J. Bangladesh Agril. Univ. 5(2): 303–312, 2007 ISSN 1810-3030

Effect of different maize based diets on the production performance and carcass characteristics of broiler

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Abstract

A feeding trial was conducted for a period of 5 weeks with 160 day-old Starbro broiler chicks with a Randomized Block Design with 4 dietary treatments. There were 40 chicks per treatment. Each treatment was replicated in 4 blocks with 10 chicks in each block. The dietary treatments were normal maize plus lysine and methionine (control diet), normal maize without lysine and methionine, Pacific 11 maize without lysine and methionine and Quality Protein Maize (QPM) without lysine and methionine. All other ingredients used in the diet were similar and all diets were isocaloric and isonitrogenous that contained around 2975 Kcal ME/kg DM and 21.5% crude protein. At 5 weeks of age, 2 broilers from each block (8 from each treatment) was randomly selected considering average body weight and slaughtered to analyze the meat yield traits. The QPM contained only slightly higher protein and lysine than Pacific 11. Other amino acid profiles of QPM were similar to that of Pacific 11. There were no differences ($p>0.05$) in feed intake, water intake, total gain, feed conversion efficiency and mortality of broilers among the dietary treatments. Liveweight at slaughter ($p<0.01$), dressing percent ($p<0.05$) and breast meat ($p<0.001$) were highest, but heart ($p<0.05$) and digestive tract weight ($p<0.05$) were lowest in diet fed maize plus lysine and methionine. However, liveweight at slaughter and dressing percent did not differ ($p>0.05$) among the treatments without lysine and methionine. Morphological characteristics such as relationship between length of drumstick and carcass characteristics was promising. Morphological characteristics played a vital role in selecting broiler strains for productive purposes and might have great impact using a scale only.

Keywords: Quality protein maize, Production performance, Carcass characteristics, Broilers

Introduction

Feed is a major cost of poultry production that accounts for 60-70% of the total cost of poultry production. This cost is increasing day-by-day throughout the world including Bangladesh. Maize is a major feed ingredients in poultry diet which constitutes 50-60% of the total diet and can contribute up to 30, 60 and 90% of the diet's protein, energy and starch, respectively (Dado, 1999). Although normal maize contains about 8-9% protein, the quality of two essential amino acids, lysine and tryptophan, is below nutritional requirements for poultry. These amino acids are usually supplemented in animal feeds by soyabeans, pulse or commercially produced synthetic amino acids. However, utilization of quality protein maize (QPM) which can correct this deficiency because QPM has approximately twice the lysine and tryptophan contents of normal maize (DMR, 2001) and may be advantageous in the diets of livestock and poultry in particular. Earlier studies have documented improved growth in pigs and poultry when QPM was used as substitute for conventional maize, thereby increasing bio-available protein (Sullivan *et* al., 1989 and Asche *et* al., 1985) and positive nutritional benefits (Bressani, 1991; Graham *et* al., 1990; Graham *et* al., 1989; Valverde *et* al., 1981). There is no data on this aspect in Bangladesh. On the other hand, much debate also exist about the magnitude and extent of protein deficiency and many questions arise about the overall nutritional impact of QPM (Lauderdale, 2000).

Therefore, a study was conducted to investigate the effect of replacement of QPM by hybrid maize and normal maize with or without lysine and methionine on production performance and carcass characteristics of broiler. Moreover, relationship between morphological characteristics and carcass characteristics were estimated in order to develop an easy tool to estimate carcass characteristics of broiler.

Materials and Methods

The study was conducted between August and September 2003 in order to compare the effect of quality protein maize with that of other available maize in the market on production performance and carcass characteristics of broiler. A feeding trial was, therefore, conducted for a period of 5 weeks with 160 day-old Starbro broiler chicks collected from a local Hatchery. The initial average live weight of chicks was between 39 and 41g. The chicks were arranged in a Randomized block design and allocated into four dietary treatments. The treatments were normal maize (maize collected from a local market) plus lysine and methionine (control), normal maize, Pacific 11 and QPM. No lysine or methionine was added to the latter three treatments. There were 40 chicks per treatment. Each treatment had 4 blocks where each block had 10 chicks.

The chicks were housed in an open sided thatched roof covered by polythene sheet. The floor was 0.6 m above the ground level, prepared by slated bamboo where the space between slated bamboo was 1.5 cm so that the droppings can be dropped off between the space. Fences were made from galvanized wire net, covered by jute made clothing sheet and polythene hanged from the hanging wall of the shed to protect the birds from unpleasant weather. The house was cleaned, washed and then disinfected before the start of the experiment. After drying, the experimental shed was divided into blocks of equal sizes according to the design mentioned above. The birds were housed with a stocking density of 1 square feet/bird on slatted floor covered with rice husk. Rice husk was dried and used as litter, and replaced fortnightly when the litter became wet and dirty.

Feeders used for the experiment were two types. First 15 days, long trough feeders were used and the last 20 days round plastic basins (40 cm in diameter and 10 cm deep) were used in every block. Drinkers were 15-cm deep rectangular 30×60-cm pottery basins. They were filled with water every morning to meet the drinking requirements of the chicks. Both feeders and drinkers were cleaned daily in the morning.

Day-old-chicks were bought from local hatcheries and allowed to take glucose water for the first three days. Brooding was done by using bulbs to manipulate smallholder farmers practice. This was managed from the first day by fitting 60 and 100 watts electric bulb in the pen that remained 12-14 cm above floor and then heat was decreased gradually by lifting up the bulb as per requirement of the temperature. Lighting was provided for 24 hours for the first 3 weeks and then from 1800h to 0600h for the rest of the days.

One thermometer and a dry and wet bulb hygro-meter were hanged in the experimental room to record temperature and relative humidity. The temperature and humidity percentages were recorded 3 times a day i.e. morning, noon and evening in each day. The birds were vaccinated against Newcastle and Gumboro disease. The vaccination schedule that was practiced in the experiment is shown in Table 1.

The ingredients used to prepare diet were rice polish, soya bean meal, normal maize (from market), two hybrid maize (Pacific 11 and QPM), protein concentrates and synthetic methionine and lysine required for the trial was purchased from the local feed company. A premix containing trace minerals and vitamins was mixed with all diets. Also, common salt and DCP was added to the diets. The chicks under the experiment were fed mash type, fed ad libitum from the day of starting the experiment that contained around 2975 Kcal ME/kg DM and 21.5% crude protein. All four dietary treatments were isocaloric and isonitrogenous. The ingredient used and the nutrient composition of the diets are shown in Table 2.

Table 1. Vaccination schedule for broiler that practiced during the experimental period

Age of broiler (day)	Name of disease	Route of administration
07- 08	Newcastle	Live- Orally
14- 15	Gumboro	Live- Orally
21- 22	Newcastle	Live- Orally
28- 29	Gumboro	Live- Orally

Table 2. Ingredients (% as fed) and nutrient composition (% in DM or as stated) of the diets

	Diets			
	Normal maize+LM	Normal maize	Pacific 11	QPM
Diet composition				
Normal maize	55	55	0	0
Pacific 11	0	0	55	0
Quality protein maize (QPM)	0	0	0	55
Rice polish	17	17	17	17
Soya bean meal	20	20	20	20
Dicalciumphosphate‡	1.25	1.25	1.25	1.25
Protein concentrate†	6.0	6.2	6.2	6.2
Lysine	0.1	0	0	0
Methionine	0.1	0	0	0
Vitamin-mineral premix††	0.25	0.25	0.25	0.25
Common salt	0.3	0.3	0.3	0.3
Total	100	100	100	100
Chemical composition				
Crude protein	21.2	21.1	21.0	21.4
Amino acid				
Lysine*	1.1	1.0	0.9	1.0
Methionine*	0.4	0.3	0.2	0.3
Methionine + cystine*	0.7	0.6	0.5	0.5
Tryptophan*	0.0	0.0	0.0	0.0
Crude fiber	3.1	3.1	2.6	2.8
Ether extract	6.1	6.1	4.0	7.3
Calcium*	1.5	1.5	1.5	1.5
Phosphorus*	1.1	1.1	1.	1.0
Available P*	0.	0.	0.4	0.4
ME, Kcal/kg*	2979	2976	2976	2976

†Composition: CP 60%, ME 3230 kcal/kg, moisture 7%, crude fat 10-12%, crude fiber 4%, ash 21%, calcium 4.8-5.8%, phosphorus 2.4%, arginine 4.1%, isoleucine 1.8%, lysine 3.2%, methionine/cystine 1.0%, phenylalanine/tyrosine 4.2%, tryptophan 0.5%, histidine 1.2%, leucine 4.3%, methionine 0.9%, phenylalanine, 2.4%, threonine 2.2%, valine 2.6%.
‡Composition: calcium 21%, phosphorus 18%, fluorine 1800mg, arsenic 30mg, lead 30mg.
*Calculated values

Feeding trial was conducted for a period of 5 weeks. Initial body weight of day old chicks was recorded immediately before the start of the trial and then weekly thereafter. All birds were weighed individually, before supplying morning feed and water. Diets were supplied in different feeders for each block and also for each treatment and offered ad libitum twice a day in the morning and evening. The amounts provided on each time depended on the intake on the previous two occasions, to minimize spoilage. The residues were gathered and weighed on the following morning to calculate the actual intakes. Feed intake including left over was recorded daily and was calculated from the difference between offer and left over. In the same way, water was also provided and measured to calculate the actual water intake per bird/day. Feed conversion ratio (FCR) was recorded for the whole period as total feed intake (kg) per kg weight gain. Temperature and humidity (%) was recorded three times a day; in the morning (0900h), noon (1300h) and evening (1700h). Room temperature of the pen ranged from 26-34^{0}C and humidity ranged from 77-96%. Health status of birds was monitored everyday and mortality of birds was recorded.

At 5 weeks of age, two birds out of 10 per block were slaughtered to analyze the meat yield traits. All birds to be slaughtered were kept off feed overnight but drinking water was provided ad libitum. Birds were slaughtered following 'halal' method (Singh *et* al., 2003) by severing the jugular vein and allowed to bleed completely and then plucked and weighed to determine blood and feather losses (Kotula *et* al., 1960; Pandey and Shyamsunder, 1990). Data on pre-slaughter live weight, blood loss weight, eviscerated weight, shank length and weight, neck length and weight, head weight, breast meat weight, drumstick weight and length, thigh bone length and weight, digestive tract weight, gizzard weight, liver weight, spleen weight, heart weight, back and breast bone weight, wing bone length and weight were recorded. Morphological characteristics such as length of neck, thigh, drumstick and wing were recorded by a measuring scale. All of the weights related to carcass characteristics were expressed as the percentage of liveweight at slaughter. The components of carcass traits were dissected according to Singh *et* al. (2003) except the birds that were not subjected to scalding at 55^{0}C for 30 seconds.

Samples of feed ingredients and diets were analyzed for crude protein (CP), crude fiber (CF) and ether extract (EE) following AOAC, (1984). Amino acids of two maize hybrids, Pacific 11 and QPM were determined by using HPLC. Dry matter (DM) was determined by oven drying the fresh material at 100°C for 48 h. Sample was ignited at 700°C for 6 hours for determining the ash.

Data were analyzed by Randomized Block Design with 4 blocks (Snedecor and Cochran, 1989) using the procedure of SPSS 10 for Windows (SPSS, 1998). Means compared for significant differences using Duncans Multiple Range Test (Duncan, 1955). Correlation and regression analyses were done according to Snedecor and Cochran (1989).

Results and Discussion

All diets were iso-caloric (ME, 2976 kcal/kg) and iso-nitrogenous (CP, 21%). Japanese Feeding Standard recommended 21% CP for chicks from 0-3 weeks (Ishibashi *et* al., 2001; Koide *et* al., 1992). The CF content of the diet ranged from 2.6-3.1% which was within the range of requirement (Singh *et* al. 2003). The EE content of Pacific 11 based diet (4.0%) was almost half of the QPM based diet (7.3%). Lysine and methionine content of the diet were highest in the diet with maize plus lysine and methionine (1.1 and 0.4 respectively) and lowest in the diet with Pacific 11 (0.9 and 0.2 respectively). This lysine in the diets was within the range recommended by Ishibashi *et* al. (2001; 0.99-1.10%) and Ueno (1998; 0.9-1.1%).

Chemical composition and amino acid profiles of QPM and Pacific 11 maize are given in Table 3. The QPM contained relatively higher ash, CP and CF than Pacific 11. QPM contained slightly higher lysine, aspartic acid, glycine, threonine, arginine and valine than Pacific 11. On the other hand, Pacific 11 contained little more glutamine, serine, alanine, tyrosine, phenylalanine, isoleucine and leucine than QPM. The CP content of QPM used in this study (9.6%) was within the range (7.4-9.5%) reported by various literature (DMR, 2001; Ortega et al., 1986; Osei et al., 1999), but was much lower than that reported by Sproule *et* al. (1988; 11.3%) and some of the strains described by DMR (2001; 10.2-11.7%). The lysine content of QPM found in the present study was only 0.19%, which was two times lower than the lysine content of QPM reported by them (0.3-0.4%) and Zhai (2002; 0.3%). However, it must be noted that most of the amino acid found in the present study was much lower than those reported by Ortega *et* al. (1986). Several factors likely to be responsible for the variation in nutritive value of crops, differences between laboratory sometimes play one of the biggest roles (Givens *et* al., 1993) which may have been happened here. In this context, an amino acid profile of QPM in the present study was determined by HPLC.

Table 3. Chemical composition and amino acid profiles (g/100g) of quality protein maize (QPM) and Pacific 11

	QPM	Pacific 11
Chemical composition		
DM%	90.2	88.4
Ash (%DM)	1.7	1.5
CP (%DM)	9.6	9.0
CF (%DM)	1.8	1.6
EE (%DM)	6.1	-
Amino acid (%)		
Aspertic acid	0.4	0.4
Glutamine	1.3	1.5
Serine	0.3	0.3
Glycine	0.3	0.3
Threonine	0.2	0.1
Arginine	0.3	0.3
Alanine	0.5	0.6
Tyrosine	0.2	0.2
Tryptophan	0.1	-
Methionine	0.1	-
Valine	0.3	0.3
Phenylalanine	0.28	0.35
Isoleucine	0.18	0.22
Leucine	0.69	0.91
Lysine	0.19	0.16

The data on final body weight, total gain, feed intake, water intake, FCR and mortality of broilers fed on different maize based diets are presented in Table 4. None of these characteristics differed (p>0.05) among diets. This results contrast with the result of Bai (2002) who reported significantly higher weight gain and FCR of broiler fed diets with normal maize plus lysine (2287.8 g and 2.00) followed by QPM (2266.0g and 2.0) and normal maize (2231.1g and 2.1) that were reared for 49 days. However, final weight (936g) and per day gain (31g) of broiler from 28 to 38 days reported by Miyasaka *et* al. (1997) was similar to the data of present study (1.1-1.2 kg and 30-33g respectively).

Table 4. Performances of broiler fed on different maize based diet

Parameters	Treatments				F value and significance
	Normal maize+LM	Normal maize	Pacific 11	QPM	
Initial weight (g)	38.7	39.1	40.8	40.7	-
Final weight (kg)	1.1	1.2	1.2	1.1	0.32, NS
Total gain (kg)	1.1	1.1	1.2	1.1	0.32, NS
Feed intake (kg)	2.1	2.2	2.2	2.0	0.55, NS
Water intake (kg)	4.5	4.7	5.0	4.5	0.54, NS
Feed conversion rate (kg feed/kg gain)	2.0	1.9	2.0	2.0	0.15, NS
Mortality (%)	0.5	0.3	0.3	0.0	0.44, NS

NS = non-significant (p>0.05).

Moreover, feed conversion of broilers in all diets was relatively better in the present study than those reported by Bai (2002), but was similar to the data of Ishibasi *et* al. (2001) who reported that the body weight gain/feed (g/g) was 0.5 (i.e. FCR = 1.9) when no amino acid was supplemented in the diet. Interestingly, while no clear advantage of using QPM over normal maize or hybrid Pacific 11 was found, similarly there was no advantage of using lysine and methionine in normal maize based diet used in the present study. While more studies are needed, the results suggest that there is no need to use lysine and methionine if ingredients used in the diet of the present study are used.

Trials on inclusion of different levels (0 to 100%) of QPM in the diet are necessary to know which level of QPM needed to be included in the diet because ingredients such as soybean included in the diet already contains lysine and methionine that can nullify the effect of the excessive amino acids in QPM. Furthermore, since there is little difference between the amino acid profiles of QPM and Pacific 11, it is anticipated that cross-pollination in QPM might have happened from the adjacent plot. Therefore, QPM must be grown separately to have trial in broiler. All these factors therefore needed to be considered before reaching a conclusion to use QPM at farmer's level.

Although lysine and methionine in normal maize based diet had no effect on production performances, it affected on the length of thigh ($p<0.01$) and drumstick ($p<0.05$). However, lysine and methionine in normal maize-based diet did not affect ($p>0.05$) the length of neck, shank and wing of broiler (Table 5). Ishibashi *et* al. (2001) reported that when dietary lysine is low, bodyweight gain increased with increased lysine level. However, there is no evidence that a little more lysine and methionine in the diet can increase length of leg (thigh and drumstick) as in the present study. As evidenced (Table 2) lysine was not a limiting factor in any of the dietary treatments and was similar between treatments.

Table 5. Morphological characteristics of broiler fed on different treatments

Parameters (cm)	Treatments				SE	F value and significance
	Normal maize+LM	Normal maize	Pacific 11	QPM		
Neck	11.2	10.2	10.56	11.69	0.32	1.07, NS
Thigh	7.5[b]	6.4[a]	6.31[a]	6.25[a]	0.17	6.53, $p<0.01$
Drumstick	9.5[b]	8.1[a]	7.98[a]	8.44[a]	0.85	4.48, $p<0.05$
Shank	6.8	6.6	6.08	8.54	0.65	0.64, NS
Wing	17.3	16.1	16.56	16.25	0.22	1.54, NS

ab, with different letters in the same row differ ($p<0.05$); NS = non-significant ($p>0.05$).

Carcass characteristics of broiler fed on different diets based on maize are presented in Table 6. Dressing percent ($p<0.05$; 81%) and breast meat ($p<0.001$; 15%) were highest, but heart ($p<0.05$; 0.58%) and digestive tract weight ($p<0.05$; 11%) were lowest in birds fed maize plus lysine and methionine. Liveweight at slaughter and dressing percent did not differ ($p>0.05$) between the treatments without lysine and methionine. The result of dressing percent of broiler contrasts with the results of Bai (2002) who found significantly higher dressing percent of birds fed diet with normal maize plus lysine (78.21%) than normal maize alone (76.99%), but the former diet nonsignificantly differed with QPM diet (77.30%). However, clearly, dressing percent of broiler using QPM in the present study (77.04%; Table 6) was similar to that reported by Bai (2002) using QPM. There were no difference ($p>0.05$) between treatments on the weight of blood, feather, head, neck, liver, spleen, thigh plus drumstick, shank, wing meat, gizzard, skin, abdominal fat, lung and back plus breast bone. However, the diet containing maize plus lysine and methionine resulted in non-significantly ($p>0.05$) lowest weight of blood, head, liver, shank, skin and lung, and non-significantly ($p>0.05$) highest weight of feather and back plus breast bone of broilers. The abdominal fat content of broilers in the present study (1.39-1.99% of body weight) was similar to that reported by Ishibashi *et* al. (2001; 1.77% of body weight) when no amino acid was supplemented, but they reported about twice higher abdominal fat at similar protein level

(17.2-21.1%) when they rear broiler up to 52 days. Bai (2002) also reported that maize source had no effect on abdominal fat whether lysine was added or not, was in line with the results of the present study but it increases with the increase in growing period.

Table 6. Carcass characteristics of broiler using different treatments

Parameters (% of liveweight or as stated)	Normal maize +LM	Normal maize	Pacific 11	QPM	SE	F-value and significance
Dressing percent	81.2[b]	80.8[b]	77.0[a]	77.0[a]	0.69	5.39, $p<0.05$
Blood weight	2.7	3.5	4.5	4.7	0.38	1.85, NS
Feather weight	5.2	4.5	4.3	4.3	0.31	0.52, NS
Head weight	3.1	3.2	3.3	3.3	0.08	0.35, NS
Neck weight	3.2	3.2	2.9	3.1	0.08	0.67, NS
Heart weight	0.6[b]	0.7[ab]	0.7[ab]	0.8[a]	0.03	1.89, $p<0.05$
Liver weight	2.1	2.6	2.4	2.5	0.09	1.49, NS
Spleen weight	0.2	0.2	0.1	0.1	0.01	2.70, NS
Breast meat weight	14.7[c]	13.0[b]	10.4[a]	10.7[a]	0.52	13.84, $p<0.001$
Thigh+drumstick	18.9	18.3	19.2	20.0	0.33	1.20, NS
Shank weight	4.6	4.8	4.8	5.1	0.11	0.84, NS
Wing meat weight	6.7	6.6	6.6	7.0	0.11	0.79, NS
Gizzard weight	3.4	4.8	3.1	3.2	0.36	1.25, NS
Skin weight	7.1	8.8	8.8	7.1	0.46	1.16, NS
Abdominal fat weight	1.6	2.0	1.8	1.4	0.15	0.76, NS
Digestive tract weight	10.8[a]	11.2[ab]	14.3[c]	13.9[bc]	0.57	3.94, $p<0.05$
Lung weight	0.5	0.6	0.5	0.6	0.03	0.68, NS
Back+breastbone weight	15.6	14.4	13.8	14.7	0.31	1.66, NS

abc, with different letters in the same row differ ($p<0.05$ to 0.001); NS = non-significant ($p>0.05$).

The correlation coefficient between liveweight and breast meat (r = 0.67) was positive. On the other hand, correlation coefficient between liveweight and head (r = -0.57), liver (r = -0.63), was negative (Table 7). Dressing percent was negatively correlated with the weight of blood (r = -0.51) and digestive tract (r = -0.89) but positively correlated with the breast meat (r = 0.79). Abdominal fat weight was highly and positively correlated with the weight of skin (r = 0.81). Skin weight was negatively correlated with wing meat (r = -0.44). The correlations of both skin and abdominal fat with other carcass components were mostly similar in nature although magnitude was different. This similarity in relationship of skin and abdominal fat with other parameters has been reflected in their highly positive correlation (r = 0.81).

Correlation between morphological and carcass characteristics of broiler is given in Table 8. Correlation between length of thigh, drumstick and liveweight (r = 0.66, 0.56 respectively), dressing percent (r = 0.31, 0.51 respectively), breast meat (r = 0.59, 0.70 respectively) were positive and high. Although correlations between length of wing and liveweight (r = 0.55), breast meat (r = 0.26) were positive, its relationship with dressing percent was low and negative (r = -0.14). Surprisingly, shank length had negative and low relationship with liveweight (r = -0.20), dressing percent (r = -0.34) and breastmeat (r = -0.19). These relationships between shank length and the stated characteristics contrast with cockerels, which were positive, but the nature of relationship of stated morphological characteristics and carcass characteristics were similar to that of cockerel where magnitude was different (Islam et *al.*, 2004). Islam *et* al. (2002) also found similar nature of relationship between morphological characteristics and carcass characteristics broiler as in the present study. The relationship between morphological and carcass characteristics might have great impact particularly in the rural areas for an instant estimation of carcass characteristics of broiler by simply measuring broilers drumstick or wing by a scale. The positive and high curvilinear nature of these relationship suggest that the longer the drumstick will be, the more improvement in carcass characteristics will occur. Therefore, these morphological characteristics may play a vital role in selecting broiler strains for productive purposes.

Table 7. Correlation (r) between liveweight and carcass characteristics of broiler

Parameters	Live wt. (g)	Dressing %	Blood wt.	Feather wt.	Head wt.	Neck wt.	Heart wt.	Liver wt.	Spleen wt.	Breast meat wt.	Thigh+ drumstick wt.	Shank wt.	Wing meat wt.	Gizzard wt.	Skin wt.	Abdominal fat wt.	Digestive tract wt.	Lungs wt.	Back +breast bone wt.
Live wt. (g)	1																		
Dressing%	0.43	1																	
Blood wt.	-0.28	-0.51	1																
Feather wt.	0.24	0.04	-0.59	1															
Head wt.	-0.57	-0.38	0.32	-0.41	1														
Neck wt.	-0.05	0.33	-0.31	0.03	-0.31	1													
Heart wt.	-0.43	-0.32	0.27	-0.25	0.13	0.07	1												
Liver wt.	-0.63	-0.26	0.20	-0.17	0.25	0.26	0.72	1											
Spleen wt.	0.03	0.25	-0.30	0.16	0.22	-0.11	-0.33	-0.02	1										
Breast meat wt.	0.67	0.79	-0.52	0.19	-0.44	0.28	-0.39	-0.44	0.37	1									
Thigh+drumstick wt.	0.03	0.07	-0.18	-0.01	-0.25	0.23	0.29	-0.11	-0.48	-0.16	1								
Shank wt.	-0.17	-0.08	0.32	-0.45	0.00	0.35	0.69	0.48	-0.44	-0.34	0.54	1							
Wing meat wt.	0.09	0.01	-0.16	-0.26	-0.11	0.33	0.40	0.09	-0.43	-0.08	0.60	0.62	1						
Gizzard wt.	-0.22	-0.02	-0.24	0.45	-0.08	-0.09	-0.24	-0.08	0.54	0.14	-0.23	-0.51	-0.55	1					
Skin wt.	-0.45	-0.06	-0.10	0.00	0.28	-0.03	0.23	0.38	0.00	-0.05	-0.26	-0.21	-0.44	0.25	1				
Abdominal fat wt.	-0.32	0.18	-0.23	0.18	0.09	0.02	0.08	0.43	0.02	0.00	-0.21	-0.24	-0.43	0.20	0.81	1			
Digestive tract wt.	-0.48	-0.89	0.28	-0.21	0.47	-0.21	0.35	0.28	-0.19	-0.72	0.04	0.14	0.23	-0.07	0.13	-0.17	1		
Lungs wt.	-0.25	-0.19	0.15	-0.12	0.48	-0.38	-0.12	-0.24	0.40	-0.17	-0.10	-0.11	-0.20	0.39	-0.11	-0.37	0.19	1	
Back+breast bone wt.	0.37	0.36	-0.26	0.11	-0.02	0.09	-0.77	-0.64	0.17	0.40	-0.09	-0.42	-0.10	0.15	-0.28	-0.16	-0.33	0.33	1

Table 8. Correlation between morphological characteristics and carcass characteristics

Parameters	Neck length (cm)	Thigh length (cm)	Drumstick length (cm)	Shank length (cm)	Wing length (cm)
Neck length (cm)	1				
Thigh length (cm)	-0.17	1			
Drumstick length (cm)	0.32	0.44	1		
Shank length (cm)	-0.10	0.01	-0.10	1	
Wing bone length (cm)	0.47	0.53	0.37	0.04	1
Live wt. (g)	0.23	0.66	0.56	-0.20	0.55
Dressing percent	-0.16	0.31	0.51	-0.34	-0.14
Blood wt.	0.37	-0.47	-0.46	-0.07	0.02
Feather wt.	-0.02	0.30	0.30	-0.12	0.23
Head wt.	-0.36	-0.04	-0.40	0.28	-0.32
Neck wt.	0.30	-0.16	0.35	-0.02	-0.07
Heart wt.	-0.07	-0.31	-0.08	0.32	-0.17
Liver wt.	-0.11	-0.38	-0.25	0.34	-0.10
Spleen wt.	-0.41	0.20	0.00	0.35	-0.06
Breast meat wt.	0.01	0.59	0.70	-0.19	0.26
Thigh+drumstick wt.	0.15	-0.29	0.26	-0.03	-0.39
Shank wt.	0.12	-0.38	-0.14	0.09	-0.32
Wing meat wt.	0.11	0.13	0.11	0.34	-0.06
Gizzard wt.	-0.04	-0.20	-0.07	0.05	-0.16
Skin wt.	-0.36	-0.11	0.00	-0.15	-0.11
Abdominal fat wt.	-0.20	-0.05	0.16	-0.22	0.03
Digestive tract wt.	-0.04	-0.24	-0.48	0.53	0.04
Lungs wt.	-0.39	-0.14	-0.49	0.24	-0.56
Back+breast bone wt.	0.17	0.31	0.17	-0.07	-0.02

In conclusion, there was no clear advantage of using QPM over normal maize or another hybrid Pacific 11 was found in terms of feed intake, total gain, feed conversion and mortality except for dressing percent. There was no advantage of using additional lysine and methionine in normal maize on productive performance of broilers. However, the dressing percent was higher in normal maize irrespective of addition of lysine and methionine than QPM and Pacific 11. Liveweight and morphological characteristics such as length of drumstick could be used as cheap and valuable tool to estimate carcass characteristics of broiler in areas where modern facilities are not available. It is almost impossible to conclude from only one trial as the final weight of broiler was only around 1.2kg, which should have been around 1.5kg in 35 days. Therefore, several batches of trials are needed to reach to a conclusion.

Acknowledgement

The authors gratefully acknowledge CIMMYT, Bangladesh for funding to carry out this work.

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