	757.2	24.3	701.7	790.4	22.8	0.6899	0.0067	0.0005
Feed conversion ratio (g/g)	7.31^{b}	7.38^{b}	8.07^{a}	8.21^{a}	0.26	7.56	7.92	0.25	0.0002	0.1973	0.6406

[ab] Means with different superscripts within each row indicate differences ($p < 0.05$). [1] ME = metabolisable energy (MJ/kg); [2] CP = crude protein (g/kg); SEM = standard error of the mean.

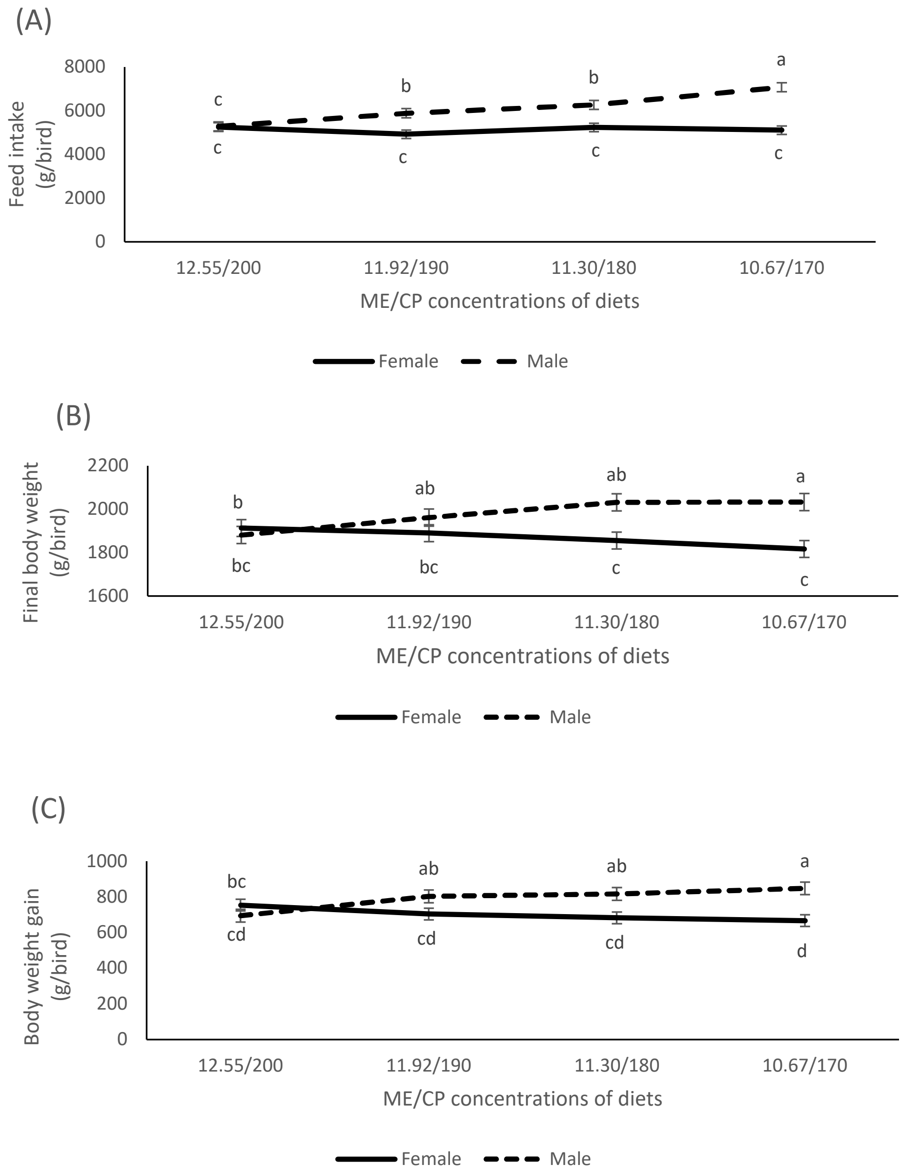

Figure 1. Diet × sex interaction of the cumulative productive performance of Mexican Creole chickens from 13 to 20 weeks of age: (**A**) feed intake, (**B**) final body weight and (**C**) body weight gain. ME = metabolisable energy (MJ/kg); CP = crude protein (g/kg). [abcd] Means with different superscripts indicate differences ($p < 0.05$).

3.2. Carcass Yield

The diet had a significant effect only on leg yield (Table 3). Differences were observed between sexes on all variables. Leg yield was higher with the 11.92/190 diet compared to 11.30/180 and 10.67/170, in contrast, that variable was not different between 12.55/200 and 11.92/190 diets. In general, males presented higher weight and yield than females, while the yields of breast, thigh and wings, were higher in females.

Table 3. Carcase yield of 20-week-old Mexican Creole pullets and immature males fed diets with different concentrations of ME and CP.

Variable	Diet of [1] ME/ [2] CP				SEM	Sex		SEM	*p*-Value		
	12.55/200	**11.92/190**	**11.30/180**	**10.67/170**		**Female**	**Male**		**Diet**	**Sex**	**Diet × Sex**
Carcase weight (g)	1136.37	12,226.12	1232.56	1247.44	52.84	872.72 [b]	1548.53 [a]	37.36	0.4450	<0.0001	0.0988
Carcase yield (%)	62.66	64.43	65.15	65.05	1.48	56.90 [b]	71.74 [a]	1.05	0.6151	<0.0001	0.9346
Breast weight (g)	274.06	297.44	313.19	295.19	14.31	237.91 [b]	352.03 [a]	10.12	0.2980	<0.0001	0.2664
Breast yield (%)	24.71	25.40	26.27	24.27	0.71	27.64 [a]	22.68 [b]	0.50	0.2278	<0.0001	0.4511
Leg weight (g)	188.31	213.12	194.81	196.25	10.64	132.19 [b]	264.06 [a]	7.52	0.4057	<0.0001	0.2608
Leg yield (%)	16.45 [ab]	17.25 [a]	15.49 [bc]	15.35 [c]	0.37	15.29 [b]	16.98 [a]	0.26	0.0018	<0.0001	0.3587
Thigh weight (g)	194.44	203.87	206.00	214.69	10.05	155.47 [b]	254.03 [a]	7.11	0.5657	<0.0001	0.1541
Thigh yield (%)	17.34	17.00	16.89	17.33	0.45	17.87 [a]	16.41 [b]	0.32	0.8559	0.0024	0.7537
Wings weight (g)	137.37	147.37	143.69	158.44	5.88	118.06 [b]	175.37 [a]	4.16	0.0937	<0.0001	0.1828
Wings yield (%)	12.40	12.44	12.22	13.04	0.27	13.69 [a]	11.36 [b]	0.19	0.1570	<0.0001	0.2789

[abc] Means with different superscripts within each row indicate differences ($p < 0.05$). [1] ME = metabolisable energy (MJ/kg); [2] CP = crude protein (g/kg); SEM = standard error of the means.

3.3. Digestive Organs and Abdominal Fat

Table 4 shows the relative measures for digestive system organs and abdominal fat. Relative weight and relative length of organs were influenced by the sex of the bird. Females showed greater empty weight of proventriculus, small intestine, caeca, liver relative weight and relative lengths of small intestine and caeca than males. The diet × sex interaction was significant for the relative weight of abdominal fat. This variable was higher in females under diet 12.55/200, followed by the other experimental diets (Figure 2).

Table 4. Relative measures (weight and length) of digestive organs and abdominal fat of Mexican Creole pullets and immature males of 20 weeks of age fed diets with different concentrations of ME and CP.

Variable	Diet of [1] ME/ [2] CP				SEM	Sex		SEM	*p*-Value		
	12.55/200	**11.92/190**	**11.30/180**	**10.67/170**		**Female**	**Male**		**Diet**	**Sex**	**Diet × Sex**
Relative empty weight (g/kg body weight)											
Crop	4.19	3.41	3.45	3.57	0.43	3.63	3.68	0.30	0.5412	0.9018	0.3147
Proventriculus	3.39	3.89	3.45	3.46	0.20	3.85 [a]	3.25 [b]	0.14	0.3017	0.0050	0.4363
Gizzard	15.82	16.76	17.59	18.65	1.02	17.46	16.95	0.72	0.2588	0.6181	0.3042
Small intestine	15.57	16.84	17.00	14.73	0.78	18.51 [a]	13.56 [b]	0.55	0.1385	<0.0001	0.1143
Caeca	2.79	3.37	2.76	3.42	0.23	3.65 [a]	2.51 [b]	0.16	0.0787	<0.0001	0.3840
Relative weight (g/kg body weight)											
Liver	22.31	22.24	21.96	20.55	0.93	23.58 [a]	19.96 [b]	0.66	0.5095	0.0003	0.3560
Pancreas	1.96	1.86	1.90	2.08	0.14	2.02	1.88	0.10	0.7328	0.3460	0.7606
Abdominal fat	23.99	13.92	9.22	11.87	3.18	27.71	1.79	2.25	0.0110	<0.0001	0.0097
Relative length (cm/kg body weight)											
Small intestine	76.81	75.34	75.31	72.06	2.00	83.04 [a]	66.72 [b]	1.42	0.4008	<0.0001	0.1807
Caeca	7.56	8.11	7.74	7.89	0.25	8.81 [a]	6.84 [b]	0.18	0.4782	<0.0001	0.0706

[ab] Means with different superscripts within each row indicate differences ($p < 0.05$). [1] ME = metabolisable energy (MJ/kg); [2] CP = crude protein (g/kg); SEM = standard error of the means.

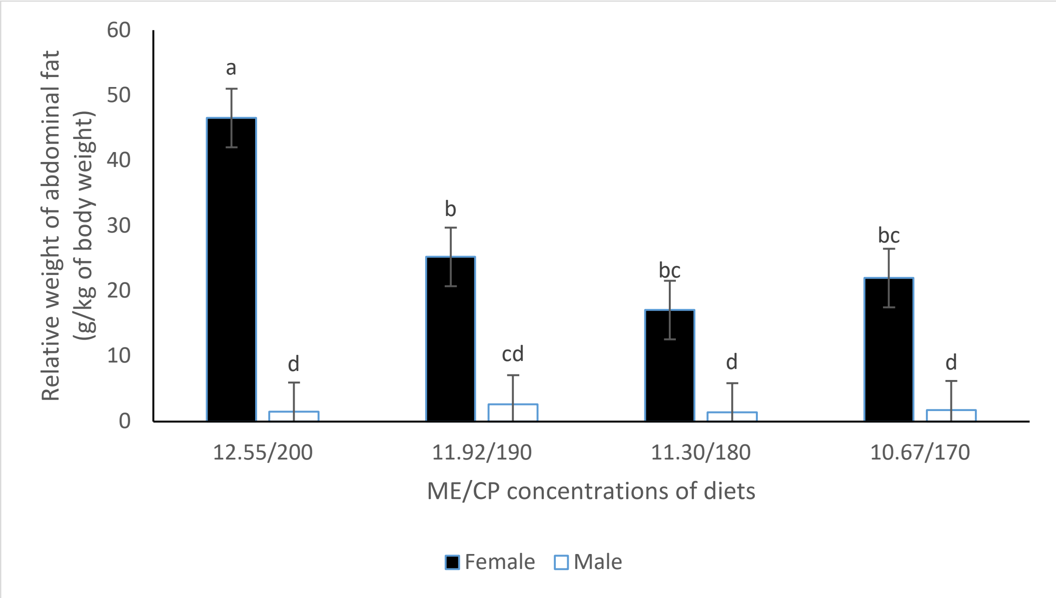

Figure 2. Diet × sex interaction for relative weight of abdominal fat (g/kg of body weight) in Mexican Creole chickens of 20 weeks of age. ME = metabolisable energy (MJ/kg); PC = crude protein (g/kg). [abcd] Means with different superscripts indicate differences ($p < 0.05$).

3.4. Whole Body Composition

Diet did not influence the whole body chemical composition of birds (Table 5); however, sex had a significant effect on moisture, DM, fat, ash and GE. Compared to the opposite sex birds, females showed higher mean values of DM, fat and GE while males showed only higher values of moisture and ash.

Table 5. Whole-body chemical composition of Mexican Creole pullets and immature males of 20 weeks of age fed diets with different concentrations of ME and CP.

Variable	Diet of [1] ME/ [2] CP				SEM	Sex		SEM	*p*-Value		
	12.55/200	11.92/190	11.30/180	10.67/170		Female	Male		Diet	Sex	Diet × Sex
Moisture (g/kg)	668.21	639.22	649.59	660.96	13.97	618.62 [b]	690.38 [a]	9.87	0.4908	<0.0001	0.0794
[3] DM (g/kg)	331.79	360.78	350.41	339.04	13.97	381.38 [a]	309.62 [b]	9.87	0.4908	<0.0001	0.0794
CP (g/kg)	169.52	187.47	196.32	182.62	7.85	178.91	189.06	5.50	0.1404	0.2104	0.2390
Fat (g/kg)	26.60	24.50	20.80	21.30	2.60	34.90 [a]	11.70 [b]	1.80	0.3441	<0.0001	0.1019
Ash (g/kg)	100.52	100.46	103.22	101.82	5.73	85.04 [b]	117.97 [a]	4.05	0.9839	<0.0001	0.5188
[4] GE (MJ/kg of DM)	36.37	38.64	37.72	34.61	1.99	40.92 [a]	32.94 [b]	1.41	0.5335	0.0006	0.1226

[ab] Means with different superscripts within each row indicate differences ($p < 0.05$). [1] ME = metabolisable energy (MJ/kg); [2] CP = crude protein (g/kg); [3] DM = dry matter; [4] GE = gross energy; SEM = standard error of the mean.

3.5. Nutrient Utilisation

Diet did not affect nutrient retention or nutrient retention efficiency, while the variables GE retention, GE retention efficiency, and N excretion were affected by bird sex. Only fat retention was affected by diet × sex interaction. Females presented higher values of GE retention, GE retention efficiency and lower N excretion than males (Table 6). Females fed the 12.55/200 diet retained more fat than females on 10.67/170 and males fed all experimental diets. Female birds under diets 11.92/190 and 11.30/180 did not differ on this variable from those fed the 12.55/200 and 10.67/170. Similarly, there were no differences amongst males under all diets (Figure 3).

Table 6. Whole-body nutrient retention and retention efficiency of 20-week-old Mexican Creole pullets and immature males fed diets with different concentrations of ME and CP.

Variable	Diet of [1] ME/ [2] CP				SEM	Sex		SEM	*p*-Value		
	12.55/200	11.92/190	11.30/180	10.67/170		Female	Male		Diet	Sex	Diet × Sex
CP retention (g/bird)	61.32	69.12	71.33	56.90	12.59	67.03	62.31	8.90	0.8353	0.7115	0.1759
Fat retention (g/bird)	124.69	118.97	84.73	82.73	14.30	170.07	35.49	10.11	0.0970	<0.0001	0.0297
[3] GE retention (MJ/bird)	23.62	24.12	22.90	19.62	1.73	25.95 [a]	19.18 [b]	1.22	0.2793	0.0008	0.0681
CP retention efficiency (%)	5.31	6.24	6.65	6.00	1.31	6.72	5.38	0.92	0.9064	0.3182	0.1352
GE retention efficiency (%)	24.06	24.67	22.67	21.68	2.15	28.86 [a]	17.68 [b]	1.52	0.7593	<0.0001	0.1457
Nitrogen excretion (g/bird)	168.00	172.76	181.68	139.24	11.71	147.68 [b]	183.15 [a]	8.28	0.0914	0.0064	0.9011

[ab] Means with different superscripts within each row indicate differences ($p < 0.05$). [1] ME = metabolisable energy (MJ/kg); [2] CP = crude protein (g/kg); [3] GE = gross energy; SEM = standard error of the mean.

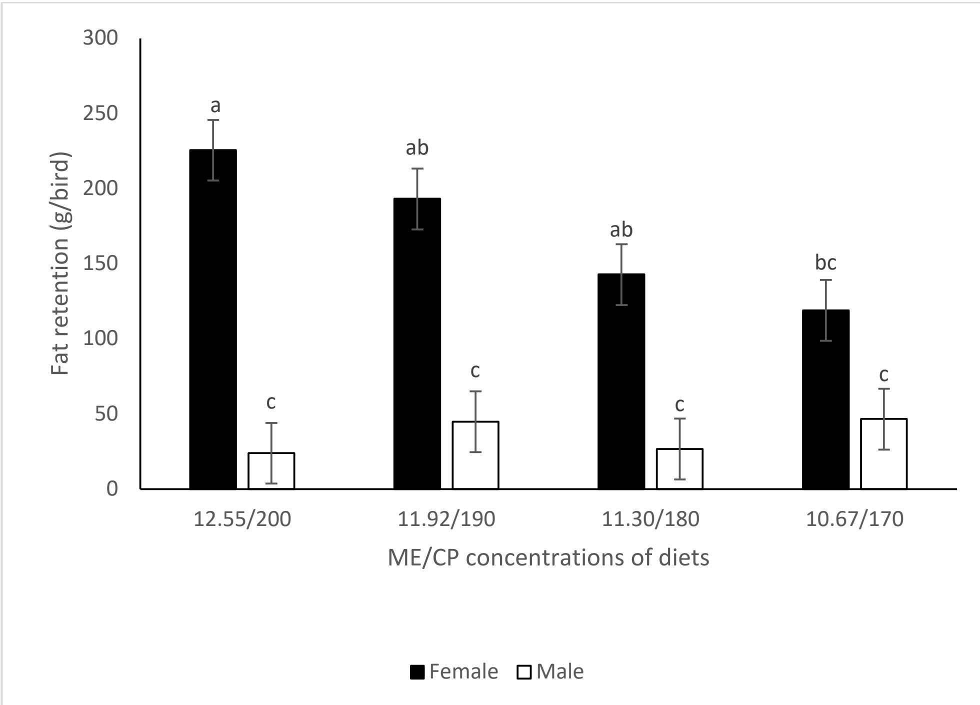

Figure 3. Diet × sex interaction in the whole body fat retention (g/chick) of 20-week-old Mexican Creole chickens. ME = metabolisable energy (MJ/kg); CP = crude protein (%). [abc] Means with different superscripts indicate differences ($p < 0.05$).

4. Discussion

The CCMX are an important genetic resource whose nutritional requirements have been little studied. The variables evaluated in this study were compared with the results of research carried out in Creole and industrial broilers. Feeding Mexican Creole birds from 13 to 20 weeks of age with diets of 12.55/200, 11.92/190, 11.30/180 and 10.67/170 (MJ/g), allowed the estimation of the ME and CP requirements in these birds.

Our findings on the bird's productive performance, agree with those previously reported by Matus-Aragón et al. [9], where feeding of birds from birth to 12 weeks of age with diets with reduced ME and CP, led to increased feed intake (FI) and feed conversion ratio (FCR). Leeson and Summers [18] and Classen [19] indicate that FI in commercial birds is regulated by their energy needs, and that FI increases when low ME diets are provided;

which could explain the differences of FI and FCR obtained in this study, however other explanations could exist as well. Birds fed the 12.55/200 diet consumed less feed; however, the consumption of ME and CP was higher by 2.51%, 1.76% and 1.71% with respect to that consumed by the birds fed the 11.92/190, 11.30/180 and 10.67/170 diets. In the period from 13 to 20 weeks of age, the final body weight (FBW) and body weight gain (BWG) were greater in males with the diets 10.67/170, 11.30/180 and 11.92/190 than in females; on the contrary, females and males receiving the diet 12.55/200 had lower body weights and BWG with respect to the males with the 10.67/170 diet. These results correlated with the findings of Lemme et al. [20] who found that high CP content diets increase the proliferation of pathogenic microorganisms and the amounts of undigested fractions in faeces, which can produce poor intestinal health, increase environmental pollution and decrease the productive performance of birds [21]. De Cesare et al. [22] found that feeding broilers with diets reduced in CP, increased the concentration of *lactobacilli* in the caeca at 42 days of age, which may improve the nutrient retention efficiency.

Regarding the carcass; while males presented higher weights and yields than females, the diet produced differences only on leg yield. This lack of differences could be explained by the constant content of essential amino acids in the experimental diets. On the contrary, Si et al. [23] and Vieira et al. [24] found that increasing amino acids such as lysine and methionine in the diets, induced a high muscular protein biosynthesis.

The relative measures of digestive organs were statistically similar amongst treatments; in contrast, the abdominal fat was 62% and 50% higher in the diet 12.55/200 compared to 11.30/180 and 10.67/170, respectively. Females had greater empty weight of proventriculous, small intestine and caeca, weight of liver and abdominal fat, as well as greater relative length of the small intestine and caeca than males. This could be due to the fact that the relative variables were obtained according to Nitsan et al. [25] as the ratio of organ weight to body weight of the bird (g/kg), and as females had lower body weight than males, higher relative weights were obtained in females.

Overall, the relative weight of abdominal fat in males was 15 times lower than in females. Baéza and Bihan-Duval [26] mention that the body fat of commercial birds increases with a high concentration of energy and CP in the diet. Furthermore, Creole birds reach sexual maturity about 22 weeks of age [27], and this fat accretion process is probably related to an oversupply of energy because the same diet was used for both males and females as well as to an increased lipogenesis of females [28,29].

The composition of the whole body of birds was not affected by the diets, probably due to the constant ratio of 0.06 between ME (MJ/kg) and CP (g/kg). With respect to birds of the opposite sex, females showed higher DM, fat and GE; in contrast, males had higher moisture and ash contents. Caldas et al. [30] found a hydrophobic effect in Cobb broilers, as CP and fat contents increase, the amount of water in the whole-body decreases. This could explain the results obtained in this study. Aletor et al. [13] found a fat concentration of 107.6 g/kg in the whole body of Lohmann male chickens (at six weeks of age), this value was greater than that found in the current investigation, which could be related with the genotype of the birds and the oversupply of energy and protein relative to their requirements. This result may indicate that the Mexican Creole birds have a lean carcass compared to commercial breeds.

High fat retention values were observed in females fed diets with high levels of ME and CP (12.55/200 diet). These high concentrations of ME and CP in the diet induce a large number of adipocytes in the abdominal region of females. This could be an evolutionary adaptation that increases fat storage capacity in females prior to reproduction [31]. Similar results were found by Marx et al. [32] and Filho et al. [33] in commercial birds, who observed more abdominal fat in female than in males. This probably explains why females showed greater retention and retention efficiency of GE than males.

Although no differences in protein retention were observed, the excretion of N was higher in males than in females, due to a higher FI. This increase in the excretion of N is influenced by the age of the birds (20 weeks of age), since the potential for protein deposition decreases with age [34]. In turn, this produces an increase in amino acid deamination and nitrogen excretion.

5. Conclusions

It is possible to feed Mexican Creole male birds from 13 to 20 weeks of age with a diet containing 10.67 MJ ME/kg and 170 g CP/kg in order to maximize final body weight and weight gain, without affecting carcass yield and whole-body composition. Furthermore, this low-calorie diet (10.67/170) could also be provided to females, in order to avoid over supplementation, without affecting productive performance, carcass yield and whole-body composition. These ME and CP values can be used as a starting point to design diets for Mexican Creole birds from 13 to 20 weeks of age.

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