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Research Article

Comparative Evaluation of Growth Performance, Meat Quality and Intestinal Development of Indigenous and Commercial Chicken Strains

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Abstract

Objective: The aim of this study was to assess the growth performance, meat quality characteristics and intestinal development of indigenous and commercial chicken strains raised under an intensive management system. **Materials and Methods:** One hundred eighty birds of local Omani and Cobb500 broiler chickens were divided into two groups of15 replicates with each replicate containing 6 birds. The birds were fed a non-medicated conventional corn-soybean meal diet. Feed intake, body weight gain and feed conversion ratio were recorded weekly. At the end of the growth experimental period (35 days), 15 birds per breed were randomly selected for morphological analysis of the jejunum and ileum, carcass and organ weight. Blood was collected for hematological and serum biochemistry analysis. **Results:** Hematological and serum analysis showed that there was no significant difference between the Omani and Cobb 500 broiler chickens, suggesting that the birds were healthy. The Cobb 500 showed a significantly higher feed intake (63.8%) and body weight gain (72.1%) and a better feed conversion ratio than that of the Omani breed (1.5 vs 1.96). Morphological analysis showed that Cobb 500 broilers had a greater villi height compared to the Omani breed ($p<0.01$). **Conclusion:** Villus development has a profound effect on the growth performance of chickens.

Key words: Growth performance, intestinal development, meat quality, morphology, Omani chickens, strain

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Local populations represent the native chicken breeds that are long-established in rural areas and are well-recognized to be well-adapted to harsh environmental conditions[1]. According to Tchoumboue *et al.*[2], local chickens represent the main source of meat and eggs in more than 80% of the rural and poor households in developing countries. However, local chicken production is among the farming activities in the rural communities of Oman[3] that provides opportunities for food security and income for many rural families. Despite the importance of this activity, there is no detailed study evaluating the performance and potential of local chicken production in Oman. An improvement in local chicken productivity would be highly valuable in the enhancement of the socioeconomic and nutritional status of farmers. With the development of animal husbandry in Oman, local chicken production is becoming more widespread. To ensure effective production of local chickens, it is critical to assess their growth performance; to the best of our knowledge, there are no studies available in the literature regarding their growth performance in detail. Availability of such information might form the basis for improving the productivity of local chicken production. Furthermore, from the literature, it is apparent that considerable variation exists in the production traits of native chicken breeds and further research is required to establish baseline values for production parameters and characterize their general performance.

Although, a lot of literature is available regarding the genetic parameters of the growth traits of commercial chicken strains, the same information may not be relevant to slow-growing native chickens[4]. There is evidence in the literature that the strain of the chicken affects its feed intake, digestibility, feed conversion ratio and growth rate at different ages[5,6]. Therefore, the objective of the present study was to compare the growth performance of local Omani and Cobb 500 broiler chickens raised using similar husbandry practices.

MATERIALS AND METHODS

Ethical approval: The study was approved by the Animal Research Ethics Board at Sultan Qaboos University.

Birds and housing: One hundred twenty 1-day-old chicks from each strain of indigenous chickens (Local Omani) and Cobb 500-type broiler chickens were used. On the day of arrival, the chicks were individually weighed and placed into narrow weight classes. Birds of relatively low or high body weight were excluded. Six birds were randomly assigned to each of 30 suspended wire cages (62×62×37 cm) such that all cages had nearly a similar average initial weight. Feed and water were provided *ad libitum.* The cages were in an environmentally controlled shed maintained at 33°C on Day 1 and reduced by 3°C each week to reach a constant 22°C. The lighting schedule was 23L:1D.

Experimental diets: The composition of the experimental diet is presented in Table 1. Chicks of both strains were fed a non-medicated conventional corn-soybean meal starter diet from day 0-35 days of age. There were 15 replicates for each strain of chicken with each replicate cage containing6 birds (a total of 90 birds/strain). Bird/replicate combinations were randomly allocated.

Growth rate and feed intake: The birds and feed of each cage were weighed on days 0, 7, 14, 21, 28 and 35. All the measurements (growth rate, feed intake and feed conversion ratio) were recorded weekly. This allowed daily gain (DG), feed intake (FI) and feed conversion ratio (FCR) to be determined during these periods.

Weight of digestive organs: On day 35, one bird from each cage/strain was randomly selected and sacrificed. The weight of the live bird, carcasses, small intestine, proventriculus, gizzard, pancreas, heart, liver plus gall bladder and caecum were recorded.

Table 1: Composition of the experimental diet (g kg^{-1} dry matter) used during the experiment

Ingredient	Amount (g kg^{-1} dry matter)
Corn	516.90
Soybean meal (46%)	396.30
Vegetable Oil	41.10
Monocalcium Phosphate	19.60
Limestone	15.00
Salt	3.10
Vitamin and Mineral Premix[1]	2.00
DL-Methionine	3.00
Calculated analysis (per kg)	
ME (kcal kg^{-1})	3035.00
Crude protein (g)	225.00
Lysine (g)	12.90
Methionine (g)	6.30

[1]The vitamin and mineral premix provide the following quantities per kilogram of diet; Vitamin A (retinol): 10,300 IU, Vitamin D_3 (cholecalciferol): 2,500 IU, Vitamin E (DL-α-tocopheryl): 40.00 mg, Vitamin K_3 (menadione): 3.75 mg, Vitamin B_1(thiamin): 1.00 mg, Vitamin B_2 (riboflavin): 6.50 mg, Vitamin B_6 (pyridoxine): 6.00 mg, Vitamin B_{12} (cyanocobalamin): 0.01 mg, Calcium pantothenate: 18.00 mg, Niacin: 30.00 mg, Folic acid: 2.00 mg, Biotin: 0.06 mg, Flavomycin: 50.00 mg, Ethoxyquin: 125.00 mg, Choline: 650.00 mg, Molybdenum: 2.00 mg, Manganese: 120.00 mg, Iron: 7.00 mg, Cobalt: 1.00 mg, Zinc: 90.00 mg, Iodine: 1.50 mg and Selenium: 0.15 mg

Meat quality assessment: Fifteen carcasses from each strain were randomly selected to evaluate meat quality characteristics. The selected carcasses were placed in labeled plastic bags, stored in a chiller (4°C) for 24 h and then frozen at -20°C for further evaluation. One type of muscle, *M. pectoralis*, from the breast was dissected from the selected carcasses for meat quality characteristic assessment. Meat quality related measurements, including ultimate muscle pH; Warner-Bratzler (WB) shear force; expressed juice and cooking loss and colors L*, a* and b* were determined as described by Al-Marzooqi *et al.*[7].

Blood sample collection: At the end of the experiment (day 35), blood samples were collected from 30 birds (1 bird/strain of chicken was randomly selected) for the determination of hematological and serum biochemical parameters as described by Al-Marzooqi *et al.*[8].

Morphological analysis: For intestinal morphological examinations, the small intestine was divided into two parts: the jejunum (from the pancreatic loop to Meckel's diverticulum) and the ileum (from Meckel's diverticulum to the ileo-caeco-colic junction). A 3 cm long middle portion of each segment was fixed in 10% formalin for later morphometrical assays. The formalin-fixed gut wall was washed in phosphate buffered saline (PBS) and embedded in paraffin wax. Cross sections (5 μm in thickness) of each intestinal segment were processed in low-melt paraffin and stained with hematoxylin and eosin. A total of 4 intact, well-oriented villi were selected for each intestinal cross section with 8 replicates for each (32 measurements for each intestinal sample with 512 measurements per chicken strain). Villus height was measured from the tip of the villus to the crypt junction; villus width was measured as the distance across the middle of each villus. Morphological indices were determined using computer-aided light microscopy (16×magnification of the objective lens) with image software analysis (Image-Pro Plus version 3.0, Media Cybernetics, Silver Spring, MD).

Statistical analysis: Analysis of variance(one-way ANOVA) was used to test the effect of dietary treatments on the experimental parameters using General Linear Models. Data were subsequently analyzed for the effect of the breed using SAS statistical program package[9]. Significant differences were assessed using the least significant difference procedure. Interaction between the treatments was excluded from the model when not significant ($p>0.05$).

RESULTS

The feed intake (g/bird/day),daily weight gain (g/bird/day) and feed conversion ratio (g FI/g Gain) for the overall period (0-35 days) and on weekly basis for both the local Omani and Cobb 500 broiler breeds are presented in Table 2. The chicken breed significantly affected feed intake, daily weight gain and feed conversion ratio during weeks 1-5. During this period (0-35 days), the broiler birds had a significantly higher feed intake (63.8%) than that of the Omani birds. When the mean weight gain for the overall period (0-35 days) was considered, the broilers had a significantly higher body weight gain (72.1%) than that of the Omani birds. In addition, the feed conversion ratio was poor for the local Omani birds during the overall period (0-35 days). The corresponding feed conversion ratios were significantly reduced by 23.5% (1.50 vs. 1.96; Broiler vs. local Omani).

The weights of the carcass yield and offal of the Omani and Cobb 500 broiler chickens fed a conventional corn-soybean meal diet are presented in Table 3. The chicken

Table 2: Feed intake (FI, g/bird/day), daily gain (DG, g/bird/day) and feed conversion ratio (FCR, g feed/g gain) between local Omani and Cobb 500 broiler breed of chickens

	Breed		Significance	
Stages	Broiler	Omani	SEM	Breed
Week 1				
FI	21.25^{a}	9.98^{b}	0.36	***
DG	18.74^{a}	7.76^{b}	0.21	***
FCR	1.14^{b}	1.29^{a}	0.02	***
Week 2				
FI	44.86^{a}	19.13^{b}	1.03	***
DG	33.38^{a}	10.29^{b}	0.88	***
FCR	1.36^{b}	1.860^{a}	0.04	***
Week 3				
FI	56.97^{a}	29.19^{b}	1.63	***
DG	82.93^{a}	15.38^{b}	1.82	***
FCR	1.48^{b}	1.910^{a}	0.04	***
Week 4				
FI	105.61^{a}	39.64^{b}	3.62	***
DG	65.07^{a}	18.54^{b}	2.17	***
FCR	1.63^{b}	2.140^{a}	0.04	***
Week 5				
FI	138.38^{a}	44.48^{b}	1.96	***
DG	87.03^{a}	20.88^{b}	1.24	***
FCR	1.59^{b}	2.150^{a}	0.07	***
Overall				
FI	78.60^{a}	28.48^{b}	1.41	***
DG	52.24^{a}	14.57^{b}	0.88	***
FCR	1.50^{b}	1.960^{a}	0.02	***

SEM: Standard error of mean. ***$p<0.001$. Means in the same row with different letters were significantly different ($p<0.05$)

Table 3: Mean weight of carcass yield and the weight of internal organs in the Omani and Cobb 500 broiler chickens

	Breed		Significance	
Parameters	Broiler	Omani	SEM	Breed
Carcass	1162.52[a]	223.47[b]	23.780	***
Heart	9.88[a]	3.17[b]	0.376	***
Liver	41.80[a]	11.58[b]	1.260	***
Proventriculus	7.18[a]	2.44[b]	0.189	***
Gizzard	32.97[a]	10.86[b]	0.607	***
Small intestine	64.42[a]	14.12[b]	2.450	***
Pancreas	4.87[a]	1.42[b]	0.126	***
Cacea	11.65[a]	3.61[b]	0.532	***

SEM: Standard error of mean. ***p<0.001. Means in the same row with different letters were significantly different (p<0.05)

Table 4: Mean weight of digestive organs per unit body weight (g kg^{-1} body weight) of local Omani and Cobb 500 broiler chickens

	Breed		Significance	
Parameters	Broiler	Omani	SEM	Breed
Small intestine	3.18[b]	3.71[a]	0.098	***
Proventriculus	0.39[b]	0.63[a]	0.013	***
Gizzard	1.81[b]	2.85[a]	0.070	***
Heart	0.57[b]	0.83[a]	0.029	***
Liver	2.43[b]	3.03[a]	0.100	***
Pancreas	0.27[b]	0.37[a]	0.015	***
Cacea	0.72[a]	0.92[a]	0.073	NS

SEM: Standard error of mean.***p<0.001. NS: Not significant. Means in the same row with different letters were significantly different (p<0.05)

breed significantly affected the carcass yield and internal organ weights (p<0.001).The parameters of the carcass and the weight of the internal organ were significantly (p<0.001) higher for the broiler versus the Omani chickens. Although the Cobb 500 broiler chickens had a higher absolute weight for the liver (72.30%), proventriculus (66.02%), gizzard (67.06%) and small intestine (78.08%),the relative weights of the small intestine, proventriculus, gizzard, liver, heart and caeca per unit body weight (g kg^{-1} body weight) were significantly higher (p<0.001) in the Omani chickens (Table 4). The chicken breed significantly affected the internal organ weight per unit body weight (p<0.001). The relative weight of the internal organ is significantly higher (p<0.001) in the local Omani chicken than in the broiler chickens.

The meat quality characteristics of *M. pectoralis* of the local Omani and Cobb 500 broiler birds are presented in Table 5. The chicken breed had no significant effect on meat quality characteristics (color, pH, expressed juice, Warner-Bratzler shear values, sarcomere length and cooking loss %).

The hematological, serum electrolytes and serum chemistry parameters of the Omani and Cobb 500 broiler chickens fed non-medicated conventional corn-soybean meal are presented in Table 5. There was no significant difference (p>0.05) in the hematological, serum electrolyte and serum biochemical parameters between the Omani and broiler chickens.

Table 5: Meat quality characteristics of local Omani and Cobb 500 broiler breast (*M. pectoralis*) chickens

	Breed		Significance	
Parameters	Broiler	Omani	SEM	Breed
pH	5.66	5.77	0.05	NS
Cooking loss (%)	20.65	20.12	0.98	NS
Expressed Juice (cm^2 g^{-1})	27.39	30.24	1.37	NS
WB-shear force value (kg)	1.44	1.35	0.14	NS
SL (μm)	1.69	1.71	0.02	NS
Lightness (L)	46.15	48.59	1.10	NS
Redness (a)	7.40	6.98	0.44	NS
Yellowness (b)	7.16	6.96	0.48	NS

SEM: Standard error of mean, NS: Not significant, SL: Sarcomere length (μm)

Table 6: Hematological, serum chemistry and serum electrolyte parameters of local Omani and Cobb 500 broiler chickens

	Breed		Significance	
	Broiler	Omani	SEM	Breed
Hematological parameters				
RBC ($mm^3 \times 10^6$)	2.2400	2.2900	0.070	NS
HB (g dL^{-1})	10.880	10.610	0.150	NS
PCV (%)	32.000	31.200	0.450	NS
MCV (fl)	145.51	138.13	5.150	NS
MCH (pg)	49.470	46.960	1.750	NS
Serum chemistry parameters				
Albumin (g dL^{-1})	1.8100	2.2400	0.330	NS
Urea (g dL^{-1})	3.7500	3.9800	0.440	NS
Creatinine (g dL^{-1})	0.3500	0.3300	0.050	NS
Total protein (g dL^{-1})	3.3400	3.1100	0.180	NS
AST (IU L^{-1})	266.68	266.14	26.04	NS
ALT (IU L^{-1})	10.670	9.0700	1.300	NS
Serum electrolyte parameters				
Sodium (mmol L^{-1})	144.75	141.67	1.970	NS
Potassium (mmol L^{-1})	3.1973	3.3900	0.790	NS
Chloride (mmol L^{-1})	106.12	103.85	1.160	NS

SEM: Standard error of mean, NS: Not significant, RBC: Red blood cell counts, HB: Hemoglobin, PCV: Packed cell volume, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration. AST: Aspartate amino transaminase, ALT: Alanine amino-transferase

The jejunum and ileum villi height (μm) and villi height: width ratio (μm μm^{-1}) measurements of the Omani and Cobb 500 broiler chickens fed a non*medicated conventional corn-soybean meal diet are presented in Table 6. For the jejunum and ileum, the broiler had a taller villi height compared to that of the Omani chicken (p<0.01). (Table 7) There was no significant difference in jejunal or ileal villi height: width ratio (p>0.05).

Table 7: Jejunum and Ileum villi height (μm) and villi height: width ratio (μm μm^{-1}) measurements of local Omani and Cobb 500 broiler chickens

		Breed			Significance	
Measurement	Segment	Broiler	Omani	SEM	Breed	Segment
Villi height	Jejunum	1053.71^{a}	898.970^{b}	36.29	**	**
	Ileum	805.20^{bc}	729.890^{c}	34.97	**	**
Villi h:w ratio	Jejunum	7.35^{a}	7.01^{ab}	0.31	NS	*
	Ileum	5.60^{c}	5.92^{bc}	0.29	NS	*

SEM: Standard error of mean. **p<0.01. NS: Not significant. Means in the same row with different letters were significantly different (p<0.05)

DISCUSSION

The present study showed that there were significant differences in the growth performance parameters between the two breeds; Cobb 500 broiler chickens showed better feed-to-gain ratios than did the local Omani chickens during all periods of the study. Similar findings were observed in other studies which showed that there are genetic differences in growth rates between broiler and indigenous chickens[10,11].

Dror *et al.*[12] found that the relative weights of the gastrointestinal segments and some of the other internal organs markedly varied among different chicken breeds. In the current study, a difference in the weight of the internal organs was observed among the two chicken strains with a significantly higher weight in the internal organs of the Cobb 500 broilers compared to that of the local Omani chickens (p<0.001), which was in line with the aforementioned observations. However, when the internal organs were expressed as a proportion of body weight, it was found that there was a higher relative weight of the internal organs in the local Omani chicken than in the Cobb 500 broilers, suggesting that the internal organs in the local Omani birds nearly doubled in size to be as efficient as those of the Cobb 500 broilers.

The development of certain segments of the alimentary tract can be a limiting factor for accelerated growth in young chicks[12]. The development of the absorptive structure of the intestine has been found to correlate with changes in digestion and feed absorption[13]. Villus growth in young chicks is stimulated by the presence of feed and the expansion of surface area that occurs with villus growth and has been used to explain increased absorptive capacity[13,14]. It may be assumed that such an increased feed intake and efficient feed utilization have also altered intestinal function, which could influence intestinal morphology[15]. In the present study, from a morphological standpoint, there were significant differences (p<0.01) in villi height across the two chicken strains. For the jejunum and ileum, the local Omani chickens had a shorter villi height compared to that of the broilers. From a morphological perspective, it could have been expected that the taller villi in the present study in the broiler chickens resulted in an increased surface area that allowed greater absorption of available nutrients[16]. Uni *et al.*[13] reported similar findings, with the Arbor Acres broilers having a taller villi height compared to that of Lohman laying chickens. Access to nutrients can initiate growth following ingestion of exogenous feed for the first time after hatching. Sklan[17] found that early access to feed resulted in a more rapid post hatch development of the intestine. The present results showed that broiler chickens consumed more feed than that of the local Omani chicken, even on the hatched day. The increase in the mass of the digestive tract and in enzymatic activity involved in digestion and metabolism was found to parallel the increase in food consumption[18,19]. During the overall study period, broiler birds had a significantly higher feed intake (63.8%) compared to that of the local Omani birds. The lack of improvement in the performance of the local Omani chickens can be attributed to their low feed intake and consequently poor growth rate. The low growth rate of the local Omani chickens indicates that they had a limited response to the improved feeding management system. One problem encountered by the local Omani chickens is that they tended to have similar behaviors of scavenger birds by wasting feed via scratching, even though the feeders were adjusted to prevent further feed loss. In addition, it is suggested that future development of the local Omani chicken breed requires, for rapid growth production, further selection of lines considering the developmental rate of the intestine in general. In addition, future studies will need to investigate histological alterations related to intestinal function.

According to Mabelebele *et al.*[20], the gastrointestinal tract develops more rapidly and earlier in broiler chickens compared to other slow-growing indigenous chickens and tends to regulate itself according to the chicken physiological requirements. In addition, Yamauchi and Isshiki[21] found that broiler chickens that are bred for rapid growth have a higher rate of small intestine development. Longer intestines are assumed to more efficiently digest feed and provide a greater surface area for nutrient absorption. The increase in small intestine weight allows broiler chickens to reach a heavier body weight more rapidly compared to that of indigenous chickens[22].

It is assumed that an increased villus height is paralleled by an increased digestive and absorptive function of the intestine because of increased absorptive surface area, expression of brush border enzymes and nutrient transport systems. Enterocyte enzymatic activity and structure are two of the most important features of intestinal mucosal physiology.

There were no significant differences in meat quality characteristics between the breeds. The nature of the feed offered to the birds influences both carcass and meat quality characteristics. Round[23] stated that high nutrient density in the broiler's diet produces high carcass fatness, live weight gain and breast meat yield. The diet type used during this experiment had no significant effect on meat quality characteristics. The pH values obtained in the current study are comparable to and within the acceptable range reported in the literature[24,25]. Shear value is an indirect measurement of muscle tenderness and lower shear values indicate more tender meat[26]. In the current study, a shear force value of 1.4 kg would be considered tender and within the acceptable range of reported values in the literature[26]. Cooking loss, or weight lost during cooking, is a measurement of water-holding capacity of the muscle. There were no differences between the experimental treatment groups. The numerical distinctions among these means may simply reflect the variable nature of measuring small weight changes in individual muscle samples.

The normal values for hematological and biochemical parameters of different chicken breeds were measured and a database was established[27,28]. However, there is a general lack of information regarding blood profiles of local Omani chickens in the literature. It is important to investigate the blood profiles of local Omani chickens to evaluate the health conditions of these birds. Blood parameters reflect the physiological responsiveness of the birds to its internal and external environment, including the type of feed the bird consumes and feeding practices[29]. In addition, it has been reported that serum biochemical constituents are positively correlated with the diet quality[30]. In the current study, the values obtained for all hematological and serological parameters are nearly uniform across the two breeds and were within the normal range and comparable to those reported in the literature for broiler chickens[31,32]. Liver function tests for glutamic oxaloacetic transaminase (AST) and glutamic pyruvic transaminase (ALT) produced similar results in both breeds and were congruent with similar reference values reported for chicks by Kaneko *et al.*[33].

The present study showed normal baseline values for the biochemical parameters in local Omani chickens. The information obtained from this study may help other researchers aim to select/develop indigenous chicken breeds.

CONCLUSION

This study found that optimal growth and development of the intestinal tract of the chicken is likely governed by early development of the intestinal tract. The study showed that optimal early development of the intestinal tract, mirrored in the significantly higher villi height in the Cobb 500 broilers, had a profound influence on growth performance during the study period.

SIGNIFICANCE STATEMENT

The present study is the first endeavor to compare the growth performance, meat quality and intestinal development of Omani chickens to that of Cobb 500 broilers. This study will help researchers better understand the inferior growth rate of indigenous/local chickens such as Omani birds. Thus, a new approach should be directed to study the development of bacterial populations among different parts of the digestive tract of local chickens that will help to understand changes in the microecosystem in the gastrointestinal tract.

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