Effect of Production Systems and Dietary Interventions on Growth Performance, Morphometrics, Physiological Response and Behaviour of the Naked Neck Chickens

ABSTRACT

The present study was planned to evaluate the growth performance, morphometrics, physiological and behavioral response of Naked Neck chicken under different production systems and nutritional regimens. For this, a total of 900 Naked Neck chickens of 6-weeks of age were used; the birds were divided into 10 treatment groups consisting of 5 replicates of 18 birds each. A 2×5 factorial arrangement of treatment was employed under Completely Randomized Design. Treatments were consisted of two production systems (intensive and free range) and five nutritional regimens (100% commercial feed, 75% commercial feed +25% kitchen waste, 50% commercial feed +50% kitchen waste, 25% commercial feed +75% kitchen waste and 100% kitchen waste). Body weight, heartbeat and respiration rate were higher in birds reared under intensive system and spent most of their time sitting whereas higher feed intake and increased pecking behavior were noted in birds reared under free range system. Regarding feeding regimens, higher feed intake, cloacal temperature, body and neck length were observed in birds fed with 100% kitchen waste whereas higher drumstick, shank and wing spread were observed in birds fed under 100% commercial feed. Furthermore, higher shank and neck length were observed in birds fed 75% kitchen waste and higher body weight was observed in birds fed 50% kitchen waste. Significant interactions were also observed regarding feed intake, cloacal temperature, drumstick circumference, shank length, feeding, sitting and walking behavior. In conclusion, Naked Neck chicken perform better in free range system whereas feeding kitchen waste up to 50% may enhance growth, morphometric, physiological traits and improve behavioral response.

INTRODUCTION

The backyard poultry are valuable asset to local populations as they contribute significantly to food security, poverty alleviation and the promotion of gender equality, especially in less favored areas (Moges & Dessie, 2010). These chickens are well adapted to the hot and humid tropical climates and have been traditionally reared for meat, egg as well as for game purpose (Sahu, 2015).

In Pakistan about 19,052 million eggs and 1,518 million tonnes of chicken meat were produced during the year 2018-19; out of which rural poultry produced 4.315 million eggs and 122.28 million tonnes of meat, respectively, with potential development of 1.5 percent as compared to 2017-18. These figures designate that backyard chicken play a significant role to boost up the economy by producing huge amount of chicken meat and egg to fulfill the nutritional requirement of the nation with (Economic Survey, 2019).

Among backyard rural poultry Naked Neck is one of the most preferred breeds for rural poultry farmers due to its better resistance...
against diseases (Sadef et al., 2015). This breed is well-known for better egg production and thermo-resistant in tropical and sub-tropical climatic zones but performance varied under various environmental conditions as well as rearing system (Sadef et al., 2015). Unfortunately, there have been no comprehensive programs that support the backyard village chicken production through viable production and low-cost feeding system to enhance the productivity of these birds. The availability of the scavenging feed resource is affected by seasonal fluctuations and the village poultry production mainly depends on a large degree on the quality and quantity of feed available from scavenging (Molla, 2010). There are several ways to reduce the cost of production such as reducing the feed cost by introducing the wastes. Now-a-days fully formulated feed with all aspects is frequently used in commercial poultry farming, whereas under free-range production system, birds fulfill their nutritional requirements from household left over’s, mostly kitchen waste, vegetables and green grasses (Fanatico et al., 2013). Therefore, alternative cheaper sources of feeding and housing systems need to be further investigated. It is necessary to provide concrete information regarding low cost production practices to help poultry producers and consumers to make informed decisions. Attempts are being made to raise the productivity of family chickens in developing countries, by improving housing, nutrition and health programs. Keeping this in view, the present study was planned to investigate the performance of Naked Neck chicken with improved feeding strategies and housing systems.

MATERIALS AND METHODS

This study was conducted at the Department of Poultry Production, University of Veterinary and Animal Sciences, A-Block, Ravi Campus, Pattoki, Pakistan. Pattoki is located at 31°1'0"N, 73°50'60"E with an altitude of 186 m. The city normally experiences hot and humid tropical climate with maximum temperature ranging from 13 °C in the winter to 45°C in the summer.

Experimental Birds

A total of 900 Naked Neck one day old chicks were picked up from available stock at random; then brooded up to six weeks and further divided into 10 treatment groups consisting of 5 replicates of 18 birds each. A 2×5 factorial arrangement of treatment was applied according to Completely Randomized Design. The treatments consisted of two production systems (intensive and free range) and five nutrition regimens i.e., (a) 100% Commercial Feed (b)75% Commercial Feed +25% Kitchen Waste (c) 50% Commercial feed +Kitchen Waste (d)25% Commercial Feed +75% Kitchen Waste and (e) 100% Kitchen Waste, respectively.

Bird’s Husbandry

All the experimental birds were individually tagged and maintained in open sided sheds (6.1m L × 6.1m W × 3.66m H) oriented east to west. In intensive housing system, birds were managed at well ventilated poultry shed and were fed commercial grower ration. The daily allowance was increased corresponding to their growth and requirement. A stocking density of 0.65 sq. ft per bird and nipple drinking system were used in intensive system at 10 birds per nipple till six weeks of age. With the progression in age, stocking density was adjusted to a maximum of 1.5 sq ft per bird. For free range system, a pen measuring 12×10 sq ft indoor area and 20×10 sq ft for outdoor access were provided to 20 birds at 10 sq ft/bird. Drinking water was provided using nipple drinking system in indoor area. While in outdoor area, supplementary feeders and drinkers were placed at 10 birds per feeder and 15 birds per drinker.

The birds in both the production systems (intensive and free range) were fed kitchen waste (KW) and commercial poultry feed in measured amount in order to calculate feed intake (Table 1). The ration (kitchen waste) was collected from university student hostels and cafeterias. The restaurants in the vicinity of Ravi Campus have also been consented to provide kitchen waste free of cost.

Ethics

The care and utilization of birds were performed in accordance with the laws and regulations of Pakistan and approved by the Committee of Ethical Handling of Experimental Birds, University of Veterinary and Animal Sciences, Lahore, Pakistan (No. DR/758).

Parameters evaluated

Growth performance

The following parameters were evaluated:

Feed intake (g): The data regarding feed intake of the experimental birds were noted on a daily basis by subtracting the measured refusal amount from the measured offered:
Table 1 – Proximate analysis of kitchen waste and ingredient & nutrient composition of experimental ration.

| Proximate          | Kitchen Waste |
|--------------------|---------------|
| Dry CF %           | 35.6          |
| Moisture %         | 42.86         |
| Crude Protein %    | 16.5          |
| Ether Extract %    | 18.03         |
| ASH %              | 6.01          |
| Feed Ingredient (%)| Grower (7-18 weeks) |
| Corn               | 61.55         |
| Soybean Meal       | 31.70         |
| Fish Meal          | 0.00          |
| Soybean Oil        | 3.00          |
| DCP                | 1.70          |
| NaCl               | 0.30          |
| Methionine         | 0.12          |
| Total              | 100           |

Nutrient Levels
- Dry Matter: 89.5
- Crude Protein: 20.02
- Metabolizable Energy (Kcal/Kg): 3020
- Calcium: 0.91
- Phosphorus: 0.35
- Lysine: 1.09
- Methionine: 0.43

Feed intake (g) = Feed offered (g) – Feed refusal (g)

Body weight (g): Body weight of each and every bird was recorded throughout the experimental period on a weekly basis with the help of electrical weighing balance (Wei Heng, China).

Body weight gain (g): it was calculated on a weekly basis by deducting the initial weight from the final weight at the end of each week.

Weight gain (g) = Final weight (g) – Initial weight (g)

Growth efficiency: it was recorded on a weekly basis by dividing the overall weight gains by the initial live weights following the method adopted by Gondwe and Wollny (2005).

Livability (%): it was counted by having a precise record of daily mortality and subtracting the figure from the total number of chicks in each experimental unit.

Livability % = \( \frac{\text{Total remaining birds}}{\text{Total birds placed}} \times 100 \)

Morphometric traits

During the growth phase (7-18 weeks), all the experimental birds from each unit were tagged properly for their identification and morphometric traits of each sex (male and female) were measured on a fortnightly basis including body, keel, shank and drumstick length and circumference and wing spread.

Physiological Response

Cloacal temperature (CT) was measured using a digital clinical thermometer that was inserted to a depth of three centimeters for 2 minutes. Surface temperatures of head (Th), back (Tb), wings (Tw) and shanks (Ts) were measured with an infrared digital thermometer (°C) with no contact with the skin, at a distance of approximately 15 cm from the bird’s body while mean body surface temperature (Tms) was derived from following equation adapted form Malheiros et al. (2000):

\[ Tms = 0.03Th + 0.70Tb + 0.15Ts + 0.12Tw \]

Heart rate (beats/min) was measured by using Littman stethoscope while counting the time with the help of a stopwatch (Mutibvu et al., 2017). For respiratory rate (breath/min), bird was held still in inverted position and respiratory movement at abdominal area was observed for one minute (Mutibvu et al., 2017).

All measurements were taken on a weekly basis, at 09:00 AM and 5:00 PM, on the same day as the collection of environmental variables, during the entire experimental period.

Behavioral Response

Behavioral observations were recorded on a weekly basis in the morning (09:00 AM) and afternoon (05:00 PM), during 2 periods of 3 hours each, using the focal animal sampling method (Table 2).

Table 2 – Ethogram of behavioral parameters.

| Behavior         | Description                                      |
|------------------|--------------------------------------------------|
| Feeding          | With head above or in the feeder and pecks directed into the feeder |
| Sitting          | Lying or sitting hocks keeping on ground surface without identifiable action |
| Walking          | Movements at normal pace or with instant gait |
| Pecking          | Pecks directed at head or body of companion bird |

Source: Eriksson (2010)

Statistical analysis

Effect of different production system and feeding regimens on growth performance, physiological response and morphometric traits were analyzed through factorial ANOVA. General Linear Model was applied in SAS software (version 9.1). Significant treatment means were compared through Duncan’s Multiple Range test (Duncan, 1955) considering probability at \( p \leq 0.05 \). The following mathematical model was applied:

\[ Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha \times \beta)_{ij} + \varepsilon_{ijk} \]
Where,

\[ Y_{ijk} = \text{Observation of dependent variable recorded on } i^{th} \text{ and } j^{th} \text{ treatment} \]

\[ \mu = \text{Population mean} \]

\[ \alpha_i = \text{Effect of } i^{th} \text{ production system (} i = 1,2) \]

\[ \beta_j = \text{Effect of } j^{th} \text{ feeding regimens (} i = 1,2,3,4,5) \]

\[ (\alpha \times \beta)_{ij} = \text{Interaction effect between } i^{th} \text{ and } j^{th} \text{ treatment} \]

\[ \epsilon_{ijk} = \text{Residual effect of } k^{th} \text{ observation on } i^{th} \text{ and } j^{th} \text{ treatment NID ~ 0, } \sigma^2 \]

**RESULTS**

**Growth performance**

Feed intake differ significantly (\(p \leq 0.05\)) among production systems, feeding regimens and their interaction (Table 3). In terms of production systems, higher feed intake (g) was observed in birds reared under free range than in those of reared under intensive system (4764.75 ± 441.16 vs. 4589.30 ± 457.15g; \(p=0.0001\)). Regarding feeding regimens, highest feed intake (g) was observed in birds fed with 25% kitchen waste and the lowest feed intake (g) was observed in birds fed with 25% kitchen waste (6975.25 ± 4.70 vs. 1671.19 ± 27.52 g; \(p=0.0001\)). Furthermore, significant interactions between production system and feeding regimens were also noted regarding feed intake (\(p=0.0001\)).

Body weight, weight gain and growth efficiency of male birds differ significantly (\(p \leq 0.05\)) among production systems, feeding regimens and their interaction (Table 3). In terms of production systems, higher body weight (g) (1394.00±16.37 vs. 1329.9± 24.34 g, \(p=0.0001\)), weight gain (g) (975.30 ± 11.75 vs. 928.58 ± 27.65g, \(p=0.0001\)) were observed in birds reared under intensive system than in those of reared under free range system. With respect to different feeding regimens, highest body weight (g) was observed in birds fed with 25% kitchen waste (1409.88± 14.54 vs. 1265.63± 37.03 g; \(p=0.0001\)), whereas the lowest weight gain (g) was observed in birds fed under 100% kitchen waste (1019.63± 11.60 vs. 846.06± 32.48 g; \(p=0.0001\)), similarly higher growth efficiency was observed in 100% commercial feed and lower in 100% kitchen waste(2.64± 0.18 vs. 2.01± 0.06 %; \(p=0.0001\)). Significant interactions were observed in body weight (\(p=0.0001\)), weight gain (\(p=0.0001\)) and growth efficiency (\(p=0.0001\)).

Body weight of female birds differ significantly (\(p \leq 0.05\)) among production systems, feeding regimens and their interaction (Table 3). In terms of production systems, higher body weight (g) (1394.00±16.37 vs. 1329.9± 24.34 g, \(p=0.0001\)), weight gain (g) (975.30 ± 11.75 vs. 928.58 ± 27.65g, \(p=0.0001\)) were observed in birds reared under intensive system than in those of reared under free range system. With respect to different feeding regimens, highest body weight (g) was observed in birds fed with 25% kitchen waste (1409.88± 14.54 vs. 1265.63± 37.03 g; \(p=0.0001\)), whereas the lowest weight gain (g) was observed in birds fed under 100% kitchen waste (1019.63± 11.60 vs. 846.06± 32.48 g; \(p=0.0001\)), similarly higher growth efficiency was observed in 100% commercial feed and lower in 100% kitchen waste(2.64± 0.18 vs. 2.01± 0.06 %; \(p=0.0001\)). Significant interactions were observed in body weight (\(p=0.0001\)), weight gain (\(p=0.0001\)) and growth efficiency (\(p=0.0001\)).

**Table 3 – Growth Performance of male Naked Neck chicken reared under different production system and nutritional regimens.**

| PS    | FI    | BW     | BWG    | GE     | LIV  |
|-------|-------|--------|--------|--------|------|
| Free range | 4764.75 | 1329.90 | 928.58 | 2.35   | 99.63 |
| Intensive | 4589.30 | 1394.00 | 975.30 | 2.34   | 99.67 |
| CF    | 6387.25 | 1367.75 | 967.81 | 2.64   | 99.49 |
| 25 % KW | 1671.19 | 1409.88 | 1019.63 | 2.63   | 99.72 |
| 50 % KW | 3342.00 | 1408.50 | 982.88 | 2.32   | 99.58 |
| 75 % KW | 5009.44 | 1358.00 | 923.31 | 2.13   | 99.68 |
| 100% KW | 6975.25 | 1265.63 | 846.06 | 2.01   | 99.77 |
| Free range CF | 6387.25 | 1441.75 | 1075.25 | 2.99   | 99.54 |
| 25 % KW | 1743.88 | 1448.00 | 1040.38 | 2.58   | 99.72 |
| 50 % KW | 3488.50 | 1314.00 | 929.50 | 2.42   | 99.63 |
| 75 % KW | 5288.88 | 1278.00 | 837.38 | 1.90   | 99.54 |
| 100% KW | 6975.25 | 1167.75 | 760.38 | 1.87   | 99.72 |
| Intensive CF | 6387.25 | 1293.75 | 900.38 | 2.29   | 99.44 |
| 25 % KW | 1598.50 | 1371.75 | 998.88 | 2.68   | 99.72 |
| 50 % KW | 3195.50 | 1503.00 | 1036.25 | 2.22   | 99.54 |
| 75 % KW | 4790.00 | 1438.00 | 1009.25 | 2.35   | 99.81 |
| 100% KW | 6975.25 | 1363.50 | 931.75 | 2.16   | 99.81 |
| SEM | 313.866 | 15.361 | 15.293 | 0.059 | 0.001 |

**Source of variation ANOVA**

| Product system | 0.0001 | 0.0001 | 0.0001 | 0.8696 | 0.6721 |
| Treatment | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.2798 |
| Production system x Treatment | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.6396 |

Superscripts on different means within column differ significantly at \(p \leq 0.05\).

**PS** = Production System; **FR** = Feeding Regimens; **FI** = Feed Intake (g); **BW** = Body weight (g); **BWG** = Body weight gain (g); **GE** = Growth efficiency; **LIV** = Livability %; **KW** = Kitchen Waste; **CF**= Commercial feed.
regimens and their interaction (Table 4). Regarding production systems, higher body weight (g) was observed in birds reared under intensive system than in those of reared under free range system (1257.00 ± 12.50 vs. 1156.20 ± 16.61g; p=0.0001). However, body weight, weight gain, growth efficiency rate and bird’s livability did not differ (p>0.05) among feeding regimens and th.

### Table 4 – Growth performance of female Naked Neck chicken reared under different production system and nutritional regimens.

| PS          | FR      | FI (g) | BW (g) | BWG (g) | GE    | LIV |
|-------------|---------|--------|--------|---------|-------|-----|
| Free range  |         |        | 4764.75 | 1156.20 | 769.40 | 2.01 | 99.43 |
| Intensive   |         |        | 4589.30 | 1257.00 | 854.75 | 2.15 | 99.50 |
| CF          | 6387.25 | 1234.13 | 791.25 | 2.42 | 99.35 |
| 25 % KW     | 1671.19 | 1169.25 | 793.14 | 2.14 | 99.31 |
| 50 % KW     | 3342.00 | 1207.25 | 798.63 | 1.98 | 99.68 |
| 75 % KW     | 5099.44 | 1224.25 | 806.25 | 1.93 | 99.44 |
| 100% KW     | 6975.25 | 1198.13 | 790.13 | 1.93 | 99.54 |
| Free range  | CF      | 6387.25 | 1149.75 | 778.75 | 2.34 | 99.35 |
| 25 % KW     | 1743.88 | 1116.75 | 799.75 | 1.83 | 99.07 |
| 50 % KW     | 3488.50 | 1182.00 | 811.50 | 2.19 | 99.72 |
| 75 % KW     | 5228.88 | 1203.50 | 778.75 | 1.84 | 99.44 |
| 100% KW     | 6975.25 | 1129.00 | 736.50 | 1.88 | 99.54 |
| Intensive   | CF      | 6387.25 | 1318.50 | 942.75 | 2.51 | 99.35 |
| 25 % KW     | 1598.50 | 1221.75 | 867.75 | 2.46 | 99.54 |
| 50 % KW     | 3195.50 | 1232.50 | 785.75 | 1.76 | 99.63 |
| 75 % KW     | 4790.00 | 1245.00 | 833.75 | 2.03 | 99.44 |
| 100% KW     | 6975.25 | 1267.25 | 843.75 | 1.99 | 99.54 |
| SEM         | 313.87  | 13.052 | 13.480 | 0.053 | 0.001 |

**Source of variation**

| PS = Production System; FR = Feeding Regimens; FI = Feed Intake (g); BW = Body weight (g); BWG = Body weight gain (g); GE = Growth efficiency; LIV = Livability %; KW = Kitchen Waste; CF = Commercial feed

### Physiological response

Physiological parameters of male birds differ significantly (p≤0.05) among production systems, feeding regimens and their interaction (Table 5). With respect to production systems, highest heart beat (bpm) (300.53± 0.52 vs. 297.55 ± 0.54 bpm; p=0.0003), respiration rate (bpm) (48.33± 0.26 vs. 46.00 ± 0.32 bpm; p=0.0001) were observed in birds reared under free range system than in those of reared under intensive system. However, back, cloacal, head, shanks, wings and body surface temperatures did not show any significant difference (p>0.05) in production system, feeding regimens and their interaction.

Physiological response of female birds differs significantly (p≤0.05) among production systems, feeding regimens and their interaction (Table 6). Regarding production systems, higher cloacal (°C) (41.57 ± 0.03 vs. 41.45 ± 0.02°C; p=0.0001), head (°C ) (34.98± 0.13 vs. 34.41 ± 0.12°C; p=0.0026), wings (°C) (36.66 ± 0.06 vs. 36.12 ± 0.08°C; p=0.0001) temperatures and heart beat (bpm) (323.33 ± 0.44 vs. 321.90 ± 0.36 bpm; p=0.0001), respiration rate (bpm) (60.12 ± 0.23 vs. 57.97 ± 0.30 bpm; p=0.0001) were observed in birds reared under free range system than in those reared under intensive system. With respect to feeding regimens, higher cloacal temperature (°C) was observed in birds fed with 100% kitchen waste, whereas the lowest was observed in birds fed under 100% commercial feed (41.62 ± 0.03 vs. 41.51 ± 0.06°C; p=0.0014). Significant interactions between production system and feeding regimens (p=0.0233) were also noted regarding cloacal temp.

### Morphometric traits

Morphometric traits of male birds differ significantly (p≤0.05) among production systems, feeding regimens and their interaction (Table 7). Regarding production systems, higher keel length (cm) (41.57 ± 0.03 vs. 41.45 ± 0.02°C; p=0.0001), heads (°C ) (34.98± 0.13 vs. 34.41 ± 0.12°C; p=0.0026), wings (°C) (36.66 ± 0.06 vs. 36.12 ± 0.08°C; p=0.0001)
**Table 5 – Physiological response of male Naked Neck chicken reared under different production system and nutritional regimens.**

|          | PS  | FR  | BK   | CL   | HD   | SK   | WG   | BS   | HB   | RP   |
|----------|-----|-----|------|------|------|------|------|------|------|------|
| Free range |     |     |      |      |      |      |      |      |      |      |
| CF       | 32.52 | 41.30 | 34.05 | 33.06 | 35.71 | 33.03 | 300.53 | 46.00 |      |      |
| 25% KW   | 32.37 | 41.31 | 33.98 | 32.83 | 35.91 | 32.92 | 300.81 | 47.09 |      |      |
| 50% KW   | 32.58 | 41.30 | 34.11 | 32.64 | 35.72 | 33.01 | 297.69 | 46.76 |      |      |
| 75% KW   | 32.39 | 41.31 | 33.95 | 33.14 | 35.48 | 32.92 | 298.69 | 47.19 |      |      |
| 100% KW  | 32.80 | 41.40 | 34.18 | 32.95 | 35.78 | 33.22 | 298.63 | 47.92 |      |      |
|           |     |     |      |      |      |      |      |      |      |      |
| Intensive |     |     |      |      |      |      |      |      |      |      |
| CF       | 32.47 | 41.28 | 33.80 | 32.99 | 35.64 | 33.03 | 300.53 | 46.00 |      |      |
| 25% KW   | 32.44 | 41.36 | 33.95 | 33.00 | 36.04 | 33.00 | 302.69 | 46.88 |      |      |
| 50% KW   | 32.58 | 41.25 | 34.52 | 32.87 | 35.86 | 32.99 | 298.94 | 47.31 |      |      |
| 75% KW   | 32.35 | 41.29 | 33.72 | 33.55 | 35.43 | 32.94 | 300.13 | 46.29 |      |      |
| 100% KW  | 32.79 | 41.36 | 34.16 | 32.94 | 35.86 | 33.23 | 299.31 | 46.44 |      |      |
|           |     |     |      |      |      |      |      |      |      |      |
| SEM      | 0.102 | 0.017 | 0.121 | 0.165 | 0.083 | 0.100 | 0.441 | 0.276 |      |      |
| Source of variation ANOVA |     |     |      |      |      |      |      |      |      |      |
| PS       | 0.9415 | 0.2813 | 0.7573 | 0.4195 | 0.8291 | 0.8603 | 0.0003 | 0.0001 |      |      |
| FR       | 0.7570 | 0.2097 | 0.9001 | 0.9287 | 0.5449 | 0.9086 | 0.1125 | 0.3954 |      |      |
| PS x FR  | 0.9977 | 0.2564 | 0.6258 | 0.9324 | 0.8661 | 0.9983 | 0.6455 | 0.1326 |      |      |

Superscripts on different means within column differ significantly at p≤0.05.

PS = Production System; FR = Feeding Regimens; BK = Back temperature °C; CL = Cloacal temperature °C; HD = Head temperature °C; SK = Shank temperature °C; WG = Wing temperature °C; BS = Body Surface temperature °C; HB = Heart Beat; RP=Respiration; KW = Kitchen Waste; CF= Commercial feed.

**Table 6 – Physiological response of female Naked Neck chicken reared under different production system and nutritional regimens.**

|          | PS  | FR  | BK   | CL   | HD   | SK   | WG   | BS   | HB   | RP   |
|----------|-----|-----|------|------|------|------|------|------|------|------|
| Free range |     |     |      |      |      |      |      |      |      |      |
| CF       | 33.65 | 41.45 | 34.41 | 34.07 | 36.12 | 34.03 | 321.90 | 57.97 |      |      |
| 25% KW   | 33.69 | 41.57 | 34.78 | 33.76 | 36.66 | 34.09 | 332.33 | 60.12 |      |      |
| 50% KW   | 33.67 | 41.42 | 34.42 | 33.82 | 36.49 | 33.99 | 298.94 | 47.31 |      |      |
| 75% KW   | 33.46 | 41.52 | 34.81 | 34.17 | 36.27 | 33.95 | 297.06 | 49.40 |      |      |
| 100% KW  | 33.76 | 41.43 | 34.21 | 32.96 | 35.70 | 33.21 | 297.94 | 44.90 |      |      |
|           |     |     |      |      |      |      |      |      |      |      |
| Intensive |     |     |      |      |      |      |      |      |      |      |
| CF       | 33.69 | 41.57 | 34.48 | 34.02 | 36.44 | 34.12 | 327.43 | 58.65 |      |      |
| 25% KW   | 33.57 | 41.42 | 34.42 | 33.82 | 36.49 | 33.99 | 298.94 | 59.18 |      |      |
| 50% KW   | 33.76 | 41.51 | 34.80 | 33.64 | 36.22 | 34.07 | 297.06 | 59.16 |      |      |
| 75% KW   | 33.46 | 41.52 | 34.81 | 34.17 | 36.27 | 33.95 | 297.06 | 59.16 |      |      |
| 100% KW  | 33.81 | 41.62 | 34.78 | 33.93 | 36.53 | 34.19 | 298.53 | 59.45 |      |      |
|           |     |     |      |      |      |      |      |      |      |      |
| SEM      | 0.1222 | 0.0200 | 0.6258 | 0.9324 | 0.8661 | 0.9983 | 0.6455 | 0.1326 |      |      |
| Source of variation ANOVA |     |     |      |      |      |      |      |      |      |      |
| PS       | 0.8800 | 0.0001 | 0.0026 | 0.4000 | 0.0001 | 0.7977 | 0.0001 | 0.0001 |      |      |
| FR       | 0.9046 | 0.0014 | 0.5747 | 0.9109 | 0.2031 | 0.9722 | 0.0682 | 0.0665 |      |      |
| PS x FR  | 0.9988 | 0.0233 | 0.2330 | 0.9191 | 0.7882 | 0.9992 | 0.6854 | 0.1110 |      |      |

Superscripts on different means within column differ significantly at p≤0.05.

PS = Production System; FR = Feeding Regimens; BK = Back temperature °C; CL = Cloacal temperature °C; HD = Head temperature °C; SK = Shank temperature °C; WG = Wing temperature °C; BS = Body Surface temperature °C; HB = Heart Beat; RP=Respiration; KW = Kitchen Waste; CF= Commercial feed.
were observed in birds reared under free range system than under intensive system. With respect to feeding regimens, higher neck length (cm) was observed in birds fed with 100% kitchen waste whereas the lowest neck length (cm) was observed in birds fed under 50% kitchen waste (19.08± 1.45 vs. 16.50± 0.13 cm; p=0.0412). The highest drumstick length (cm) was observed in birds fed with 100% commercial feed and lowest was observed in 50% kitchen waste(13.67 ± 0.67 vs. 12.08± 0.15 cm; p=0.0178). Moreover, higher shank length was observed in birds under 75% kitchen waste and lower in 50% kitchen waste(16.25± 0.17 vs. 14.67± 0.17 cm; p=0.216), higher wing spread was observed in bird fed with 100% commercial feed and lower in 25% kitchen waste (15.17± 0.44 cm; p=0.0183) and higher body weight was observed in 50% kitchen waste and lower in 100 kitchen waste % (1408.50±35.85 vs. 1265.63±37.03 gm; p=0.0001). Significant interactions were observed in body weight (p=0.0001) and drumstick circumference (p=0.0039).

Morphometric traits of female birds differ significantly (p≤0.05) among production systems, feeding regimens and their interaction (Table 8). Regarding production systems, higher neck (cm) (17.17±0.26 vs. 16.53±0.19 cm; p=0.0310), shank (cm) (14.27±0.34 vs. 13.28±0.13 cm; p=0.0001), body length (cm) (61.07±0.71 vs. 59.07±0.73 ; p=0.0205) and body weight (g) (1153.35±18.89 vs. 1228.25±17.06 g; p=0.011) were observed in birds reared under free range system than in those under intensive system. With respect to feeding regimens, higher neck length (cm) was observed in birds fed with 75% kitchen waste, whereas the lowest neck length (cm) were observed in birds fed under 25% kitchen waste (17.58 ± 0.42 vs. 16.08 ± 0.20 cm; p=0.0213). The higher shank length was observed in birds under 100% commercial feed and lower shank length was observed in 25% kitchen waste (14.45± 0.57 vs. 12.83± 0.17 cm; p=0.0001). Body length (cm) were maximum in 100% kitchen waste while lowest in 25% kitchen waste (62.00 ± 0.93 vs. 57.67 ± 1.20 cm; p=0.0089). Significant interactions were observed in drumstick length (p=0.0201), circumference (p=0.0496) and shank length (p=0.0001).
Effect of Production Systems and Dietary Interventions on Growth Performance, Morphometrics, Physiological Response and Behaviour of the Naked Neck Chickens

Bughio E, Hussain J, Mahmud A, Khalique A

Table 8 – Morphometric traits of female Naked Neck chicken reared under different production system and nutritional regimens.

| Source of Variation | ANOVA | SEM | ANOVA | SEM |
|---------------------|-------|-----|-------|-----|
| PS                  | 0.5788 | 0.2367 | 0.0310 | 0.7711 |
| FR                  | 0.2783 | 0.2303 | 0.0213 | 0.9978 |
| PS × FR             | 0.6581 | 0.3199 | 0.4381 | 0.0201 |

behavioral response

Male birds in free range system spent most of their time feeding (%) (25.53 ± 1.49 vs. 20.71 ± 0.84%; p=0.0011), walking (%) (40.67 ± 1.27 vs. 30.23 ± 0.79%; p=0.0001) and pecking (%) (32.24 ± 1.72 vs. 28.52 ± 1.40%; p=0.0032). Regarding feeding regimens, females fed with 25% kitchen waste and 75% commercial feed exhibited more walking (%) (49.12 ± 0.53 vs. 41.80 ± 1.01%; p=0.0001) and sitting (%) (28.52 ± 1.60 vs. 24.62 ± 6.10%; p=0.3976) and pecking (%) (39.81 ± 1.75 vs. 38.82 ± 2.52%; p=0.0763) behavior than the rest of the treatment groups. Males fed with 50% commercial feed were more involved in pecking (%) (30.17 ± 3.18 vs. 23.54 ± 1.79%; p=0.0470) and walking (41.67 ± 2.29 vs. 29.25 ± 2.16%; p=0.0001) (Table 9). Significant (p<0.05) interactions were observed in feeding (%) (p=0.0258) and sitting (%) (p=0.0001).

Female birds in free range system spent most of their time in feeding (%) (23.68 ± 0.39 vs. 19.35 ± 0.26%; p=0.0005), walking (%) (45.04 ± 1.38 vs. 25.86 ± 0.52%; p=0.0001) and pecking (37.90 ± 0.98 vs. 26.24 ± 0.40%; p=0.0763). Regarding feeding regimens, females fed with 100% kitchen waste and 100% commercial feed exhibited more walking (%) (52.37 ± 0.89 vs. 37.48 ± 5.64%; p=0.0001), sitting (%) (17.37 ± 7.29 vs. 10.48 ± 0.66%; p=0.4621) and pecking (%) (35.95 ± 1.96 vs. 31.34 ± 1.97%; p=0.4344) behavior than the rest of the treatment groups. Females fed with 100% commercial feed were more involved in pecking (%) (35.95 ± 1.96 vs. 26.74 ± 0.34%; p=0.4344) and walking (%) (52.37 ± 0.89 vs. 22.59 ± 0.28%; p=0.0001) (Table 9). Significant interactions were observed in feeding (%) (p=0.0001) and walking (%) (p=0.0005).

Discussion

The results of the present study revealed evidence of several differences regarding performance, physiology, morphometrics, and behavioral response in Naked Neck chicken under different housing environment and feeding regimens. Birds consumed more feed in free range system as they have the choice for walking and searching, interestingly, they prefer small amounts of kitchen waste (25%) to accommodate their nutrients. Accordingly, several studies reported significant...
Effect of Production Systems and Dietary Interventions on Growth Performance, Morphometrics, Physiological Response and Behaviour of the Naked Neck Chickens

Influence of house type on feeding habits of chicken genotypes and comparatively higher feed intake was reported in extensive systems (Binda et al., 2012; Mutayoba et al., 2012) and lower in intensive systems (Fu et al., 2015; Radikara et al., 2016). Body weight is a good indicator of the bird’s activity, as the slow growing chickens are generally lighter (live weight) and more active than their fast-growing counterparts. A similar trend was observed in this study, higher body weight of Naked Neck chickens (both male and females) were noted in intensive reared birds than free range birds. Moreover, these birds also select smaller quantity of kitchen waste (25%) apart from their commercial feed. This corresponds to the findings of Lamidi (2014) who found that the battery cages gave higher meat yield than deep litter in broiler chicks due to less activities of the bird. However, another study reported no significant difference in weight gain of birds raised on litter floor and in batteries (El-Sagheer et al., 2012).

Birds reared under free-range system showed difference in physiological response, as heartbeat and respiration rate were higher in male birds. Moreover, cloacal, head and wings temperatures were also higher in female birds than in those reared under intensive system. This is obvious that increase movement of birds in free range area influenced their physical state which ultimately raised their body temperature as well. Findings of Yakubu et al. (2018) are in accordance with this study who reported that housing systems affects physiological traits of Sasso laying hens. Furthermore, birds reared in cages appeared to be more stressed as compared to the birds kept in free range system. Higher cloacal temperature was observed in birds fed with 100% kitchen waste whereas the lowest was observed in birds fed under 100% commercial feed. This corresponds to the findings of Attia et al. (2018) who observed that physiological traits of broiler chickens affected by various feeding regimens.

Free-range housing system also impact birds morphometrics and this might be attributed to increase exercise of the birds during their life span, ultimately spending more calories in formation of body morphometrics. Similar findings reported differences in body weight, body and keel length in crossbred chickens when reared under free range, semi intensive and intensive housing systems (Ahmad et al., 2019). Campbell et al. (2017a) reported that in commercial intensive systems domesticated adult hens spend less than 10% of their time for feeding. The opportunities of foraging are less favorable in intensive systems.

### Table 9 – Behavioural response of Naked Neck chicken reared under different production system and nutritional regimens.

| PS         | FR         | Male     | Female    | FD | WK | ST | PK | FD | WK | ST | PK |
|------------|------------|----------|-----------|----|----|----|----|----|----|----|----|
| Free range | CF         | 25.53a   | 40.67a    | 12.56b   | 32.24a   | 23.68a   | 45.04a   | 10.34a | 37.90a |
|            | Intensive  | 20.71b   | 30.23b    | 14.92b   | 28.52b   | 19.35b   | 25.86b   | 21.97b | 26.24b |
| 25 % KW    | CF         | 21.81c   | 32.96     | 10.75b   | 33.27a   | 23.51a   | 32.40a   | 16.16  | 30.67  |
| 50 % KW    | CF         | 24.69c   | 37.52     | 12.77c   | 32.75c   | 20.71a   | 36.82a   | 19.21  | 33.16  |
| 100 % KW   | CF         | 22.15c   | 34.38     | 20.35c   | 34.67c   | 19.49c   | 37.48c   | 13.92  | 31.34  |
| Free range | CF         | 25.17c   | 34.38     | 8.13c    | 30.83     | 25.88a   | 35.79a   | 10.35  | 34.19  |
| 25 % KW    | CF         | 34.25a   | 41.46     | 15.38ac  | 25.67     | 24.93a   | 41.80a   | 10.58  | 38.82  |
| 50 % KW    | CF         | 21.08ad  | 41.67     | 10.83ad  | 30.17     | 23.76a   | 46.14a   | 10.37  | 40.75  |
| 75 % KW    | CF         | 23.92bc  | 44.13     | 8.08a    | 37.88     | 22.75a   | 49.12a   | 9.91   | 39.81  |
| 100 % KW   | CF         | 23.25bc  | 41.71     | 20.38a   | 36.67     | 21.10a   | 52.37a   | 10.48  | 35.95  |
| Intensive  | CF         | 18.25a   | 31.54     | 13.38a   | 35.71     | 21.15a   | 29.00a   | 21.97a | 27.15  |
| 25 % KW    | CF         | 21.58bc  | 32.42     | 12.54a   | 23.04     | 19.76a   | 27.27a   | 24.62a | 25.29  |
| 50 % KW    | CF         | 17.21cd  | 29.25     | 11.88c   | 23.54     | 19.30c   | 25.90c   | 17.38c | 25.52  |
| 75 % KW    | CF         | 25.46bc  | 30.92     | 16.46b   | 27.63     | 18.67a   | 24.53b   | 28.52b | 26.51  |
| 100 % KW   | CF         | 21.04bc  | 27.04     | 20.33a   | 32.67     | 17.88a   | 22.59a   | 17.37c | 26.74  |
| SEM        | 0.929      | 1.114    | 0.733     | 1.135     | 0.418     | 1.699     | 1.416   | 1.070 |

Source of variation ANOVA

| PS          | FR          | 0.0011 | 0.0001 | 0.0017 | 0.0032 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
|-------------|-------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| PS × FR     | 0.0258      | 0.0716 | 0.0001 | 0.1276 | 0.0005 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0763 |

Superscripts on different means within column differ significantly at p≤0.05.

PS = Production System; FR = Feeding Regimen; FD = Feeding; WK = Walking; ST = Sitting; PK = Pecking; KW = Kitchen Waste; CF= Commercial feed.
as compared to free range system (Campbell et al., 2017b). Nandi et al. (2017) reported linear increase in body morphometrics like keel, shank and body length, shank and head circumference and breast angle reared under semi-intensive production system. Likewise, feeding habits influenced some morphological traits, the birds consumed 100% kitchen waste had the longer neck whereas drumstick, shank and wing spread were better in birds reared under 100% commercial feed. Additionally, higher shank and neck length were noted in 75% kitchen waste treatment group. Similarly, several studies reported significant influence of house type and feeding regimens on growth rate and body morphometrics of chicken genotypes (Lay et al., 2011; Binda et al., 2012; Mutayoba et al., 2012). However, Mutayoba et al. (2012) reported that differences in shank length were not significant (p>0.05) between the feeding regimens.

Birds reared under free range system showed more explorative behaviors and spent most of their time in feeding, walking and pecking. Increased frequency in natural behaviors could be due to free access of the bird as the birds have full liberty to express their natural behavior and explore their feed. Earlier observations of Lay et al. (2011) are in accordance with the findings of present study who reported that behavioral traits in chicken like feeding, walking, sitting and pecking significantly influenced by outdoor or free-range system. Behavior in birds is mostly house dependent and birds show more natural behavior when kept in enriched cages, which has a favorable effect on their welfare (de Jong et al., 2013a, b; de Haas et al., 2014a, b; Tahamtani et al., 2016). Feeding regimens had also impact on bird's behavior as the results indicated that birds fed with 100% kitchen waste or commercial feed exhibited more walking, pecking and feeding behavior. The most likely explanation of these behavior is feeding habits and bird's choice, as in both treatments' birds have plenty of food available in form of commercial feed and kitchen waste, therefore, they spent most of their time in walking, pecking and feeding. Stimulating foraging by having litter to forage is important for preventing pecking (Rodenburg et al., 2013; de Haas et al., 2014a, b; Janczak and Riber, 2015). Similar findings also reported significant influence of production systems on feeding behavior of chicken genotype and comparatively higher feed intake was reported in extensive systems (Lay et al., 2011; Binda et al., 2012; Mutayoba et al., 2012).

**CONCLUSIONS**

It may be concluded that Naked neck chicken perform better in free range system whereas feeding kitchen waste up to 50% may enhance growth, morphometric, physiological traits and improve behavioral response.

**ACKNOWLEDGEMENTS**

The authors gratefully acknowledge the cooperation extended by the administration at the Department of Poultry Production, University of Veterinary and Animal Sciences, Lahore, Pakistan for facilitating and providing required necessary facilities to carry out this research work during the entire experimental period.

**REFERENCES**

Adekoya KO, Oboh BO, Adefenwa MA, Ogunkanmi LA. Morphological characterization of five Nigerian indigenous chicken types. Journal of Science Research and Development 2013;14:55-66.

Ahmad S, Mahmud A, Hussain J, Jawed K. Morphometric traits, serum chemistry and antibody response of three chicken genotypes under free-range, semi-intensive and intensive housing systems. Brazilian Journal of Poultry Science 2019;21:1-8.

Attia AY, Al-Harthi MA, Elhaggar AS. Productive, physiological and immunological responses of two broiler strains fed different dietary regimens and exposed to heat stress. Italian Journal of Animal Science 2018;17(3):686-697.

Binda BD, Yousif IA, Elamin KM, Eltayeb HE. A comparison of performance among exotic meat strains and local chicken ecotypes under Sudan conditions. International Journal of Poultry Science 2012;11:500-504.

Campbell DLM, Ali ABA, Karcher DM, Siegford JM. Laying hens in aviaries with different litter substrates: behavior across the flock cycle and feather lipid content. Poultry Science 2017a;96:3824-3835.

Campbell DLM, Hinch GN, Downing JA, Lee C. Outdoor stocking density in free-range laying hens: effects on behavior and welfare. Animal 2017b;11:1036-1045.

Duncan DB. Multiple range and multiple F tests. Biometrics 1955;11:1-42.

Economic Survey of Pakistan 2018-19. Islamabad: Ministry of Finance, Finance Division; 2019.

El-Sagheer M, El-Hamamy HY, Farghly MFA. Productive and reproductive performance of Japanese quail raised in batteries and on litter floor at two densities under the prevailing climatic conditions in Assiut, Upper Egypt. Proceedings of the 3rd Mediterranean Poultry Summit and 6th International Poultry Conference; 2012 Mar 26-29; Alexandria, Egypt. Proceedings of the 3rd Mediterranean Poultry Conference; 2012 Mar 26-29; Alexandria, Egypt. 2012 p.693–710.

Eriksson M. Protein supply in organic broiler production using fast-growing hybrids [thesis]. Uppsala (SWE): Swedish University of Agriculture Science; 2010.

Fadare AO. Morphometric and growth performance variations of Naked Neck, Frizzled Feathered and normal feathered crosses with exotic Giri-Raja chickens. Jordan Journal of Agricultural Sciences 2014;10(4):811-820.
Effect of Production Systems and Dietary Interventions on Growth Performance, Morphometrics, Physiological Response and Behaviour of the Naked Neck Chickens

Bughio E, Hussain J, Mahmud A, Khalique A

Fanatico AC, Brewer VB, Owens-Hanning CM, Donoghue DJ, Donoghue AM. Free choice feeding of free-range meat chickens. Journal of Applied Poultry Research 2013;22:750-758.

Fu D, Zhang D, Xu G, Li K, Wang Q, Zhang Z, et al. Effects of different rearing systems on meat production traits and meat fiber microstructure of Beijing-you chicken. Animal Science Journal 2015;86:729–735.

Gondwe TN, Wollny CBA. Evaluation of the Growth Potential of Local Chickens in Malawi. International Journal of Poultry Science 2005;4:64-70.

Haas EN, Bolhuis JE, Jong IC, Kemp B, Janczak AM, Rodenburg TB. Predicting feather damage in laying hens during the laying period. Is it the past or is it the present? Applied Animal Behavior Science 2014b;160:75–85.

Haas EN, Bolhuis JE, Kemp B, Groothuis TGG, Rodenburg TB. Parents and early life environment affect behavioral development of laying hen chickens. PLoS One 2014a;9:e90577.

Janczak AM, Riber AB. Review of rearing-related factors affecting the welfare of laying hens. Poultry Science 2015;94:1454–1469.

Jong IC, Gunnink H, Rommers JM, Bracke MMB. Effect of substrate during early rearing on floor- and feather pecking behaviour in young and adult laying hens. Archiv fur Geflügelkund 2013a;77:15–22.

Jong IC, Reivekamp BFJ, Gunnink H. Can substrate in early rearing prevent feather pecking in adult laying hens? Animal Welfare 2013b;22:305–314.

Lamidi WA. Comparative analysis of broilers’ rearing in different housing systems in wet humid climate, South West Nigeria. Journal of Biology Agriculture and Healthcare 2014;4:34-40.

Lay Jr DC, Fulton RM, Hester PY, Karcher DM, Kjaer JB, Mench JA, et al. Hen welfare in different housing systems. Poultry Science 2011;90:278–294.

Malheirovs RD, Moraes VMB, Bruno LDG, Malheirovs EB, Furlan RL, Macari M. Environmental temperature and cloacal and surface temperatures of broiler chickens in first week post-hatch. Journal of Applied Poultry Research 2000;9:111-117.

Moges F, Dessie T. Characterization of village chicken and egg marketing systems of Bure district, North-West Ethiopia. Livestock Research for Rural Development 2010;22(10).

Molla M. Characterization of village poultry production and marketing system in Gomawereda of Jimma Zone [thesis]. Jimma (ET): Jimma University; 2010.

Mutayoba SK, Katule AK, Minga U, Mthambo MM, Olsen JE. The effect of supplementation on the performance of free range local chickens in Tanzania. Livestock Research for Rural Development 2012;24(5).

Mutibvu T, Chimonyo M, Haliman TE. Physiological responses of slow-growing chickens under diurnally cycling temperature in a hot environment. Brazilian Journal of Poultry Science 2017;5:2398-2403.

Qureshi M, Qadri AH, Gachal GS. Morphological study of various varieties of Aseel chicken breed inhabiting district Hyderabad. Journal of Entomology and Zoological Studies 2018;6(2):2043-2045.

Radikara MV, Moreki JC, Mareko MHD, Kgwatalala PM. Effect of feeding commercial broiler diets on growth performance of Tsawana and Orpington chickens reared up to 18 weeks of age under intensive system. International Journal of Poultry Science 2016;15:407-413.

Rodenburg TB, Krimpén MM, Jong IC, Haas EN, Kops MS, Riedstra BJ, et al. The prevention and control of feather pecking in laying hens: identifying the underlying principles. World’s Poultry Science Journal 2013;69:361–374.

Sadef S, Khan MS, Rehman MS. Indigenous chicken production in Punjab: a detailed survey through participatory rural appraisals. The Journal of Animal and Plant Science 2015;25(5):1273-1282.

Sahu PK, Das B, Sahoo L, Senapati S, Nayak GD. Genetic relationship and population structure of three Indian local chickens. Mitochondrial DNA 2015;12:1-3.

Tahamtani FM, Brantsæter M, Nordgreen J, Sandberg E, Hansen TB, Nødtvedt A, et al. Effects of litter provision during early rearing and environmental enrichment during the production phase on feather pecking and feather damage in laying hens. Poultry Science 2016;95:2747-2756.

Yakubu A, Ekpo EI, Oluremi OIA. Physiological adaptation of sasso laying hens to the hot-dry tropical conditions. Agriculturae Conspectus Scientificus 2018;83(2):187-193.
