Assessing growth performance, morphometric traits, meat chemical composition and cholesterol content in four phenotypes of naked neck chicken

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ABSTRACT The present study was conducted to assess the growth performance, morphometric traits, muscle chemical composition and cholesterol content in four phenotypes of naked neck chicken (black, white-black, light brown and dark brown). A total of 320-day-old chicks, 80 from each phenotype, were randomly stratified into 20 replicates (16/replicate), according to a completely randomized design. The results showed higher final body weight, weight gain, and better FCR in both light brown and dark brown phenotypes whereas time of gains was found to be greater in dark brown phenotype. Keel length and shank circumference were greater in dark brown whereas wing spread was found to be higher in light brown phenotype. Drumstick circumference and body length did not show any significant differences ($P > 0.05$) across the phenotypes. Dry matter was found to be higher in white black, crude protein in black, white black and dark brown, moisture in light brown, and cholesterol content in black whereas ether extract and ash content were found to be greater in black and white black phenotypes. In conclusion, both light brown and dark brown phenotypes showed superior growth performance and morphometric traits. Similarly, from a health point of view, the dark brown and light brown phenotypes seem superior because their cholesterol content was low. Thus, it is strongly recommended that there should be a conscious effort to improve economically important traits of the light and dark brown birds to be used as dual-purpose slow growing chicken, especially in developing countries.

Key words: growth performance, morphometric trait, chemical compositional, cholesterol, phenotype

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INTRODUCTION

Severe shortage of animal proteins is becoming one of the major issues in developing countries (Shafiq, 2016). In Pakistan, the poultry industry is one of the most systematized segments of agriculture sector providing employment to more than 1.5 million people in country, with an investment of more than Rs 750 billion (Pakistan Economic Survey, 2020-2021). This industry is growing at an impressive rate of approximately 7.5% per annum over the last decade (Pakistan Economic Survey, 2020-2021). There are 91.22 million indigenous poultry birds contributing 4,472 million eggs, 127.22 million tons of meat sharing of 28% in the total meat production of the Pakistan (Pakistan Economic Survey, 2020-2021). Growth is normally attained by a systematic sequence of maturational changes and involves deposition of protein and increase in length and size of morphometric parts (Edward, 2000). A number of morphological characteristics are known to be the pointers of body growth and market value of chicken apart from body weight (Edward, 2000).

Meat is a highly nutritious food because it provides not only all the essential amino acids (**EAA**), but also micronutrients, such as minerals and vitamins (Biesalski, 2005).

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Among meat sources, chicken meat contains higher protein as well as lower fat and cholesterol contents as compared with the red meat, and is considered beneficial for human health (Choe et al., 2010). The consumption of poultry meat has increased mainly because of their nutritional, sensory, and aesthetic characteristics (Bogosavljevic-Boskovic et al., 2010). Chicken lipids are characterized by relatively high level of unsaturated fatty acids, especially polyunsaturated fatty acids (**PUFA**), which are regarded as a positive healthy aspect by consumers (Bonoli et al., 2007).

Recently, growing consumer interest in eating healthier meat has resulted in an increasing interest in indigenous chicken breeds, because the meat of indigenous chicken breeds has higher protein and lower fat contents as well as unique flavors compared with the broilers (Jayasena et al., 2013). Therefore, consumers prefer indigenous chicken meat rather than to commercial broiler meat, because indigenous chicken meat has more chewy and tasty meat (Shafiq, 2016). Indigenous chicken breeds are regarded as a superior source for the production of meat (Ibrahim et al., 2019) having high nutritional value (Jung et al., 2015). The success of any food product is determined by consumer acceptability, which is largely determined by the perception of quality (Dransfield et al., 2001). The cholesterol levels are comparatively lower in naked neck chicken eggs as compared to other egg laying breeds (Rajkumar et al., 2010). For the fatty acid composition of naked neck and indigenous chickens, both breast and thigh muscles contained more saturated fatty acids than unsaturated fatty acids (Wattanachant, 2008).

In Pakistan, naked neck, Fayoumi, Desi, and Aseel are the most important rural chickens, being reared as backyard poultry (Sadef et al., 2015). Among all these, naked neck is getting popularity for better performance, significantly higher body weight and egg production (Fathi et al., 2008; Sharifi et al., 2010). Its ability to withstand and produce better in hot climatic conditions has made it ideal for backyard poultry farming especially in tropical areas (Patra et al., 2002). Keeping in view that, it is need of the time to work on getting baseline information regarding morphometric traits, growth performance, compositional profile, and cholesterol content of different phenotypes of naked neck chicken in local climatic condition of Pakistan. The present study was designed to assess the growth, morphometric traits, compositional profile, and cholesterol content in 4 phenotypes of naked neck chicken (black, white-black, light brown, and dark brown) located in Pakistan.

MATERIALS AND METHODS

Location and Duration of Experiment

The study was executed at Indigenous Chicken Genetic Resource Centre (**ICGRC**), Department of Poultry Production, UVAS, Ravi campus Pattoki, Pakistan. Pattoki is located at 31° 1′ 0 N and 73° 50′ 60 E with an altitude of 186 m (610 ft). This city experiences normally hot and humid tropical climate with temperature ranging from 05°C in winter and + 45°C in summer. The study was approved by the Ethical Review Committee after they had ensured that the welfare of the birds would be protected. The experiment lasted for 20 wk.

Experimental Birds and Husbandry

A total of 320-day-old naked neck chicks comprising four phenotypes (black, white black, light brown, and dark brown) were divided into 4 treatment groups having 5 replicates of 16 birds each, according to a completely randomized design. Chicks were kept in 20 different cages (each measuring 4−2 feet) placed in a well-ventilated open sided poultry house under similar management and nutritional conditions. Brooding temperature was maintained at 34 ± 1°C to 26 ± 1°C from first to third week of rearing, after which, the birds were kept at a natural ambient temperature up to 20 wk of age. The chicks were vaccinated against Newcastle disease and infectious bronchitis disease to avoid spread of infection. All birds were wing-tagged and weighed individually and provided free access to clean and fresh drinking water through nipple drinkers up to 8 weeks of age. Thereafter, nipples were replaced by round drinkers up to 20 wk of age and were provided only natural day light. The experimental birds were fed a balanced ration, containing 17% crude protein and 2,850 kcal metabolizable energy/kg (Table 1).

Data Collection

In the present study, the data for growth performance (feed intake, body weight, and livability) and morphometric traits (body length, neck length, keel length, wing span, shank length, shank circumference, drumstick length, drumstick circumference) of different phenotypes were recorded at 8 wk of age. Feed intake was measured by subtracting the feed refused from the total feed offered. Weight gain was measured as the difference between final weight and initial weight. Dead birds were collected twice daily and livability percentage was

Table 1. Dietary composition of grower ration.

Ingredient (%)	Value
Corn	62.11
Soybean meal (48% CP)	31.05
Soybean oil	3.01
Sodium chloride	0.33
Dicalcium phosphate	1.74
Limestone, pulverized	1.31
Supplement	0.30
DL- Methionine	0.15
Total	100.00
Nutrient composition (calculated)	
ME, kcal/kg	2,850
CP%	17.00
Calcium%	2.81
Phosphorus%	0.93
Lysine%	1.09
Methionine%	0.45

calculated as the ratio between remaining birds and total number of birds multiplied by 100. The data for meat chemical composition and cholesterol content were recorded at 20 wk of age. For that, 5 birds from each experimental group were chosen randomly and kept off feed for 5 to 6 h. After that, the birds were manually slaughtered and the carcasses were processed and cooled for 24 h at 0 to 4°C. Muscle tissues were sampled from breast and thighs of the dressed cold carcass of each bird for chemical analysis. The meat samples were stored in a deep freezer at −21°C until analysis. The frozen samples were dissected into small pieces and homogenized in a blender at −10°C. Chemical analysis was performed according to the official methods of AOAC (1999) in Nutrition laboratory, Department of Food and Nutrition, UVAS, Lahore. Cholesterol content of meat sample was evaluated in nutrition laboratory of the UVAS, Lahore by using Liebermann Burchard reaction method (Liebermann, 1985).

Statistical Analysis

Collected data were analyzed through one-way ANOVA techniques (Steel et al., 1997) using PROC GLM procedure of SAS software (version 9.1.0), and significant means were separated through Tukey's HSD test at a significant level of $P \leq 0.5$. The following mathematical model was used:

$$Yij = \mu + Si + \varepsilon ij$$

Where, Y, each observation; μ, Population mean; S_i, Effect of i^{th} treatment; ε_{ij}, Random error.

RESULTS AND DISCUSSION

Growth Performance

Growth performance indicators are often used to assess poultry production (Zhang et al., 2018). The present results showed significant differences ($P < 0.05$) in final body weight and weight gain among the four phenotypes of naked neck chicken. Birds of both dark and light brown phenotypes showed the highest final body weight and weight gain at 8 wk of age followed by those of white black and black (Table 2). The variations in body weight and weight gain among phenotypes could be a result of genetic differences (Bell and Weaver, 2005) as other factors like diet, management, disease prevention, and environmental conditions were same in all experimental groups. The dark and light brown genes may have a linkage with some of the genes which control body weight and weight gain in chicken. Hence, the higher body weight and weight gain observed in dark and light brown phenotypes compared with black and white black may be attributed to the superior genetic potential of the dark and light brown phenotypes for body weight and weight gain as feed intake was similar across the four phenotypes.

The results are in agreement with those of Adedeji et al. (2006), who reported significant differences ($P < 0.05$) in growth-related parameters between naked neck chicken and their normal feathered counterparts. Azharul et al. (2005), likewise, recorded a significantly higher ($P < 0.05$) body weight among crossbred chickens compared with a pure breed. Njenga (2005) compared the growth of naked neck, frizzle, dwarf, and normal feathered birds from 1-day-old to wk 5, and found significantly higher ($P < 0.05$) body weight in naked neck birds than all the other chicken genotypes. Similarly, Adomako et al. (2014) observed that body weight and weight gain of naked neck birds was significantly higher ($P < 0.05$) as compared to their normal feathered counterparts, suggesting that body weight and weight gain tend to vary among strains (N'Dri et al., 2005; Santos et al., 2005; Chatterjee et al., 2007; Adekoya et al., 2013), varieties (Khawaja et al., 2012; Jatoi et al., 2014; Alam et al., 2021), breeds (Singh et al., 1999; Thakur et al., 2006; Adebambo et al., 2010; Oleforuh-Okoleh et al., 2017), and genotypes (Faruque et al., 2007; Islam and Nishibori, 2009; Sharifi et al., 2010; Das et al., 2014b; Batkowska et al., 2015). In contrast to these findings, Duah et al. (2020) observed no significant differences ($P > 0.05$) between the means of the live weights of the chicken with the three genotypes.

Feed conversion ratio (**FCR**) is a measure of how well a bird converts feed intake into live weight. The efficient conversion of feed into live weight is essential for profitability. In the present study, birds of dark brown and light brown phenotypes exhibited better FCR than those of the black phenotype (Table 2) that may be attributed to the fact that the dark and light brown birds might have a gut development for better digestion and nutrient utilization. According to de Verdal et al. (2010), functional anatomical and histological characteristics of the avian gastrointestinal tract are critical to their feed conversion efficiency. Our results are supported by Ajayi (2010), who reported that the frizzling and Naked-Neck genes conferred better FCR than the normal feathered chicken. Adomako et al. (2014), likewise, found that the naked neck birds had a significantly lower ($P < 0.05$) FCR values compared to their normal feathered counterparts, indicating that FCR values may vary ($P < 0.05$) among varieties (Jatoi et al., 2014; Alam et al., 2021), genetic groups (Khawaja et al., 2012; Das et al., 2014a) and breeds (Khantaprab and Tarachai, 1998) of poultry. Time of gain of a bird is defined as the ratio of final body weight to initial weight. In the current study times of gain were found to be highest in dark brown followed by light brown then white black and black (Table 2). As stated above, this could be related to the superior genetic potential of dark brown birds for growth rate, which was also evident from higher body weight and weight gain of dark brown birds (Table 2).

In the present study, no significant differences ($P > 0.05$) were observed in feed intake across the four

Table 2. Feed intake, body weight, weight gain, times of gain, FCR and livability in four phenotypes of naked neck chicken at 8 wk of age[1].

Parameters[3]	Varieties[2]			
	B	DB	LB	WB
FI (g)	1,148.27 ± 69.41	1,154.63 ± 71.87	1,161.46 ± 36.06	1,086.80 ± 54.52
BW (g)	370.54 ± 5.04[c]	440.93 ± 5.48[a]	441.48 ± 3.56[a]	400.52 ± 2.6[b]
WG (g)	340.36 ± 4.75[c]	409.29 ± 5.24[a]	408.82 ± 3.31[a]	367.83 ± 2.7[b]
TG[4]	12.24 ± 0.09[c]	13.94 ± 0.09[a]	13.52 ± 0.08[b]	12.25 ± 0.13[c]
FCR	3.37 ± 0.18[a]	2.82 ± 0.19[b]	2.84 ± 0.09[b]	2.95 ± 0.15[ab]
L (%)	71.56 ± 5.43	81.56 ± 3.52	79.38 ± 1.68	73.59 ± 2.76

[abc]Different alphabets on means within row show significant difference ($P < 0.05$).
[1]Values are means ± SE of 5 replicates (n = 5).
[2]B = black, DB = dark brown, LB = light brown, WB = white black.
[3]Abbreviations: BW, body weight; FI, feed intake, FCR, feed conversion ratio; L, livability; TG, times of gain; WG, weight gain.
[4]Times of gain of a bird is defined as the ratio of final body weight to initial weight.

phenotypes (Table 2). In agreement with these findings, Adomako et al. (2014) also observed non-significant differences ($P > 0.05$) in average weekly feed intake among the 2 chicken genotypes. However, Alam et al. (2021) in their study found significant variations ($P < 0.05$) in feed intake among the different chicken genotypes. In the current study, livability exhibited no differences ($P > 0.05$) among the phenotypes (Table 2). However, Adomako et al. (2014) observed that naked neck birds had a significantly higher ($P < 0.05$) survivability than their normal feathered counterparts.

Morphometric Traits

Variations in morphometric traits could provide valuable information for the design of genetic improvement and selection programs for chickens, which depend primarily on the variations present within and among breeds or populations.

Analysis of variance exposed significant differences ($P < 0.05$) in neck and keel length of different phenotypes. Dark brown phenotype had longer neck length as compared to light brown, white black and black phenotypes (Table 3). Keel length is related to the breast meat yield in chicken. The present results showed higher keel length values in light and dark brown phenotypes followed by black and white black. The naked neck lines reared for the purposes of this trial were kept in 20 different cages (each measuring 4−2 feet) placed in a well-ventilated open sided poultry house and were fed the same diet. It is, thus, assumed that any differences that were recorded in morphometric measurements between phenotypes are a result of genetic differences. The morphometric traits results can be compared with those of Fadare (2014), who reported significant differences ($P < 0.05$) in keel length of naked neck, Frizzled Feathered and Normal Feathered Crosses with Exotic Giri-Raja Chickens. Results are also corroborated by Liyanage et al. (2015), who reported definite difference in keel length among different phenotypic groups of village chicken in Sri Lanka. Likewise, Fayeye et al. (2014) found significant variations ($P < 0.05$) in neck and keel length values between Isa Brown and Ilorin ecotype birds. Ahmad et al. (2019), however, observed that keel length did not differ significantly ($P > 0.05$) among genotypes.

The current results revealed significant differences in wing spread and shank circumference among different phenotypes. Higher wing span was observed in light and dark brown phenotypes as compared to black and white black at 8 wk of age (Table 3). These results are similar to the findings of Udeh and Obgu (2011), who observed significant differences ($P < 0.05$) in wing spread in three strains of broilers (Ross, Arboracre, and Marshal) at 8 wk of age. Likewise, Fayeye et al. (2014) recorded significant differences ($P < 0.05$) in values of wing length between Isa Brown and Ilorin ecotype birds. As far as shank circumference is concerned, light brown plumage showed the highest shank circumference followed by white black and black phenotypes. Similar findings have also been reported by Liyanage et al. (2015), who observed that shank circumference varied significantly ($P < 0.05$) among different phenotypic groups of village chicken in Sri Lanka. Similarly, Oleforuh-Okoleh et al. (2017) observed significant differences ($P < 0.05$) in shank circumference between the normal feathered and naked neck birds during the early growth phase (4−8 wk). Ahmad et al. (2019), likewise, observed significant differences ($P < 0.05$) in shank circumference among different genotypes of chicken.

Table 3. Morphometric traits in four phenotypes of naked neck chicken at 8 wk of age[1].

Parameters[3]	Varieties[2]			
	B	DB	LB	WB
NL (cm)	7.36 ± 0.05[c]	7.76 ± 0.05[b]	7.97 ± 0.06[a]	7.49 ± 0.05[c]
KL (cm)	6.39 ± 0.05[c]	6.89 ± 0.05[a]	6.87 ± 0.05[a]	6.67 ± 0.04[b]
WS (cm)	5.52 ± 0.04[bc]	5.59 ± 0.04[ab]	5.66 ± 0.04[a]	5.44 ± 0.06[c]
SL (cm)	4.97 ± 0.04	5.08 ± 0.05	5.01 ± 0.05	4.97 ± 0.04
SC (cm)	2.13 ± 0.04[c]	2.77 ± 0.01[a]	2.45 ± 0.03[b]	2.06 ± 0.03[c]
DL (cm)	7.79 ± 0.05	7.99 ± 0.06	8.07 ± 0.06	7.91 ± 0.05
DC (cm)	3.42 ± 0.04[c]	3.89 ± 0.04[b]	4.02 ± 0.04[a]	3.94 ± 0.05[ab]
BL (cm)	40.02 ± 0.35	40.25 ± 0.39	41.26 ± 0.37	40.98 ± 0.40

[abc]Different alphabets on means within row show significant difference ($P < 0.05$).
[1]Values are means ± SE of 5 replicates (n = 5).
[2]B = black, DB = dark brown, LB = light brown, WB = white black.
[3]Abbreviations: BL, body length; DL, drumstick length; DC, drumstick circumference; KL, keel length; NL, neck length; SC, shank circumference; SL, shank length; WS, wing spread.

The present results showed higher drumstick circumference in dark and light brown phenotypes as compared to white black and black (Table 3). The differences between four naked neck chicken ecotypes in morphometric traits were similar to those of Bett et al. (2014), who observed variations in body measurements of native chicken populations in Bangladesh, Sri Lanka, Vietnam, and Pakistan. Likewise, Adekoya et al. (2013) found discrepancies in morphological characteristics of five Nigerian indigenous chicken types, suggesting that morphometric measurements could vary due to genotype (Islam and Dutta, 2010; Ogah, 2013). In the current study, shank length, drumstick length and body length of 4 naked neck phenotypes did not show differences ($P > 0.05$) at 8 wk of age (Table 3). These results are supported by Ahmad et al. (2019), who observed no differences ($P > 0.05$) in shank length, drumstick length and body length between the naked neck and crossbred birds. Similarly, Oleforuh-Okoleh et al. (2017) observed no differences ($P > 0.05$) between the naked neck and normal feathered birds in shank length and body length. Adomako et al. (2014), likewise, observed nonsignificant differences ($P > 0.05$) in shank length between the normal feathered and naked neck birds. Fayeye et al. (2014), however, found significant differences ($P < 0.05$) in shank length and body length values between the Isa Brown and Ilorin ecotype birds.

Compositional Profile

Muscle chemical composition contributes to the overall consumer acceptance of poultry and other meat products. Proximate analysis is the simplest method used for the quantitative analysis of the muscle chemical composition, including moisture, crude protein, crude fat and ash content (Hui, 2012). Meat is composed of muscle, connective tissue, fat, and bone. Chemical analysis has shown that muscle contains around 75% water, and 20% protein, while the remaining 5% is represented by fat, carbohydrates, and minerals (Adeyanju et al., 2013). Composition of the poultry meat is mainly influenced by species. Line, diet, and feeding, environment, and processing are the factors that may affect within species differences (Owens et al., 2010). In the present study, the birds of white black phenotype displayed the highest dry matter content (Table 4). As stated above, the naked neck lines used in this study were kept in 20 different cages (each measuring 4−2 feet) under similar management and environmental conditions and were fed the same diet. It is, therefore, assumed that any differences that were observed in muscle chemical composition and cholesterol content between phenotypes could be a result of genetic differences among the phenotypes.

The chemical composition results can be compared well with those of Packard (2014) and Wattanachant (2008), who reported that muscle chemical composition of the birds is influenced by genetics. The effect of genotype on dry matter content is evident from the findings that meat composition including dry matter varies according to the genotype (Tougan et al., 2013; Farzana et al., 2017). Alam et al. (2021) compared meat composition of naked neck, exotic Rhode Island Red (**RIR**) and their crossbred NNRIR chickens, and recorded significantly higher ($P < 0.05$) thigh and drumstick meat dry matter for exotic RIR. The birds of light brown manifested the highest moisture content followed by those of black, dark brown, and then white black. Moisture content is affected by ante-mortem factors of the chicken life, such as genetics, physiology, nutrition, management, disease (Fletcher, 2002), and strain of chicken (Packard, 2014). Variations in moisture content could be attributed to the genetic factor as other factors like nutrition, management, disease prevention and environmental conditions were same in all experimental groups. Similarly, Jung et al. (2015) concluded that the moisture content of the meats was significantly affected by line. Sokoya et al. (2019) observed that moisture content of Marshal were higher than FUNAAB indigenous chickens, showing that moisture content varies according to the genotype (Suriani et al., 2014). Souza et al. (2011), however, found no correlation between moisture content and different genetic strains of poultry.

Protein content of the meat from chicken varies from 16 to 24% (Owens et al., 2010). The nutritional value of poultry meat is closely associated with the content of high quality proteins. In the present study, black, white black and dark brown phenotypes exhibited higher crude protein as compared to that of light brown. These results are supported by Jung et al. (2015), who maintained that black birds are superior in terms of protein contents in meat. Likewise, Alam et al. (2021) reported significant differences ($P < 0.05$) in crude protein among different genetic groups of poultry. Sokoya et al. (2019) also reported significant differences ($P < 0.05$) among different genotypes of poultry for crude protein. Significant genotype effect on crude protein has already been reported by Wattanachant et al. (2004), indicating that protein content tend to vary between chicken varieties (Wattanachant, 2008; Farzana et al., 2017), strains (Suriani et al., 2014), or genetic groups (Packard, 2014). Jung et al. (2011) and Souza et al. (2011), however, reported no variety or strain effect on crude protein.

Fat content has a major influence on the muscle composition (Hui, 2012). Fat contributes greatly to the flavor and juiciness of the meat (Adeyanju et al., 2013). In the current study, black and white black exhibited the highest ether extract in their meat. Similarly, a significant phenotype effect on fat or ether extract has already been reported by (Jung et al., 2015), indicating that ether extract or lipid content varies from variety to variety (Suriani et al., 2014; Farzana et al., 2017). Alam et al. (2021), likewise, reported significant differences ($P < 0.05$) in fat content between different genotypes of chicken. Sokoya et al. (2019), similarly, found significant differences ($P < 0.05$) in fat content between Marshal and FUNAAB indigenous broiler chickens, with significantly higher fat content in Marshal than FUNAAB indigenous chickens. Also, Wattanachant et al. (2004) found significant variations ($P < 0.05$) in

Table 4. Muscle chemical composition in four phenotypes of naked neck chicken at 20 wk of age[1].

Variable[2,3]	DM	Moisture	CP	EE	ASH	Cholesterol
	(%)					(mg/100 g)
B	26.71 ± 0.02^{b}	73.28 ± 0.02^{b}	24.34 ± 0.03^{a}	0.85 ± 0.01^{a}	1.14 ± 0.01^{a}	67.00 ± 0.80^{a}
WB	26.98 ± 0.08^{a}	73.03 ± 0.08^{c}	24.36 ± 0.07^{a}	0.88 ± 0.02^{a}	1.19 ± 0.02^{a}	65.70 ± 0.86^{b}
LB	26.10 ± 0.02^{c}	74.37 ± 0.03^{a}	23.51 ± 0.0^{b}	0.80 ± 0.01^{b}	1.06 ± 0.01^{b}	63.70 ± 0.81^{c}
DB	26.67 ± 0.03^{bc}	73.32 ± 0.03^{b}	24.41 ± 0.16^{a}	0.73 ± 0.01^{c}	1.04 ± 0.01^{b}	61.90 ± 0.84^{d}
P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[a-d]Means without a common superscripts within row show significant difference ($P < 0.05$).
[1]Values are means ± SE of 5 replicates (n = 5).
[2]Abbreviations: A, ash; CP, crude protein; DM, dry matter; EE, ether extract; M, moisture.
[3]B = black, WB = white black, LB = light brown, DB = dark brown.

fat content between Thai indigenous chicken and broiler chicken studied. Jung et al. (2011) observed that fat content of native chicken was relatively lower compared to commercial chicken. Souza et al. (2011), however, reported no variety or strain effect on fat content.

Ash represents the mineral portion constituting roughly 1% of the muscle composition and is primarily represented by the elements potassium, phosphorus, sodium, chlorine, magnesium, calcium, and iron (Hui, 2012). Among the different phenotypes, black and white black showed higher ash content. High ash content is an indication of mineral and energy availability in food (Souza et al., 2011; Ogunmola et al., 2013). The differences in ash content among phenotypes might be due to the genetic variations among the phenotypes. Wattanachant et al. (2004), likewise, reported that Thai indigenous chicken meat contained lower percentage of ash contents than those of commercial broiler, indicating that ash content varies according to variety (Packard, 2014; Farzana et al., 2017). Jung et al. (2015), similarly, observed significantly higher ash in muscle composition of yellow-brown plumage color birds, which contrasted the findings of the present study where black and white black phenotypes of indigenous naked neck expressed higher ash content. Sokoya et al. (2019) also found variations in ash content among different genetic groups of poultry. Souza et al. (2011) and Alam et al. (2021), however, observed no effect of strains on ash content.

Cholesterol Content

Consumers have become conscious of their dietary cholesterol intake. Literature has shown a strong correlation between the dietary intake of cholesterol and a number of health issues such as coronary heart disease (Baggio and Bragagnolo, 2006). In the current study, birds with black plumage color showed the highest cholesterol content in their meat followed by those of white black, light brown and dark brown (Table 4). Cholesterol content differences among species are generally attributed to the various factors such as differences in absorption and biosynthesis of cholesterol, lipoprotein metabolism, diet, muscle fiber type distribution, genetic constitution, subcutaneous, intramuscular fat, and body weight (Bragagnolo, 2008), as well as cell size. These findings are in consonance with the reports of earlier works by Wattanachant (2008), who reported that the meat of the two indigenous Thai strains had lower contents of cholesterol compared with that of the imported breeds. According to Sokoya et al. (2019), cholesterol content was significantly different ($P < 0.05$) among different genotypes of chicken. Suriani et al. (2014) observed high cholesterol content ($P < 0.05$) in commercial broilers meat than the indigenous Manado chicken and spent hen meat. Duah et al. (2020), however, found no correlation between cholesterol content and different genetic strains of poultry.

CONCLUSIONS

In the current study, the light brown and dark brown naked neck phenotypes exhibited better growth performance, superior morphometric traits and lower cholesterol content, signifying that there should be a conscious effort to develop and commercialize the light and dark brown birds as dual-purpose slow growing chicken especially in developing countries, helping the farmers in reviving a prestigious agro-based rural poultry activity, producing quality chickens, and having livelihoods for their households.

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DISCLOSURES

All authors of the present study declare that there is no financial or any other conflict of interest.

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