

# Phenotypic characterization of four indigenous naked neck chicken ecotypes in Pakistan

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## Abstract

A study was conducted to characterize four phenotypes (black, white with black tips, light brown and dark brown) of naked neck chickens [n=320; 80(40♂, 40♀)] for qualitative and quantitative traits at 20 weeks of age. Qualitative phenotypic characterization was based on head appearance, comb type, wattle size, plumage pattern, shank color, spurs prevalence and number of toes. Quantitative phenotypic characterization was based on neck length, keel length, shank length, drum stick length, body length, wing span and circumference. Males and females of all phenotype had plain head and single comb. Plain feather pattern was predominantly most frequent on breast, wing bow, wing bar, wing bay, saddle and tail followed by stippled, penciled and laced. Males had most frequent yellow shanks followed by grey, off-white and green. White black, light and dark brown phenotypes expressed maximum yellow shank coloration whereas grey shanks were most frequent in black birds. Morpho-metric measurements were significantly higher in males than females. Light and dark brown phenotypes had higher values of quantitative traits than those of black and white black. All males and females of naked neck phenotypes possessed four toes, normal spurs and tuft feathers on the ventral portion of the neck above crop. The phenotypic variation observed in indigenous naked neck chickens could provide valuable basic information to develop effective utilization and conservation programs.

## Introduction

In developing countries, indigenous poultry is playing important role in poverty alleviation, food security and promotion of gender equality (Gueye 2000). This reflects the potential of this sector which needs to be further exploited by promoting indigenous poultry in the country through various management and genetic tools. Indigenous chickens retain unique adaptive traits that permit them to survive and reproduce under harsh climatic, nutritional and poor management, characteristically related with low input–output production systems (Mwacharo et al. 2007). Global reports suggest that indigenous breeds of livestock are becoming extinct as they cannot economically compete with high yielding commercial breeds (Kiani 2000). In the last decade of 20th century, scientists and livestock owners became worried about the potential loss of native breeds. Due to future changes in climate, management and feeding habits, there is need to collect, evaluate and conserve different genotypes (Crawford 1984). A program was launched for genetic conservation of poultry resources (Scherf 1995). In such scenario, the sustainable management, utilization and conservation of a particular population of domestic animals require its characterization. Phenotypic characterization of available breeds is vital for proper management of these resources. This is a way to classify the individuals on the basis of their morphological and productive trait (FAO 2012), which helps to understand the diversity and distinctiveness of a genetic resource. Due to lack of such information, it is difficult to know about different breeds and their uses. Therefore, phenotypic characterization is of much importance to manage the livestock genetic resources according to their ecological and physiological requirement.

The local chickens vary widely in body size, body conformation, plumage color and many other phenotypic characteristics, which are commonly classified worldwide as non-descriptive types due to lack of information (FAO 2012). Non-descriptive local chicken breeds are important source of income and house hold food security in rural farm families (Cabarles et al. 2012). In Pakistan Aseel, Naked neck, Desi and Fayoumi are reared as backyard chickens mainly as a source of high quality animal protein and income. Among these breeds, local Aseel and Naked neck chickens are especially notable for their genetic potential. Naked neck birds are very colorful-black brownish, multicolor, red brownish and black feather combinations (Faruque et al. 2010). This study was designed to phenotypically characterize different varieties of indigenous naked neck chickens for qualitative and quantitative traits as well as productive and reproductive traits, to generate information for advanced conservation genetic studies on native breed of Pakistan.

## Methodology

The experimental method was approved by the Ethical Review Committee of the University of Veterinary and Animal Sciences, Lahore-Pakistan.

## Location and Meteorological data

The study was conducted at Indigenous Chicken Genetic Resource Centre (ICGRC), Department of Poultry Production, University of Veterinary and Animal Sciences (UVAS), Ravi Campus, Pattoki. 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.

## Bird, s Husbandry

Birds were maintained in an independent open-sided laying housed with the east to west dimension measuring 6.10 × 6.10 m (37.21 m<sup>2</sup>), equipped with two rows of 3-tiered laying cages measuring 5.18 × 1.52 m (47.42 m<sup>2</sup>) with sloping wire floor to facilitate egg collection. The ventilation, humidity, and house temperature were controlled using ceiling fans, curtains, and other helpful manual techniques. Variations in daily temperature (°F) and humidity (%) were noted using a wet and dry bulb hygrometer (Mason's type, Zeal, England) and later an average of the temperature and humidity were derived on weekly basis (FIGURE 1). The removable dropping trays were fitted under the mesh floor for the removal of faecal material. Feeding of the birds was done through removable individual trough feeders installed outside the cage and watering through the automatic

nipple drinker system fitted therein. Birds were offered a commercial laying ration (Table 6) at 06:00 AM with an allowance of 100 g/bird/day and availability of fresh water was ensured with nipple drinking system throughout the experimental period.

## **Bird, s Population**

Three hundred twenty day old naked neck chicks comprising different plumage colors were bought from commercial hatchery Gujranwala, Punjab. Similar managerial and feeding practices were provided for all experimental units. At 20 weeks of age, data of 80 birds (40 males and 40 females) from each plumage group were recorded for seven qualitative traits (head shape, comb type, wattles size, shank color, prevalence of spurs, and number of toes, feather patterns on breast, wing-bow, wing-bar, wing-bay, saddle and tail) and seven quantitative traits (neck length, keel length, shank length, drum stick length, body length, wing span and circumference), as per the method described by Cuesta (2008) and Amjad et al. (2015) and the patterns on the feathers were compared against the British Poultry Standards (Roberts 2008). The qualitative traits for each chicken were scored visually, while the quantitative traits were measured in centimeters using a measuring tape and Vernier caliper (0.01 mm). All measurements were taken by the same person to avoid individual variation during observation.

## **Statistical Analysis**

Data on qualitative traits were analyzed with descriptive statistics as percentages, while data on quantitative traits were analyzed by one-way analysis of variance, followed by Duncan's multiple range test to test significant differences between means ( $P < 0.05$ ).

## **Results**

### **Qualitative Measurements**

#### **Head Appearance, Comb Types, And Wattles**

Both sex and phenotypes of naked neck chickens had plain head and single comb type. In the present study, black phenotype naked neck had small sized wattle (56%), followed by medium (34%), very small (8%) and large (2%). White black phenotype had medium sized wattles (51%) followed by small (26%), large (14%) and very small (9%); light brown naked neck chickens had medium sized wattles (73%) followed by small (16%), large (9%) and very small (2%).

#### **Plumage Patterns on Breast, Wing Bow, and Wing Bar**

The results of present study regarding feather patterns on breast, wing bow, wing bar, wing bay, saddle and tail in different phenotypes of naked neck chickens are shown in Table 1. Breast plumage pattern showed variation in sex and phenotypes. Mostly females expressed plain feather pattern followed by stipple, single laced, penciled and double laced. Stippled feather pattern was dominant on breast in male than plain. As concern of phenotype, black had higher coverage of stippled feather followed by plain. White with black phenotype birds had maximum plain feather pattern as compared to other phenotypes. Light brown birds had both plain and stippled feather pattern in higher ratio followed by penciled and laced. The breast of dark brown birds had also higher ratio of plain and stippled feathers.

In this study, it was noticed that all phenotypes of naked neck chicken breed had different patterns in wing-bows. Different phenotypes of naked neck birds presented arrangement of wing-bow feather pattern as black phenotype: plain (35%), stippled (31%), laced (18%) and penciled (16%), white black: plain (70%), penciled (11%), stippled (10%) and laced (9%), light brown: plain (55%), stippled (28%), penciled (12%) and laced (5%) and dark brown: plain (52%), stippled (23%), laced (12%) and penciled (11%). All phenotypes of naked neck chickens showed variation in feather pattern on the wing bar. Plumage patterns were observed in wing-bar of different phenotypes of naked neck chickens as: black phenotype had plain feather pattern (45%), stippled (26%), penciled (15%) and laced (14%), white black had plain (72%), penciled (14%), stippled (9%) and laced (7%), light brown showed plain pattern (64%), stippled (19%), penciled (12%) and laced (5%) and dark brown had plain (68%) plain feather pattern (16%) stippled, (8%) laced and also (8%) penciled, respectively.

#### **Plumage Patterns on Wing Bay, Saddle and Tail**

Variations on wing-bay feather pattern in different phenotypes of naked neck birds were noted. Black phenotype expressed plain pattern (36%), stippled (32%), laced (19%) and penciled (13%), white black had plain feather pattern (70%), penciled (12%), stippled (10%) and laced (8%), light brown had (60%) plain, (24%) stippled, (9%) penciled and (7%) laced feather pattern and dark brown expressed (58%) plain feather pattern, (17%) stippled, (13%) laced and (12%) penciled, respectively. Sex, phenotypes and their interaction displayed differences in arrangement of feather on saddle. Males had maximum plain feather pattern succeeded by stippled, penciled and single laced. Females also had higher range of plain feathers followed by stippled, single laced and penciled. As the phenotypes pattern arrangement concerned, white black, dark brown and light brown phenotypes showed maximum range of plain feathers followed by stippled, penciled and laced whereas black phenotype had higher stippled feathered pattern on tail followed by plain, penciled and laced. White black female had maximum plain feathered pattern whereas light brown males expressed maximum stippled feather patterns compared to other phenotypes and sex. Black females expressed high single and

double lacing as compared to other phenotypes and sex. Dark brown males showed maximum penciled pattern compared to other competitor phenotype and sex (Table 2).

Both sex and phenotypes showed variations in tail feather pattern. Over all, females had maximum plain, penciled and single laced as well as double laced feather patterns as compared to males, while males expressed higher percentage of stippled feather pattern. As concerned phenotypes, plain and penciled feather pattern was dominant in white black compared to those of other phenotypes. Stippled pattern was mostly expressed in light brown followed by dark brown, black and white black phenotypes. Double laced feather pattern was frequent in dark brown while single laced was in black phenotype with respect to other competitor phenotypes. Maximum single laced pattern was observed in feathers of black females, double laced in dark brown females. Plain pattern percentage was higher in white black males and light brown females. Stippled pattern was noticed maximum in feathers of light brown males. Maximum penciled pattern was recorded in feathers of white black females (Table 3).

## Shank Color

The results of the present study with respect to the shank color revealed significant differences in both sex and phenotypes. Yellow shanks were predominantly most common in males followed by grey and off-white shanks (Table 4).

## Quantitative Measurements

### Neck and Keel Length

In the present study, both sex and phenotypes were significantly different in terms of neck and keel length. Males had higher neck and keel length than females. Light brown phenotype expressed higher neck length while keel length was higher both in light and dark brown compared to those of other phenotypes (Table 5). In sex and phenotype interaction, light brown male showed higher neck length; however, keel length was maximum both in light and dark brown males.

### Wing Span, Shank Length And Circumference

The mentioned morpho-metric traits demonstrated significant differences in sex, phenotype and their interaction. Males had greater wing span, shank length and shank circumference as compared to females. Wing span and shank length were observed significantly higher in dark brown males as compared to those of other phenotypes, while males of all phenotypes had no difference in shank circumference (Table 5). The mentioned morpho-metric traits demonstrated significant differences in sex, phenotype and their interaction. Males had greater wing span, shank length and shank circumference as compared to females. Both light and dark brown phenotypes had higher wing span and shank length whereas there was no difference in shank circumference among various phenotypes. In interaction, wing span and shank length were observed significantly higher in dark brown males as compared to those of other phenotypes, while males of all phenotypes had no difference in shank circumference (Table 5).

### Body Length, Drum Stick Length And Circumference

Significant differences were observed in sex, phenotypes and interaction regarding above stated quantitative morpho-metric traits. Males had significantly longer body and drum stick length as well as more circumference than females (Table 5). Phenotypes had no variation regarding drum stick length, while circumference was significantly higher in dark brown, though body length was longer in light brown phenotype. It was observed that there is no difference in drumstick length among males of all phenotypes, however, circumference was higher in dark brown male and body length was in light brown male.

## Discussion

### Qualitative Traits

Qualitative traits in poultry are gaining importance due to their wide application and recognition (Mancha 2004). These genes are linked to the adaptation and productivity of the chicken in its local environment, influencing both their meat and egg-laying traits (Ikeobi et al. 2001).

Present findings showed that the head feathers of the naked neck chickens were extended in the form of a tassel in accordance with British Poultry Standards (Roberts 2008). However, Sarker et al. (2012) reported some cases with strawberry comb and cushion comb (Evertt 2010). The naked neck chickens presented hundred percent existence of single comb, which is in accordance with Roberts (2008) who reported hundred percent prevalence of single-comb in naked neck chickens. Amjad et al. (2015) also reported hundred percent prevalence of single comb in naked neck chickens located in Pakistan. A single comb was also common in indigenous chickens in Sri Lanka (Liyanaage et al. 2015), Bangladesh (Faruque et

al. 2010), and Nigeria (Apuno et al. 2011; Rotimi et al. 2016). However, Al-Rawi & Al-Athari (2002) reported 90 percent prevalence of single-comb in white naked neck lines. Likewise, a recent study by Maharani et al. (2021) reported four comb types (Pea, walnut, single, and rose) across the six breeds of chicken where the majority of chickens (above 80.00%) had a single comb across the breeds and in both males and females. According to Saeed et al. (2019), combs help reduce heat levels through convection. As the climate in Pakistan is predominantly characterized by high ambient temperature, a single comb would be beneficial for heat loss through the process of vasodilatation.

In the present study, black phenotype naked neck had small sized wattle (56%), followed by medium (34%), very small (8%) and large (2%). White black phenotype had medium sized wattles (51%) followed by small (26%), large (14%) and very small (9%); light brown naked neck chickens had medium sized wattles (73%) followed by small (16%), large (9%) and very small (2%). These findings are in agreement with those of Roberts (2008) who illustrated medium sized wattles in Transylvanian naked neck chickens. Dark brown phenotype had wattle size as; medium (68%), small (19%), large (10%) and very small (3%). Amjad et al. (2015) also reported most frequent medium sized wattles in naked neck ecotype of Pakistan. In the present study, as mentioned above, mostly females expressed plain feather pattern followed by stipple, single laced, penciled and double laced. Iqbal et al. (2015) observed that mostly naked neck birds had plain feathered pattern, which is in accordance with our findings. Syakir (2018) and Asmara et al. (2019) also found variation in plumage pattern in different breeds of chicken. Maharani et al. (2021), likewise, found considerable phenotypic variation in qualitative traits among indigenous chicken breeds.

In the present study, yellow shanks were predominantly most common in males followed by grey and off-white shanks. In line with these results, Rogelio et al. (2013) observed yellow shanks among the roosters in the whole province of Palawan, Philippine, Kutle and Guni, revealing that yellow shanks were most frequent in the native chicken of the Southern Highlands of Tanzania. Frequent yellow shanks were also observed in native chickens of Iran (Cabarles et al. 2012). Similarly, it was recorded that hens of southern Palawan in Philippine had most frequent green shank color than roosters. Maharani et al. (2021), likewise, observed that the most common shank color was yellow (35.29% in males and 37.36% in females), followed by gray-green, black, white, green, black-white, and black-yellow green. Yellow shank coloration was found to be higher in dark brown phenotype, off-white shank color was higher in white black, grey and green shank color was higher in black phenotype. White black males had maximum yellow and off-white shank coloration and black females were higher in grey and green shank coloration. Similar to these findings, Faruque et al. (2010) observed predominantly yellow shanks followed by white, black and green in naked neck chickens of Bangladesh whereas Sarker et al. (2012) observed all the birds had yellowish shank color in Aseel chickens of Bangladesh. Roxas et al. (1996) and Onate (1991) recognized five shank colors in Palawan which include yellow, white, green, black and bluish-black. Variations in shank color were also observed in Black Kedu chickens (Johari et al. 2009) and Sri Lanka chickens (Liyanaage et al. 2015). The existence of various types of shank colors in this study might have been due to combinations of pigment controlling genes responsible for color determination. Petrus (2011) stated that production of carotenoid, dermal melanin and epidermal melanin is controlled by  $W^+$  and  $w^{-}ld$  and  $id^+$ ; and  $E$  and  $e^+$  genes, respectively, with the resultant incidence of different shank color shades. According to Negassa et al. (2014), variations in shank color are primarily affected by the nutrition of feed sources containing carotene.

## Quantitative Traits

Variations in quantitative 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.

In the present study, males had higher neck and keel length than females. Liyanage et al. (2015) supported our finding that male naked neck chickens had greater keel length than females. Light brown phenotype expressed higher neck length, while keel length was higher both in light and dark brown compared to those of other phenotypes. Our results are in accordance with the study of Yakuba et al. (2009) who reported significant difference in neck length among different genotype of indigenous Nigerian chickens. These findings are also supported by Fadare (2014) who reported significantly different keel length in Naked-Neck, Frizzled feathered and normal feathered crosses with Exotic Giri-Raja chickens. Results are also corroborated by Liyanage et al. (2015) who observed that differences were present in keel length among different phenotypic groups of village chicken in Sri Lanka. In the current study, males had greater wing span, shank length and shank circumference as compared to females. Dana et al. (2010) endorsed our finding that males had greater shank length than females. As stated above, both light and dark brown phenotypes had higher wing span and shank length whereas there was no difference in shank circumference among various phenotypes. Similar to these findings, Banerjee (2012) also recorded variation regarding shank length in Naked-Neck and frizzle chicken of West Bengal and Sikkim. Wing span and shank length were observed significantly higher in dark brown males as compared to those of other phenotypes, while males of all phenotypes had no difference in shank circumference. These results are in accordance with those of Udeh & Obgu (2011) who observed wing span difference in three different strains of broilers (Ross, Arbor-acre and Marshal).

In the present study, males had significantly longer body and drum stick length as well as more circumference than females. Similar to our findings, Dorji & Sunar (2014) reported that Frizzle, Seim and Bhutanese Indigenous Chicken breeds had larger and longer drumstick, which could support the heavy body weight of the bird. Phenotypes had no variation regarding drum stick length, while circumference was significantly higher in dark brown, though body length was longer in light brown phenotype. Similar findings were recorded by Olawunimi et al. (2008) who demonstrated that body length of Bhutanese Indigenous Chicken was longer than the Nigerian birds. Dorji & Sunar (2014) also observed that Bhutanese Indigenous

hens, Seim, Naked-Neck and Yuebjha Narp have longer body than the Shekheni and Frizzle breeds of chicken. It was observed that there is no difference in drumstick length among males of all phenotypes, however, circumference was higher in dark brown male and body length was in light brown male.

Considerable phenotypic variations in the qualitative and quantitative traits of naked chicken varieties suggest that a further molecular characterization should be used to back up the present findings and determine genetic variation within the phenotypes. Both phenotypic and genetic variation should be considered together for the design of selection and genetic improvement programs.

## Declarations

### Acknowledgements

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### Declarations

### Funding

Not applicable

### Competing Interests

No potential conflict of interest was found by the authors.

### Ethics Approval

The study was approved by the Ethical Review Committee of the University of Veterinary and Animal Sciences, Lahore, Pakistan.

### Consent to Participate

Informed consent was obtained from all individual participants included in the study.

### Consent for Publication

The authors have consented to the submission of the manuscript to the journal.

### Availability of Data and Material

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

### Code Availability

Not applicable

### Authors' Contribution

All authors contributed to the study conception, design, material preparation, data collection, analysis and drafting of the manuscript.

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## Tables

**Table 1** Comparative breast feather pattern percentage in males, females and four phenotypes of naked neck chicken and their interaction (Sex × Phenotype).

Variables	Parameters					
	Single laced	Double laced	Plain	Stippled	Penciled	
Sex						
Male	7.5	0	38	42	12.5	
Female	9	4.75	54.25	23.75	8.25	
Phenotypes						
Black	16	2.5	30	38	13.5	
White black	4.5	4.5	61.5	15.5	14	
Light brown	3.5	1	48	40.5	7	
Dark brown	9	1.5	46	31.5	12	
Sex × Phenotypes						
Male	Black	15	0	28	42	15
	White black	0	0	64	22	14
	Light brown	3	0	32	54	11
	Dark brown	12	0	30	38	20
Female	Black	17	5	32	34	12
	White black	9	9	59	9	14
	Light brown	4	2	64	27	3
	Dark brown	6	3	62	25	4

**Table 2** Comparative saddle feather pattern percentage in males, females and four phenotypes of naked neck chicken and their interaction (Sex × Phenotype).

Variables	Parameters					
	Single laced	Double laced	Plain	Stippled	Penciled	
Sex						
Male	4.75	0	40.25	39.75	15.25	
Female	8.25	5.5	53.75	24.75	7.75	
Phenotypes						
Black	10.5	4	32.5	39.5	13.5	
White black	4.5	3	64.5	14	14	
Light brown	3.5	2.5	45	41.5	7.5	
Dark brown	7.5	1.5	46	34	11	
Sex × Phenotypes						
Male	Black	7	0	35	43	15
	White black	0	0	64	22	14
	Light brown	3	0	32	53	12
	Dark brown	9	0	30	41	20
Female	Black	14	8	30	36	12
	White black	9	6	65	06	14
	Light brown	4	5	58	30	03
	Dark brown	6	3	62	27	02

**Table 3** Comparative tail feather pattern percentage in males, females and four phenotypes of naked neck chicken and their interaction (Sex × Phenotype).

Variables	Parameters					
	Single laced	Double laced	Plain	Stippled	Penciled	
Sex						
Male	6.25	0	48	33	12.75	
Female	12	4.5	53.25	17	13.25	
Phenotypes						
Black	15.5	2.5	43	23.5	15.5	
White black	6.0	2.0	56	18	18	
Light brown	6.5	1.5	52.5	30	9.5	
Dark brown	8.5	3.0	51	28.5	09	
Sex × Phenotypes						
Male	Black	10	0	42	29	19
	White black	0	0	58	27	15
	Light brown	06	0	47	43	04
	Dark brown	09	0	45	33	13
Female	Black	21	05	44	18	12
	White black	12	04	54	09	21
	Light brown	07	03	58	17	15
	Dark brown	08	06	57	24	05

**Table 4** Comparative shank color percentage in males, females and four Phenotypes of naked neck chicken and their interaction (Sex × Phenotype).

**Table 5** Comparative measurements of morpho-metric traits in males, females and four phenotypes of naked neck chicken and their interaction (Sex × Phenotype) at 20 week of age.

Noted: Different alphabets on means within the column show significant difference ( $P < 0.05$ ).

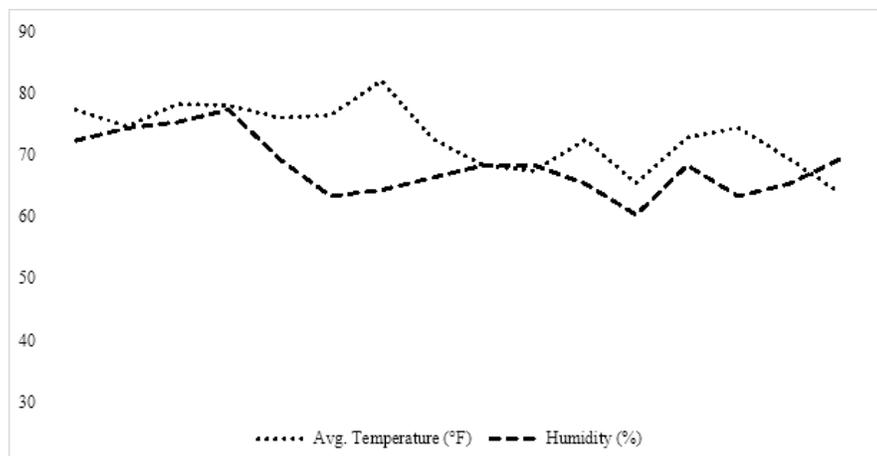
<sup>1</sup>NL: Neck Length, KL: Keel Length, WS: Wing Spread, SL: Shank Length, SC: Shank Circumference, DL: Drumstick Length, DC: Drumstick Circumference, BL: Body Length.

Table 6 Composition of the ration offered to the experimental birds.

Variables	Parameters				
	Yellow	Off-white	Green	Grey	
Sex					
Male	47.75	11.5	10.75	30	
Female	29.5	9	21.25	40.25	
Phenotypes					
Black	10.5	—	34.5	55	
White black	50	15.5	9	25.5	
Light brown	41	11	9.5	38.5	
Dark brown	53	14.5	11	21.5	
Sex × Phenotypes					
Male	Black	21	—	25	54
	White black	66	23	—	11
	Light brown	56	14	—	30
	Dark brown	48	9	18	25
Female	Black	—	—	44	56
	White black	34	8	18	40
	Light brown	26	8	19	47
	Dark brown	58	20	04	18

Ingredient	Inclusion rate (g/100g)
Corn	62.30
Guar Meal	3.00
Raw rice Bran	4.00
Soybean Meal 44%	1.31
Rape Seed Meal	2.00
DL-Methionine	0.23
L-threonine	0.08
Calcium Carbonate	8.29
Salt	0.11
Corn Gluten	1.00
Canola Meal	8.00
Cotton Seed Meal	4.00
Lysine Sulphate	0.36
Premix	0.30
L-Tryptophan	0.01
Fish Meal 47%	1.00
Feather Meal 54%	4.00
Quantum 600FTU	0.01
Total	100.00
Crude Protein%	16.5%
Metabolisable Energy	2902 Kcal/Kg

## Figures



**Figure 1**

Variations in temperature (°F) and humidity (%) by a wet and dry bulb hygrometer (Mason's type, Zeal, England).

Variables	Parameters <sup>1</sup>								
	NL	KL	WS	SL	SC	DL	DC	BL	
Sex									
Male	14.15±0.09 <sup>a</sup>	11.79±0.09 <sup>a</sup>	11.04±0.19 <sup>a</sup>	10.84±0.14 <sup>a</sup>	4.23±0.05 <sup>a</sup>	13.50±0.03 <sup>a</sup>	8.33±0.07 <sup>a</sup>	57.80±0.63 <sup>a</sup>	
Female	12.58±0.13 <sup>b</sup>	10.37±0.06 <sup>b</sup>	10.07±0.1 <sup>b</sup>	9.36±0.04 <sup>b</sup>	3.74±0.03 <sup>b</sup>	12.54±0.04 <sup>b</sup>	7.50±0.04 <sup>b</sup>	52.25±0.33 <sup>b</sup>	
Phenotypes									
Black	13.26±0.27 <sup>b</sup>	10.66±0.25 <sup>c</sup>	9.74±0.12 <sup>c</sup>	9.81±0.20 <sup>c</sup>	3.91±0.12	12.95±0.18	7.90±0.15 <sup>ab</sup>	53.90±0.94 <sup>b</sup>	
White black	12.98±0.35 <sup>b</sup>	11.00±0.20 <sup>b</sup>	10.45±0.24 <sup>b</sup>	9.94±0.23 <sup>bc</sup>	3.95±0.08	12.96±0.16	7.76±0.16 <sup>b</sup>	54.50±1.1 <sup>ab</sup>	
Light brown	13.96±0.21 <sup>a</sup>	11.30±0.26 <sup>a</sup>	10.87±0.20 <sup>a</sup>	10.24±.33 <sup>ab</sup>	4.05±0.11	13.11±0.17	7.98±0.14 <sup>ab</sup>	56.20±1.24 <sup>a</sup>	
Dark brown	13.28±0.28 <sup>b</sup>	11.36±0.27 <sup>a</sup>	11.17±0.26 <sup>a</sup>	10.41±0.32 <sup>a</sup>	4.03±0.08	13.06±0.14	8.03±0.17 <sup>a</sup>	55.50±1.2 <sup>ab</sup>	
Sex × Phenotypes									
Male	Black	14.02±0.16 <sup>b</sup>	11.38±0.13 <sup>b</sup>	9.84±0.22 <sup>ef</sup>	10.38±0.15 <sup>c</sup>	4.22±0.11 <sup>a</sup>	13.50±0.07 <sup>a</sup>	8.34±0.10 <sup>ab</sup>	56.20±0.86 <sup>b</sup>
	White black	14.00±0.17 <sup>b</sup>	11.56±0.13 <sup>b</sup>	11.08±0.22 <sup>bc</sup>	10.60±0.15 <sup>c</sup>	4.14±0.10 <sup>a</sup>	13.42±0.06 <sup>a</sup>	8.14±0.19 <sup>b</sup>	57.20±1.3 <sup>ab</sup>
	Light brown	14.56±0.12 <sup>a</sup>	12.06±0.10 <sup>a</sup>	11.44±0.09 <sup>ab</sup>	11.06±.38 <sup>ab</sup>	4.36±0.11 <sup>a</sup>	13.60±0.07 <sup>a</sup>	8.34±0.14 <sup>ab</sup>	59.60±1.02 <sup>a</sup>
	Dark brown	14.04±0.17 <sup>b</sup>	12.16±0.09 <sup>a</sup>	11.80±0.30 <sup>a</sup>	11.32±0.21 <sup>a</sup>	4.20±0.12 <sup>a</sup>	13.48±0.09 <sup>a</sup>	8.52±0.08 <sup>a</sup>	58.20±1.6 <sup>ab</sup>
Female	Black	12.50±0.18 <sup>d</sup>	9.94±0.07 <sup>d</sup>	9.64±0.12 <sup>f</sup>	9.24±0.06 <sup>d</sup>	3.60±0.07 <sup>b</sup>	12.40±0.07 <sup>c</sup>	7.46±0.05 <sup>c</sup>	51.60±0.81 <sup>c</sup>
	White black	11.96±0.10 <sup>e</sup>	10.44±0.07 <sup>c</sup>	9.82±0.16 <sup>ef</sup>	9.28±0.08 <sup>d</sup>	3.76±0.05 <sup>b</sup>	12.50±0.07 <sup>bc</sup>	7.38±0.08 <sup>c</sup>	51.80±0.58 <sup>c</sup>
	Light brown	13.36±0.08 <sup>c</sup>	10.54±0.07 <sup>c</sup>	10.30±0.10 <sup>ed</sup>	9.42±0.13 <sup>d</sup>	3.74±0.05 <sup>b</sup>	12.62±0.10 <sup>bc</sup>	7.62±0.11 <sup>c</sup>	52.80±0.37 <sup>c</sup>
	Dark brown	12.52±0.23 <sup>d</sup>	10.56±0.05 <sup>c</sup>	10.54±0.14 <sup>cd</sup>	9.50±0.07 <sup>d</sup>	3.86±0.06 <sup>b</sup>	12.64±0.05 <sup>b</sup>	7.54±0.08 <sup>c</sup>	52.80±0.86 <sup>c</sup>