Comparative growth performance and carcass characteristics of guinea fowl (*Numida meleagris*) and three chicken genotypes

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ABSTRACT

A study was conducted to compare the growth performance and carcass characteristics of guinea fowl (GF) with Horro (HR) and Tilili (TL) local chickens, and Potchefstroom Koekoek (PK) exotic chicken. Seventy-five-day-old chicks from each genotype were used in 3 replications in a completely randomized design. Commercial starter and grower feed was fed *ad libitum* during the 20 weeks of the study. Daily dry matter intake in g/bird was greater for PK (70) than GF (63), HR (59), TL (61). The final body weight (FBW) g/bird was higher for PK (2022), intermediate for HR (1567) and TL (1539), and low for GF (1286). The average daily weight gain (ADG) was 9 g/bird for GF, 11 g/bird for HR and TL and 14 g/bird for PK. The eviscerated weight g/bird was highest for PK (1679), followed by HR (1323) and TL (1249) and lowest for GF (913). The breast weight (g/bird) was higher for PK (436) than GF (281), HR (311), and TL (284). The thigh weight was higher for PK (303) and HR (252), followed by TL (208) and lowest for GF (157). The abdominal fat content was higher for PK (29 g), followed by HR and TL (12 g each), and low for GF (6 g). The ultimate $pH_{24\ h}$ of the breast was higher for GF (6.0) followed by PK (5.8), HR and TL (5.7). GF had higher pH_{24h} thigh meat (6.2), others had 5.8. The meat from GF was darker than normal in color compared to chickens. The GF, HR and TL local chickens could be used as alternate meat-type poultry species with continuous selection.

Keywords: Chicken; Growth; Guineafowl; Meat
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INTRODUCTION

Poultry production has important economic, social and cultural benefits and plays a significant role in family nutrition and income generation in developing countries.

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Under circumstances of extreme poverty where people cannot keep larger species of livestock due to shortage of land and capital, village chicken provide high-quality animal protein and income for the household (Copland and Alders, 2005). According to the World Population Review (2020), the human population of Ethiopia is estimated to be about 116 million with an annual growth rate of 2.6%, which will significantly increase the demand for animal source food. Accordingly, the government has planned to double meat, egg and milk production to increase the current low production and to enhance livestock product consumption for food and nutrition security.

Poultry is considered to be the best option to lift the proposed plan of animal protein supply and to enhance livestock product consumption through increased egg and meat production within a short period of time. In this regard, besides importing high producing exotic chicken breeds, increasing productivity and use of alternate poultry species that are adapted to the local environment are indispensable. In line with this, guinea fowl can be an option to assist the smallholder and family poultry sector in the country and can contribute to the stretched demand for egg and meat as indicated in the Ethiopian Livestock Master Plan (Shapiro *et al*., 2015). Demand for guinea fowl meat is increasing throughout the world, and when compared with broilers, guinea fowl meat has higher protein and lower fat contents (CAB, 1987). Most consumers of poultry meat have certain expectations of flavor. However, most studies that focused on guinea-fowl meat quality were conducted in barn conditions (Tufarelli and Laudadio, 2015).

Although the smallholder farmers in Metema and Quara districts of the Amhara Regional State of Ethiopia started domesticating and keeping guinea fowl (*Numida meleagris*) for egg and meat production, for income generation and home consumption since the 1990s by introducing them from Sudan, the existence of these birds in Ethiopia was not assessed, tested and reported. Guinea fowls are reared traditionally under the extensive system just like the local chicken and hence their productivity is low. Domestic guinea fowls can be an important alternative poultry species with a promising future for both rural and commercial poultry production system not only due to increasing demand for its gamy flavored meat throughout the world but also for their great potential for providing the much-needed animal protein in human diets in the developing countries (Premavalli, 2013).

Even though the available information about the growth performance and carcass traits of local chickens is minimal (Tadelle Dessie *et al*., 2003; Halima Moges, 2007; Nigussie Dana, 2011; Wondmeneh Esatu, 2015), there was no work done on domestic guinea fowls under indoor systems to investigate their growth performance, carcass yield and characteristics in Ethiopia. The comparative

investigation of the performance of the guinea fowl with local and exotic chicken genotypes, and among the chicken genotypes will provide baseline information to design a genetic improvement strategy for these poultry species for future use as alternative meat-type birds in the country. Therefore, this study was carried out to compare growth performance, carcass yield and characteristics of these poultry types kept under indoor management systems.

MATERIALS AND METHODS

Study area description

The experiment was conducted at Andassa Livestock Research Center (ALRC) of Amhara Agricultural Research Institute (ARARI), Ethiopia. The centre is located at 11°29'N latitude and 37°29'E longitude with an elevation of 1730 meters above sea level. It receives an average annual rainfall of 1150 mm with a temperature ranging from 6.5 to 30°C.

Egg collection and hatching

Eggs for Horro (HR) local chicken were obtained from the 11th generation and Potchefstroom Koekoek (PK) from Debre Zeit Agricultural Research Center, whereas eggs for Tilili (TL) local chicken were collected from smallholder farmers in the Amhara Region, Awi administrative Zone, Tilili area, and domestic guinea fowl (GF) eggs were collected from households at Metema district, West Gondar Administrative Zone, Amhara Regional State of Ethiopia. The number of eggs acquired from the source area were 1100 for HR, 1200 for PK, 900 for TL, and 600 for GF. The eggs were transported to ALRC and stored for 24 hours at room temperature. The eggs were selected for artificial incubation based on size, shape, breakages, cleanliness, and fumigated with 37% formalin aqueous solution to disinfect the eggs against microbes. Seven g of formalin solution per cubic meter of space were heated in an electric frying pan and held for 15 minutes in fumigating chamber with formaldehyde gas. Eggs were coded, tagged and incubated in Pas Reform setter (Smart Set™ of Pas Reform Hatchery Technology BV, The Netherlands) on a separate tray. Eggs were candled on the 9th day of incubation for fertile and clear eggs and transferred at the 19th day of incubation to Smart Hatch™ hatchery on a separate hatch basket, which was coded with the respective genotypes. Guinea fowl eggs were incubated 7 days ahead of chicken eggs since the hatching date for guinea fowl eggs takes 28 days. Hatched chicks and keets (baby guinea fowl) were used for the study by keeping them under an intensive management system.

Management of experimental animals

A total of 75 unsexed baby chicks from each of the poultry genotypes were randomly taken from each of the hatch baskets. Study treatments were the four poultry genotypes in a completely randomized design (CRD). Each treatment was replicated three times comprising of 25 birds per replicate. Pens with a size of 3.5 m × 3.5 m were prepared for guinea fowls and covered with 0.5 × 0.5 cm wire mesh to prevent birds from flying out. Nine pens (2.5 m × 2.5 m) were made and used for the chicken genotypes. The pens, watering and feeding troughs were thoroughly cleaned, disinfected and sprayed with hydrogen peroxide against external parasites before the commencement of the experiment. The floor of each pen was bedded with disinfected grass hay and was replaced when deemed appropriate. The birds were brooded by using 1500-Watt Infra-red electric heaters with gradual hanging height adjustments as a source of heat. The white light bulbs were used for lighting in the experimental house. All chicks and keets were vaccinated against Newcastle, Gumburo (Infectious Bursal Disease-IBD) and Fowl Typhoid diseases using appropriate vaccine according to the manufacturer's recommendation. Birds were fed commercial starter ration up to week 8 and grower ration from week 9 to week 20 (Table 1).

Table 1. Nutrient composition of the diet fed to experimental birds.

Nutrients	Starter	Grower
Metabolizable energy (ME-Kcal/kg)	3000.0	2950.0
Crude protein (% DM)	20.5	18.8
Crude fiber (% DM)	5.5	5.8
Calcium (% DM)	0.9	0.9
Fat (% DM)	6.5	5.0
Moisture (%)	10.0	10.0

The composition is as provided by the manufacturer (Alema Koudjis Feed PLC, Debre Zeit, Ethiopia); DM = Dry matter.

Dry matter intake, average daily gain and feed conversion ratio

Commercial starter and grower feed was offered *ad libitum* twice per day at 0800 and 1700 hours and clean tap water were available all the time. The amount of feed offered and refused per pen was recorded daily, and the amount consumed was determined as the difference between the amount offered and refused. Before the allocation of the birds to the experimental pens, initial body weight (IBW) was taken individually and the average weight was calculated by using an electronic sensitive balance of 0.01 g precision. Then, birds were individually weighed at weekly intervals for the entire experimental period and the pen average of both

sexes was calculated. Bodyweight change (BWC) was calculated as the difference between the final body weight (FBW) and IBW. Average daily gain (ADG) was calculated as BWC divided by the number of experimental days. The feed conversion ratio (FCR) was computed as the ratio of daily dry matter (DM) intake per average daily gain. Mortality was registered as it occurred and general health status was monitored throughout the experiment.

Carcass measurements

At the end of the experiment, three randomly selected male birds from each replicate were withdrawn from feed for 12 hours, weighed and exsanguinated by severing the neck. The body was dry de-feathered by hand plucking and eviscerated and carcass cuts and non-edible offal components were determined according to the procedure described before (Kubena *et al.,* 1974; Kekeocha, 1985). Dressed carcass weight was measured after the removal of blood and feather and the dressing percentage was calculated as the proportion of dressed carcass weight to slaughter weight multiplied by 100. The shank, head, kidney, lungs, pancreas, crop, proventriculus, small intestine, large intestine, caeca and urogenital tracts were removed from the dressed carcass and eviscerated percentage was computed as the proportion of the eviscerated weight to slaughter weight. From eviscerated carcass, drumstick, thigh and breast meat were separated, weighed and expressed as a percentage of slaughter weight. Fat around the proventriculus, gizzard and against the abdominal wall and the cloacae were removed and weighed, and the abdominal fat percentage was calculated as a percentage of slaughter weight. The edible offal components (heart, gizzard and liver) were expressed as a percentage of slaughter weight. Weight of the gastrointestinal tract parts was weighed without contents and slaughter body weight. The lengths of the gut parts were measured using a measuring tape.

Meat pH and color measurements

Meat pH was measured at fifteen minutes (pH_{15min}) and twenty-four hours ($pH_{24\ h}$) of postmortem after evisceration using a penetrating glass electrode of a portable meat pH meter (HI99163, HANAN) on the breast and thigh muscle. The probe was calibrated with pH 4.1 and 7.1 standard buffer solutions. The electrode pointer was thoroughly cleaned with distilled water and a cotton towel before and after each reading. For meat color measurements, the cut surface of samples frozen at 4 °C was freshly exposed on a flat surface of the white background and allowed to bloom for about 30 minutes at ambient temperature. Then, meat color parameters, i.e., CIE L*a*b*values (L* = lightness, a* = redness and b* = yellowness) were obtained using the digital colorimeter (Hunter Lab MiniScanEZ, Serial No. Ms EZ1547,

45/0° illumination/viewing system, D65 light source, and 10° observer angle) calibrated with black and white standardized calibration plates between sample measurements (AMSA, 2012). Three random readings at different locations per sample were taken and averaged.

Statistical analysis

Data were analyzed using the general linear model procedure of Statistical Analysis Systems Software (SAS, 2009). When F-test declare significant differences at $\alpha < 0.05$, differences among treatment means were separated using Tukey Kuramer Test. The model used for data analysis was $Y_{ij} = \mu + G_i + e_{ij.}$ Where: Y_{ij} = represents the j observation in the i^{th} breed level; μ = overall mean; G_i = genotype effect; and e_{ij} = random error.

RESULTS

Dry matter intake, average daily gain and feed conversion ratio

Dry matter intake during the starter and finisher phase as well as the entire experimental period was higher ($p < 0.05$) for PK than HR and TL (Table 2). Dry matter intake of GF was similar to that of PK during the starter phase but consumed less feed in the finisher and the whole experiment compared to PK, and GF has greater feed intake than HR and TL for the entire experiment ($p < 0.05$). The hatched-out weight (IBW) was significantly highest ($p < 0.0001$) for PK, followed by HR and TL and lowest for GF. The FBW during the starter phase for PK was significantly higher, intermediate for GF, lowest for HR and TL ($p < 0.0001$). The starter phase BWC and ADG for PK and GF were significantly higher ($p < 0.0001$) than that for HR and TL local chickens. Although no FCR difference was observed among GF, HR, and TL, the values were significantly higher ($p < 0.0001$) than the FCR values. However, PK has relatively a better ratio value during the starter phase than the grower and the entire experiment period. The BWC and ADG during the growing phase were significantly highest for PK, intermediate for HR and TL and lowest for GF ($p < 0.0001$). The final BW, BWC and ADG during the entire experiment period were significantly highest ($p < 0.0001$) for PK, intermediate for HR and TL and the lowest for GF. There were no differences ($p > 0.05$) in the survival rate among the genotypes and the mortality was within the acceptable rate.

Carcass measurements

Carcass weights of slaughter, dressing, wing, back, and eviscerated were significantly higher for PK ($p < 0.0001$) than other genotypes (Table 3). Dressing,

eviscerated, thigh, wing, and neck percentages were not ($p > 0.05$) different among genotypes. Breast weight was significantly higher ($p < 0.0001$) for PK, but similar among GF, HR, and TL genotypes. The proportion of breast was significantly highest ($p < 0.05$) for GF, intermediate for HR and PK, and lowest for TL.

Table 2. Performances of different poultry genotypes kept under an intensive management system.

Parameters	Genotypes				SE	*p*-value
	GF	HR	TL	PK		
Starter phase (0-8 weeks)						
IBW (g/bird)	21.7^{c}	31.5 ^{b}	31. 8^{b}	35.6 ^{a}	0.36	<0.0001
DM intake (g/bird)	48.9^{ab}	48.1^{b}	47.7^{b}	50.0^{a}	0.49	0.0480
FBW (g/bird)	696.9^{b}	635.5^{c}	644.2^{c}	740.7^{a}	11.96	<0.0001
BWC (g/bird)	675.3^{a}	603.9^{b}	612.4^{b}	705.1^{a}	12.15	<0.0001
ADG (g/day)	12.1^{a}	10.8^{b}	10.9^{b}	12.6^{a}	0.21	<0.0001
FCR (feed: gain)	4.1^{a}	4.5^{a}	4.4^{a}	3.9^{b}	0.05	<0.0001
Survival (%)	96.0	96.0	94.7	97.3	0.94	0.3300
Growing phase (8-20 weeks)						
DM intake (g/bird)	76.4^{b}	70.2^{c}	73.6b^{c}	90.5^{a}	1.17	<0.0001
BWC (g/bird)	589.2^{c}	931.7^{b}	894.3^{b}	1280.9^{a}	20.38	<0.0001
ADG (g/day)	6.5^{c}	10.2^{b}	9.8^{b}	14.1^{a}	0.22	<0.0001
FCR	11.8^{a}	6.9b^{c}	7.5^{b}	6.4^{c}	0.23	<0.0001
Survival (%)	97.2	94.4	95.8	97.2	1.20	0.3630
Entire experiment (0-20 weeks)						
DM intake (g/bird)	62.7^{b}	59.1^{c}	60.7^{c}	70.3^{a}	0.61	<0.0001
FBW (g/bird)	1286.2^{c}	1567.1^{b}	1538.5^{b}	2021.6^{a}	14.00	<0.0001
BWC (g/bird)	1264.5^{c}	1535.6^{b}	1506.7^{b}	1985.9^{a}	13.99	<0.0001
ADG (g/day)	9.0^{c}	11.0^{b}	10.8^{b}	14.2^{a}	0.69	<0.0001
FCR	6.9^{a}	5.4^{c}	5.6^{b}	6.0^{a}	0.07	<0.0001
Survival (%)	93.3	90.7	90.7	94.7	1.76	0.3430

^{a,b,c}Means within a row with different superscripts differ ($p < 0.05$); GF = Guineafowl; HR= Horro local chicken; TL = Tilili local chicken; PK = Potchefstroom Koekoek; SE = Standard error of the mean; DM = Dry matter; IBW = initial bodyweight; FBW = final bodyweight; BWC = bodyweight change; ADG = Average daily weight gain; FCR = Feed Conversion Ratio.

The thigh and drumstick cut weights were significantly higher ($p < 0.0001$) for the PK and HR and intermediate for TL and lowest for GF genotypes. The proportion of thigh was similar ($p > 0.05$) across all genotypes, whereas the proportion of drumstick was significantly highest for HR and TL, followed by PK and lowest for GF ($p < 0.0001$). The highest ($p < 0.01$) neck weight was measured for PK and TL,

intermediate for HR and lowest for GF. Compared to guinea fowls, chickens recorded higher weights for the heart, liver, and gizzard. Among the chicken genotypes, PK recorded significantly greater weights of the edible offal components ($p < 0.0001$). However, the percentage share of the edible offal components was not different ($p > 0.05$) among all genotypes.

Table 3. Carcass components of meat from different poultry genotypes kept under an intensive system.

Parameters	**Genotypes**				**SE**	***p*-value**
	GF	**HR**	**TL**	**PK**		
Slaughter weight (g)	1308.3^{c}	1853.9^{b}	1788.9^{b}	2448.4^{a}	86.58	<0.0001
Dressed weight (g)	966.7^{c}	1388.1^{b}	1310.4^{b}	1759.1^{a}	58.61	<0.0001
Dressing (%)	73.8	74.8	73.2	72.2	1.19	0.4740
Eviscerated weight (g)	913.1^{c}	1322.8^{b}	1249.1^{b}	1679.3^{a}	57.12	<0.0001
Eviscerated (%)	69.7	71.3	69.7	68. 9	1.14	0.5080
Breast weight (g)	281.3^{b}	310.7^{b}	283.8^{b}	436.3^{a}	16.77	<0.0001
Breast (%)	21.4^{a}	16.7^{b}	15.8^{c}	17.9^{b}	0.59	<0.0001
Thigh weight (g)	157.3^{c}	252.2^{ab}	208.0^{b}	303.0^{a}	17.02	<0.0001
Thigh (%)	12.0	13.6	11.6	12.0	0.58	0.1292
Drumstick weight (g)	113.8^{c}	231.3^{ab}	209.6^{b}	262.9^{a}	12.84	<0.0001
Drum stick (%)	8.7^{c}	12.5^{a}	11.7^{ab}	10.8^{b}	0.43	<0.0001
Wing weight (g)	64.9^{c}	83.7^{b}	83.9^{b}	104.3^{a}	4.95	0.0002
Wing (%)	5.0	4.5	4.7	4.3	0.23	0.2243
Back weight (g)	110.2^{c}	157.6^{b}	170.1^{b}	236.8^{a}	12.95	<0.0001
Neck weight (g)	48.4^{c}	63.9^{b}	70.0^{ab}	94.5^{a}	5.23	0.0018
Neck (%)	3.7	3.4	3.9	3.8	0.20	0.4970
Gizzard weight (g)	22.4^{c}	26.7^{b}	27.4^{b}	42.4^{a}	1.43	<0.0001
Gizzard (%)	1.7	1.4	1.5	1.8	0.10	0.1415
Liver weight (g)	17.1^{c}	25.1^{b}	27.3^{b}	35.7^{a}	1.96	<0.0001
Liver (%)	1.3	1.4	1.5	1.5	0.12	0.5061
Heart (g)	6.7^{c}	9.7^{b}	9.4^{b}	11.2^{a}	0.54	<0.0001
Heart (%)	0.5	0.5	0.5	0.4	0.03	0.4940
Abdominal fat (g)	6.1^{c}	12.1^{b}	11.2^{b}	29.3^{a}	1.61	<0.0001
Abdominal fat (%)	0.5^{b}	0.7^{b}	0.6^{b}	1.2^{a}	0.07	<0.0001

^{a,b,c}Means within a row with different superscripts differ ($P < 0.05$); GF = Guinea fowl; HR= Horro local chicken; TL = Tilili local chicken; PK = Potchefstroom Koekoek; SE = Standard error of the mean.

The abdominal fat weight was significantly highest ($p < 0.05$) for PK, intermediate for local chicken genotypes and lowest for GF. The percentage of the abdominal fat was significantly higher for PK than the other chicken genotypes. The meat from GF was leaner compared to chicken genotypes.

Chicken genotypes had significantly heavier and longer ($p < 0.0001$) small and large intestines than guinea fowls (Table 4). However, among the chicken genotypes, PK had the heaviest and longest small and large intestines. The esophagus and crop weight were significantly higher ($p < 0.0001$) for PK, followed by HR and lowest for GF and TL. The proventriculus weight was the highest for PK, intermediate for TL and lowest for GF and HR. Guinea fowl had significantly higher weight and longer caeca than other genotypes. The length of the proventriculus was the highest for PK and TL, and GF was intermediate whereas, HR has the shortest ($p <0.01$).

Table 4. Weight and length of gut parts of male birds from different poultry genotypes kept under an intensive system.

Parameters	**Genotypes**				**SE**	***p*-value**
	GF	**HR**	**TL**	**PK**		
Esophagus and crop weight (g)	8.9^{c}	9.7^{b}	8.5^{c}	12.0^{a}	0.19	<0.0001
Proventriculus weight (g)	6.6^{c}	6.8^{c}	8.1^{b}	9.5^{a}	0.28	<0.0001
Small intestine weight (g)	46.2^{c}	62.5^{b}	64.7^{b}	84.9^{a}	2.05	<0.0001
Large intestine weight (g)	5.6^{c}	7.2^{b}	7.1^{b}	8.2^{a}	0.24	<0.0001
Caeca weight (g)	8.9^{a}	7.2^{b}	7.1^{b}	7.6^{b}	0.27	0.0004
Esophagus and crop length (cm)	13.6	14.2	12.7	15.2	0.86	0.2505
Proventriculus length (cm)	5.0b^{c}	4.1^{c}	5.8^{ab}	7.2^{a}	0.49	0.0023
Small intestine length (cm)	86.4^{c}	108.3^{b}	111.3^{b}	138.8^{a}	3.19	<0.0001
Large intestine length (cm)	21.1^{c}	26.0^{b}	25.0^{b}	33.5^{a}	1.06	<0.0001
Caeca length (cm)	16.5^{a}	13.1^{c}	13.4^{c}	14.4^{b}	0.31	<0.0001

^{a,b,c}Means within a row with different superscripts differ (P < 0.05); GF = Guineafowl; HR= Horro local chicken; TL = Tilili local chicken; PK = Potchefstroom Koekoek; SE = Standard error of the mean.

Meat pH and color measurements

The breast muscle pH_{15min}, pH_{24h} and the thigh meat pH_{15min} were significantly highest for GF, followed by PK, and lowest for HR and TL. Thigh muscle pH_{24h} was significantly higher ($p < 0.0001$) in GF than the rest of chicken genotypes, while there was no difference among the chicken genotypes (Table 5). However, the ultimate pH (pH_{24h}) values for both meat cuts tended to be lower compared to the initial (pH_{15min}) values. The breast meat color after 15 minutes and 24 h of postmortem was not different ($p > 0.05$) among all of the genotypes although breast meat in GF tended to be redder ($p < 0.09$). The lightness (L*) color of the thigh meat of chicken genotypes was significantly higher ($p < 0.01$) compared to GF both at initial and 24 hours readings. The redness (a*) color for breast and thigh meat from GF after 24 h of storage were significantly higher ($p < 0.0001$) than the rest of

chicken genotypes, whereas chickens showed similar redness (a*) reading. There was no difference ($p > 0.05$) in yellowness (b*) color of breast meat across all of the genotypes after cold storage. However, the yellowness (b*) values of thigh muscle cut after storage for 24 h showed the highest ($p < 0.0001$) for HR and PK but intermediate for TL and lowest for GF genotypes.

Table 5. Initial and ultimate pH and color of breast and thigh meat from different poultry genotypes kept under an intensive system.

	Parameters	**GF**	**HR**	**TL**	**PK**	**SE**	***p*-value**
Breast	pH_{15min}	6.2^{a}	5.8^{c}	5.8^{c}	6.0^{b}	0.03	0.000
(Pectoralis	L*	47.2	51.0	50.5	51.0	2.08	0.463
major)	a*	5.3	4.0	3.3	4.1	0.52	0.090
	b*	12.2	12.3	12.0	12.7	0.58	0.868
	pH_{24h}	6.0^{a}	5.7^{c}	5.7^{c}	5.8^{b}	0.02	0.000
	L*	45.5	51.0	51.8	49.8	2.59	0.352
	a*	8.6^{a}	6.1^{b}	5.9^{b}	5.2^{b}	0.46	0.000
	b*	11.9	11.9	10.5	11.8	0.89	0.635
Thigh	pH_{15min}	6.4^{a}	5.9^{c}	5.9^{c}	6.1^{b}	0.03	0.000
(*biceps*	L*	36.5^{b}	43.9^{a}	43.9^{a}	44.2^{a}	1.49	0.003
femoris)	a*	10.3^{a}	8.3^{b}	7.3^{b}	7.4^{b}	0.62	0.011
	b*	10.8	14.1	11.9	10.9	1.35	0.304
	pH_{24h}	6.2^{a}	5.8^{b}	5.8^{b}	5.8^{b}	0.05	0.000
	L*	35.2^{b}	45.9^{a}	44.4^{a}	44.9^{a}	1.25	0.000
	a*	10.5^{a}	8.9^{b}	7.6^{b}	8.1^{b}	0.42	0.000
	b*	7.7^{c}	10.8^{ab}	9.5^{b}	11.4^{a}	0.48	0.000

^{a,b,c} Means within a row with different superscripts differ ($P < 0.05$); pH_{15} = pH value after 15 minutes of postmortem; pH_{24} = meat pH value after 24 hours; L* = lightness; a* = redness; b* = yellowness; GF = Guineafowl; HR= Horro local chicken; TL = Tilili local chicken; PK = Potchefstroom Koekoek; SEM = Standard error of the mean.

DISCUSSION

The ADG of GF during starter phase was higher and similar with PK as compared to other chicken genotypes. Saina (2005) reported ADG of 12.3 g for guinea fowls under an intensive system at the age of 16 weeks, which was higher as compared to the ADG recorded at 20 weeks in the present study. Similar to the present study, Mohammed and Dei (2017) recorded daily weight gains of 7.8 g/bird/day for the first eight weeks of local GF keets brooded under an intensive management system.

The variation in ADG from the current study might be due to the protein content of the feed, which was assumed to be a contributing factor to affect ADG as reported by Avornyo *et al*., (2013). The average daily gain of the GF keets declined as the growers fed crude protein content reduced to 18.5% in the commercial diet. In this regard, Seabo *et al*. (2011) noted that the feed intake and body weight gain of GF increased with increasing dietary protein. During the first eight weeks of the starter phase, GF had better ADG and final BW compared to chicken genotypes. In line with the current finding, Nahashon *et al*. (2006) reported a mean body weight of 787.1 g at eight weeks of age from a meat-type variety of GF in the USA. A lower live weight of 377.7 g at eight weeks of age in local GF raised under an intensive system was also reported in a study conducted in Bangladesh (Khairunnesa *et al*., 2016). The highest DM intake and ADG from PK could be a result of the past genetic improvement interventions made in this chicken breed.

For local chickens, Solomon Demeke (2003) observed a live weight of 1300 g under intensive production at 20 weeks of age, and Halima Moges *et al*. (2006) reported initial body weight, final body weight, ADG, and FCR of 27.2 g, 1191 g, 7.6 g, and 11.9 for Tilili local chickens under the indoor system, respectively. Wondmeneh Esatu (2015) also reported FBW of 964.2 and FCR of 12.4 for Horro chickens during 16 - 20 weeks under indoor system rearing. An FBW of 824.4 and 590.7 g at 20 weeks of age were reported for Savannah and Forest ecotypes of Benin local chicken ecotypes, respectively under an indoor system (Youssao *et al*., 2012). These authors also reported an ADG of 8.4 g and 5.8 g for Savannah and Forest ecotypes reared to 16 to 20 weeks of age. These results were lower when compared to the current findings for GF and local chicken genotypes. The higher result obtained in the current study could be an attribute of differences in the quality of feed offered to chickens, health care, and environmental conditions and the genetic difference between the ecotypes.

The FCR for the GF keets during the first eight weeks of age was 4.1, which was in the range of FCR value of 4 - 4.5 reported for GF (Nobo *et al*., 2012). Seabo *et al*. (2011) reported an FCR values of 6.4 to 6.7 for GF keets fed on commercial poultry rations during the first six to 12 weeks of age, and was similar to the average FCR results (6.9) of the current study. Mwale *et al*. (2008) noted that decreasing FCR with the lower age could be due to increasing feed quantities needed for the fast growth. However, the result on DM intake of GF in the present study seems to be overestimated due to pronounced selective feeding and use of its beak for tearing with abrupt head movements, a form of behavior that leads to tremendous mash feed wastage from the feeders. The performances of GF during the first eight weeks of age indicated their growth potential on a better protein content diet indicating the opportunity to develop meat-type guinea fowls. Similarly, TL local chicken

ecotypes possess the potential for the development of meat-type local chicken breed through selection as indicated by their relatively better growth. The PK showed greater performance than the GF and indigenous chicken genotypes in all parameters analyzed in the current study. The better DM intake and growth performances of PK might be attributed to genotypic differences. There was no statistical survivability difference among all genotypes. Confining the birds with the provision of sufficient and balanced feed, water, heat and light under an intensive management system significantly reduced keet and chicken mortality (Mohammed and Dei, 2017).

Significant differences were observed between chickens and domestic guinea fowls in terms of their carcass yield, gastrointestinal parts, and meat physicochemical properties. The dressing percentage (DP) of all of the genotypes tested was similar, suggesting that domestic GF can be adopted to complement chickens as a source of poultry meat in Ethiopia. Contrary to our findings, Musundire *et al*. (2018) reported that guinea fowls had heavier body weight and relative hot carcass and cold dressed weight than chickens from scavenging production system. The higher pre-slaughter live weight of chicken genotypes compared to GF genotypes has been associated with significantly heavier dressed, eviscerated, and primal meat cut weights. Besides the confinement of domestic GFs, which limited their performance, the lower results obtained for all of the parameters analyzed might be attributed to genotypic differences. In line with GF genotypes evaluated in the current study, the mean body weight of Sudanese GF from the Blue Nile population was reported to be 1263.3 g with the corresponding average dressed carcass weight of 934.1 g (Eltayeb *et al*., 2015). Similarly, the dressing percentage (DP) for poultry meat from the current study ranged from 72.2 to 74.8%, which is in agreement with the average DP value of 73% (Muth *et al*., 2006). Moreover, the 75.4% DP of the GF reared under intensive management system (Ahaotu *et al*., 2019) and 72.8% for PK at 15 weeks of age (Melesse *et al*., 2013) were in line with the current findings.

A significantly higher share of breast muscles of GF as compared to chicken genotypes was in line with Swatland (1994), who reported extensive variation in poultry body proportions across breeds. Guinea fowls are fast runners, which could explain their lighter leg (thigh and drumstick) than chickens, which was in line with the report of Musundire *et al*. (2018). The lower weights observed for the prime cuts of breast, thigh, and drumsticks in guinea fowls might be due to the small skeletal frame of the GF compared to chicken genotypes, as reported by Musundire *et al*. (2018). Generally, the heavier carcass and carcass components obtained from the PK genotypes could be attributed to genotypic differences since PK is a dual-purpose line with a heavy frame (Van Marle-Köster *et al*., 2009). The greater gizzard, liver, and heart relative weights in chickens than in GF, might be due to the variation in species morphology and genetics. Guinea fowls and indigenous

chickens of HR and TL accumulated less abdominal fat than PK in the study as they are characterized by having lean meat composition. It was stated that guinea fowl meat has a low-fat content of 4% as compared to chickens, beef (21%), lamb (25%), and pork (21%), which makes it appealing to health-conscious consumers (Musundire *et al.*, 2018). The heavier weight of the liver in PK and local chickens compared to GF can be related to the high abdominal fat content of the chicken species that makes animals prone to metabolic disorders such as fatty liver diseases and sudden death (Skřivan *et al*., 2000). The higher abdominal fat contents of PK compared to GF and local chicken genotypes were consistent with the results obtained by Musundire *et al.* (2018).

The caecum is an important organ in the digestive system because it is responsible for cellulose digestion, fermentation and immune cell production (İlgün *et al*., 2018). Chicken caeca length was reported to range from 14.2 to 20.1 cm (Taşbaş, 1978). The GF caeca were longer than the chicken genotypes, which was in agreement with İlgün *et al*. (2018). The relatively long and heavy caeca observed for GF could be an attribute of scratching and ingesting grass used as litter material as observed during the entire experiment. Fibrous feed requires space for fermentation and cellulose digestion. The longer caeca might have the advantage to assist digestion of the fibrous feed materials. Since the experimental animals were all reared under the same housing and management conditions and compared at the same age, differences between breeds in the parameters measured indicate the genetic variations. Although the PK is top-performing among the birds compared, the local chicken genotypes and GF showed a promising result for carcass yield and characteristics, indicating the potential to develop local meat-type poultry species that are best adapted for future use through a selective breeding scheme.

The pH is one of the most important physicochemical characteristics in meat since it is related to water holding capacity and color (Bosque *et al.,* 2020). The pH of broiler meat is the function of the amount of glycogen in the muscle before slaughter and the rate of glycogen conversion into lactic acid after slaughter (Mir *et al*., 2017). A high pH value shortens the meat shelf life since it creates a more favorable environment for bacteria (Sarica *et al.,* 2019). The current study pH measurement results indicated that the initial pH ($pH_{15\ min}$) of breast and thigh meat was higher compared to the ultimate pH (pH_{24h}) for all of the genotypes in the current study, which is in line with the studies in Chinese indigenous chickens (Guan *et al*., 2013). The decline in postmortem pH can be related to the most important events in the conversion of muscle to meat due to its impact on meat texture, color, and water holding capacity and the rate of declining is dependent on the activity of glycolytic enzymes just after death and the initial glycogen reserves of the muscle (Devatkal *et al.*, 2018). In line with the current findings, the pH of GF

breast and thigh meat ranged between 6.1 and 6.5 (Kokoszynski *et al*., 2011). However, the breast and thigh-meat pH values from 18-weeks-old male GF reared under the indoor system had a higher value of 6.8 and 7.3 (Sarica *et al*., 2019) than in the present study. The pH values of breast and thigh meat of GF were higher than that of chicken genotypes (Laudadio *et al*., 2012). The pH value of the thigh meat in the current study was higher compared to the breast meat from all genotypes and mainly from GF, which is in agreement with the reports of Laudadio *et al*. (2012). In line with the current findings, the pH values from breast and thigh meat of Chinese indigenous chicken breeds were reported to range from 5.5 to 5.8 and 5.9 to 6.3, respectively (Guan *et al*., 2013). Generally, the studies show that pH values for breast meat were lower compared to thigh meat. The pH of meat may be influenced by other internal factors such as muscle type, chicken strain, and external factors including feed, fasting, stress, electrical stimulation and chilling (Santos *et al*., 2005).

The pH of the meat seems to have a strong influence on the color of the meat. As a result, the meat from GF in the current study was darker than the meat from chicken genotypes. In this regard, it was noted that higher pH values resulting in darker meat color, while lower muscle pH values are associated with lighter meat (Wideman *et al*., 2016). For poultry fillets, the typical range of pH values 24 h after slaughter is between 5.6 and 6.2 (Bruckner *et al*., 2012), which can be considered normal. Hence, the ultimate pH results of all genotype breast in the present study are in line with the above range indicating the meat from all poultry genotypes fall within the normal range.

Besides the meat pH value, meat color is highly correlated to the amount of haem-containing compounds such as myoglobin, haemoglobin, and cytochrome-c (Wideman *et al*., 2016). Meat color is one of the first traits noticed by consumers and thus an indicator of meat quality (Guan *et al*., 2013). Therefore, the characteristic differences in meat color of the current study between GF and chicken genotypes may influence consumer preference when they are used to make the same dish (Jayasena *et al*., 2013). Qiao *et al*. (2001) determined the border values for color of chicken breast muscle: lighter than normal ($L^* > 53$), normal ($48 < L^* < 53$) and darker than normal ($L^* < 48$). According to this border value, the lightness (L*) color values in the present study for the fresh and cold raw breast meat without skin from chicken genotypes fall under the normal range, while that of GF breast meat tends to be darker than normal. Chicken breast meat generally appears to have a pink color, which is considered a desirable characteristic by the consumers and has a normal color (Choo *et al*., 2014).

The lightness color (L*) for thigh meat from chicken genotypes from the current study is in line with the values ranged from 41.78 - 42.6 for fowl thigh meat

(Tufarelli and Laudadio, 2015; Kokoszynski *et al*., 2011; Laudadio *et al*., 2012). The L* value of chicken breast and thigh meat is higher than the GF breast and thigh meat, which can be related to lower pH values of chicken breast and thigh meat (Hasan *et al.,* 2019), where the L* value of broiler breast meat was higher than cockerel breast meat with the lower pH values of broiler breast meat. The thigh meat L* color in GF genotype was in line with the previous relationship of pH value and L* values. It is well documented that the darker color of leg/thigh meat is due to the larger amount of myoglobin and haem pigments, as well as relatively a higher pH when compared to breast meat (Wideman *et al.*, 2016). It was noted that the red fibers are high in myoglobin as compared to white fibers and hence contributed to the thigh meat color to have a lower lightness value from the current study (Barbut, 2001). This was because the leg and thigh meat have a higher proportion of red muscle fibers, while the breast meat is almost entirely composed of white fibers.

The redness (a*) color in GF breast meat after cold storage for 24 h was higher compared to chicken genotypes, which is consistent with the reports of Bosque *et al*. (2020). The redness (a*) values of breast and thigh meat of GF from the current study was higher and lower than the values reported by Sarica *et al*. (2019) and Kokoszynski *et al*. (2011), respectively but similar to that of Laudadio *et al*., (2012). In agreement with the present finding, a higher value of redness in GF meat in comparison to broilers chickens was reported by López-Pedrouso *et al*. (2019). Although the genetic differences might have contributed to the variation in breast and thigh meat color, the tendency for GF meat to be darker or redder under an intensive production system might be due to slower growth and higher physical activity in the experimental pens.

There was no difference among genotypes in the yellowness (b*) color of breast meat, but chicken showed a higher yellowness color for thigh muscle cut compared to the GF. However, the values in yellowness color (b*) of the current study is in line with the values ranged from 8.2 to 13.8 reported for the breast meat of four different Chinese indigenous chicken genotypes (Guan *et al*., 2013). Contrary to the current yellowness (b*) color result, lower values of 5.1 and 2.0 for breast and thigh meat of GF, respectively (Sarica *et al.,* 2019), and higher values (17.4 - 19 for breast and 17.2 - 18.9 for thigh) for Korean native chickens (Jayasena *et al*., 2013) were reported. The higher yellowness color content of the thigh muscle from HR and PK may be related to the higher intramuscular fat content of the meat cut from this muscle portion (Fanatico *et al.,* 2005).

CONCLUSION

The DM intake, ADG, and the final BW were confirmed to vary with bird genotypes, whereby PK had higher values. Similarly, slaughter, dressed, and eviscerated weights of the carcass varied with chicken genotypes, i.e., high for PK. Patterns were the same for the main meat cuts and the breast weight. Higher abdominal fat content from PK might be associated with higher liver weight. Higher caeca length and weight observed on GF might be related to the feeding habit of the bird. Adaptation to scavenging also appeared to have a role, where GF birds were found more stressed in confined conditions. The pH values of meat cuts followed a similar pattern in all genotypes, i.e., high for initial pH and less for ultimate pH. Meat color varied with part of the meat cuts, i.e, breast (normal) for chicken and thigh (dark), whereas both meat cuts of GF inclined to be dark. From the result of the current study, it could be concluded that the higher performance of PK genotypes for all parameters investigated is expected since the breed was a well-developed dual-purpose breed of South Africa. The relative performance recorded by HR and TL chicken genotypes showed the potential for implementing future selection and breeding schemes to use as alternate locally adapted meat-type poultry breeds.

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Conflict of interest

The authors declare no conflicts of interest regarding the publication of this paper.

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