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Original Article

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

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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 deducing 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.

$$\text{Liveability \%} = \frac{\text{Total remaining birds}}{\text{Total birds placed}} \times 100$$

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 (ºC) 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} = Observation of dependent variable recorded on i^{th} and j^{th} treatment

μ = Population mean

α_i = Effect of i^{th} production system (i = 1,2)

β_j = Effect of j^{th} feeding regimens (i = 1,2,3, 4, 5)

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

ε_{ijk} = Residual effect of k^{th} observation on i^{th} and j^{th} treatment NID ~ 0, σ^2

RESULTS

Growth performance

Feed intake differ significantly ($p\leq0.05$) 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 ($p\leq0.05$) among production systems, feeding

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

PS	FR	FI	BW	BWG	GE	LIV
Free range		4764.75^{a}	1329.90^{b}	928.58^{b}	2.35	99.63
Intensive		4589.30^{b}	1394.00^{a}	975.30^{a}	2.34^{b}	99.67
	CF	6387.25^{b}	1367.75^{b}	987.81^{b}	2.64^{a}	99.49
	25 % KW	1671.19^{e}	1409.88^{a}	1019.63^{a}	2.63^{a}	99.72
	50 % KW	3342.00^{d}	1408.50^{a}	982.88^{b}	2.32^{b}	99.58
	75 % KW	5009.44^{c}	1358.00^{b}	923.31^{c}	2.13^{b}	99.68
	100% KW	6975.25^{a}	1265.63^{c}	846.06^{d}	2.01^{c}	99.77
Free range	CF	6387.25	1441.75^{b}	1075.25^{a}	2.99^{a}	99.54
	25 % KW	1743.88^{g}	1448.00^{b}	1040.38^{b}	2.58^{bc}	99.72
	50 % KW	3488.50^{e}	1314.00^{d}	929.50^{b}	2.42^{bcd}	99.63
	75 % KW	5228.88^{c}	1278.00^{f}	837.38^{f}	1.90^{e}	99.54
	100% KW	6975.25^{a}	1167.75^{g}	760.38^{g}	1.87^{e}	99.72
Intensive	CF	6387.25^{b}	1293.75^{e}	900.38^{e}	2.29^{d}	99.44
	25 % KW	1598.50^{h}	1371.75^{c}	998.88^{c}	2.68^{b}	99.72
	50 % KW	3195.50^{f}	1503.00^{a}	1036.25^{b}	2.22^{d}	99.54
	75 % KW	4790.00^{d}	1438.00^{b}	1009.25^{c}	2.35^{cd}	99.81
	100% KW	6975.25^{a}	1363.50^{c}	931.75^{d}	2.16^{ed}	99.81
SEM		313.866	15.361	15.293	0.059	0.001
Source of variation				ANOVA		
Production system		0.0001	0.0001	0.0001	0.8696	0.6721
Treatment		0.0001	0.0001	0.0001	0.0001	0.2798
Production system × Treatment		0.0001	0.0001	0.0001	0.0001	0.6396

Superscripts on different means within column differ significantly at $p\leq0.05$.

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	BW	BWG	GE	LIV
Free range		4764.75[a]	1156.20[b]	769.40	2.01	99.43
Intensive		4589.30[b]	1257.00[a]	854.75	2.15	99.50
	CF	6387.25[b]	1234.13	871.25	2.42	99.35
	25 % KW	1671.19[e]	1169.25	794.13	2.14	99.31
	50 % KW	3342.00[d]	1207.25	798.63	1.98	99.68
	75 % KW	5009.44[c]	1224.25	806.25	1.93	99.44
	100% KW	6975.25[a]	1198.13	790.13	1.93	99.54
Free range	CF	6387.25[b]	1149.75	778.75	2.34	99.35
	25 % KW	1743.88[g]	1116.75	799.75	1.83	99.07
	50 % KW	3488.50[e]	1182.00	811.50	2.19	99.72
	75 % KW	5228.88[c]	1203.50	778.75	1.84	99.44
	100% KW	6975.25[a]	1129.00	736.50	1.88	99.54
Intensive	CF	6387.25[b]	1318.50	942.75	2.51	99.35
	25 % KW	1598.50[h]	1221.75	867.75	2.46	99.54
	50 % KW	3195.50[f]	1232.50	785.75	1.76	99.63
	75 % KW	4790.00[d]	1245.00	833.75	2.03	99.44
	100% KW	6975.25[a]	1267.25	843.75	1.99	99.54
SEM		313.866	13.052	13.480	0.053	0.001
Source of variation				ANOVA		
Production system		0.0001	0.0001	0.6609	0.8630	0.5649
Treatment		0.0001	0.3031	0.4683	0.3822	0.3773
Production system × Treatment		0.0001	0.2231	0.7797	0.8140	0.6648

Superscripts on different means within column differ significantly at p≤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

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) (332.33 ± 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 ~~of~~ 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) (11.05 ± 0.2 vs. 10.28±0.3 cm; p=0.0346), and body weight (g) (1328±24.07 vs. 1377.15±15.81 g; 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		32.52	41.30	34.05	33.06	35.71	33.03	300.53[a]	46.00[b]
Intensive		32.53	41.34	33.97	32.76	35.67	32.99	297.55[b]	48.33[a]
	CF	32.47	41.28	33.80	32.99	35.56	32.96	299.40	46.89
	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
Free range	CF	32.42	41.25	33.89	32.95	35.64	32.93	301.73	45.21
	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	35.58	33.04	298.79	45.21
	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
Intensive	CF	32.53	41.31	33.71	33.04	35.48	33.00	297.06	48.56
	25 % KW	32.31	41.26	34.02	32.66	35.79	32.83	298.94	47.31
	50 % KW	32.59	41.36	33.71	32.42	35.86	32.99	296.58	48.31
	75 % KW	32.43	41.34	34.19	32.74	35.52	32.90	297.25	48.08
	100% KW	32.80	41.43	34.21	32.96	35.70	33.21	297.94	49.40
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 × 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 $p \leq 0.05$.

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		33.65	41.45[b]	34.41[b]	34.07	36.12[b]	34.03	321.90[b]	57.97[b]
Intensive		33.69	41.57[a]	34.98[a]	33.76	36.66[a]	34.09	332.33[a]	60.12[a]
	CF	33.73	41.51[b]	34.65	34.02	36.44	34.12	327.43	58.65
	25 % KW	33.57	41.42[c]	34.42	33.82	36.49	33.99	326.39	59.18
	50 % KW	33.76	41.51[b]	34.80	33.64	36.22	34.07	326.16	58.80
	75 % KW	33.46	41.52[b]	34.81	34.17	36.27	33.95	327.07	59.16
	100% KW	33.81	41.62[a]	34.78	33.93	36.53	34.19	328.53	59.45
Free range	CF	33.63	41.37[b]	34.59	33.99	36.28	34.03	321.94	57.00
	25 % KW	33.61	41.41[b]	33.83	33.90	36.24	33.99	321.56	59.04
	50 % KW	33.79	41.44[b]	34.52	33.87	35.89	34.07	321.35	57.63
	75 % KW	33.38	41.44[b]	34.39	34.60	35.96	33.90	321.96	58.23
	100% KW	33.84	41.60[a]	34.73	33.90	36.22	34.16	322.67	57.96
Intensive	CF	33.82	41.65[a]	34.71	34.04	36.59	34.21	332.92	60.29
	25 % KW	33.54	41.42[b]	35.02	33.66	36.75	33.99	331.21	59.31
	50 % KW	33.74	41.57[a]	35.09	33.42	36.56	34.07	330.96	59.98
	75 % KW	33.55	41.59[a]	35.23	33.74	36.58	33.99	332.19	60.08
	100% KW	33.79	41.63[a]	34.83	33.96	36.83	34.21	334.40	60.94
SEM		0.1222	0.020	0.097	0.164	0.065	0.109	0.881	0.256
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	0.6665
PS × 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 $p \leq 0.05$.

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 7 – Morphometric traits of male Naked Neck chicken reared under different production system and nutritional regimens.

PS	FR	BL	KL	NL	DL	DC	SL	SC	WS	BDL
Free range		3.63	11.05^{a}	17.17	12.91	7.81	15.47	4.21	15.48	64.60
Intensive		3.73	10.28^{b}	18.10	12.73	8.13	15.40	4.27	14.95	64.13
	CF	3.75	10.07	16.67^{b}	12.83^{ab}	8.17	15.58^{abc}	4.25	16.12^{a}	64.50
	25 % KW	3.67	11.25	17.50^{ab}	12.08^{b}	7.72	14.92^{bc}	4.25	14.58^{b}	63.33
	50 % KW	3.58	11.25	16.50^{b}	12.18^{b}	8.22	14.67^{c}	4.20	14.67^{b}	63.17
	75 % KW	3.67	10.75	18.42^{ab}	13.33^{a}	7.83	16.25^{a}	4.25	14.75^{b}	65.33
	100% KW	3.75	10.00	19.08^{a}	13.67^{a}	7.92	15.75^{b}	4.25	15.95^{a}	65.50
Free range	CF	3.67	10.90	16.33	13.17	8.67^{a}	16.33	4.33	17.07	65.33
	25 % KW	3.50	11.17	17.33	12.17	7.77^{bc}	15.00	4.17	15.17	64.33
	50 % KW	3.67	12.00	16.33	11.87	7.77^{bc}	14.83	4.23	14.67	63.00
	75 % KW	3.67	10.67	19.00	13.67	7.50^{c}	16.00	4.17	14.67	65.67
	100% KW	3.67	10.50	16.83	13.67	7.33^{c}	15.17	4.17	15.83	64.67
Intensive	CF	3.83	9.23	17.00	12.50	7.67^{c}	14.83	4.17	15.17	63.67
	25 % KW	3.83	11.33	17.67	12.00	7.67^{bc}	14.83	4.33	14.00	62.33
	50 % KW	0.50	10.50	16.67	12.50	8.67^{a}	14.50	4.17	14.67	63.33
	75 % KW	3.67	10.83	17.83	13.00	8.17^{abc}	16.50	4.33	14.83	65.00
	100% KW	3.83	9.50	21.33	13.67	8.50^{ab}	16.33	4.33	16.07	66.33
SEM		0.066	0.282	0.468	0.291	0.197	0.213	0.054	0.329	0.551
Source of variation						ANOVA				
PS		0.2870	0.0346	0.1175	0.5902	0.0666	0.8264	0.6142	0.1375	0.4344
FR		0.7603	0.0665	0.0412	0.0178	0.3015	0.0216	0.9972	0.0183	0.0554
PS × FR		0.5022	0.2781	0.0567	0.6790	0.0039	0.1046	0.7591	0.2321	0.2973

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

BL= Beak length; KL= Keel length; DL=Drumstick length; DC= Drumstick circumference; NL= Neck length; SL=Shank Length; SC = Shank Circumference; WS=Wing spread; BDL= body length; BW=Body weight; 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± 0.13cm; 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 (16.12± 0.71 vs. 14.58± 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 ($p \leq 0.05$) among production systems, feeding regimens and their interaction (Table 8). Regarding production systems, higher neck (cm) (17.17±0.26 vs. 16.53±0.19cm; 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 under100% 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).

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

PS	FR	BL	KL	NL	DL	DC	SL	SC	WS	BDL
Free range		3.66	10.77	17.17^{a}	12.50	8.15	14.27^{a}	4.03	13.50	61.07^{a}
Intensive		3.59	11.03	16.53^{b}	12.43	7.43	13.28^{b}	3.99	13.43	59.07^{b}
	CF	3.53	11.33	16.75^{abc}	12.42	7.53	14.45^{a}	4.00	13.67	61.50^{a}
	25 % KW	3.48	11.00	16.08^{c}	12.50	7.92	12.83^{b}	3.97	13.08	57.67^{c}
	50 % KW	3.53	10.83	16.58^{bc}	12.50	7.83	13.08^{b}	4.08	13.50	58.50^{bc}
	75 % KW	3.83	10.50	17.58^{a}	12.42	7.92	14.33^{a}	4.00	13.83	60.67^{ab}
	100% KW	3.75	10.83	17.25^{ab}	12.50	7.75	14.17^{b}	4.00	13.25	62.00^{a}
Free range	CF	3.67	11.00	16.67	12.13^{ab}	7.07^{b}	15.67^{a}	4.17	14.17	63.00
	25 % KW	3.63	11.33	16.33	13.00^{ab}	7.67^{ab}	12.83^{c}	4.00	12.83	59.33
	50 % KW	3.50	10.50	17.33	11.83^{b}	8.33^{ab}	12.83^{c}	4.00	13.67	60.00
	75 % KW	3.83	10.33	17.83	12.17^{ab}	9.67^{a}	15.33^{ab}	4.00	14.17	61.33
	100% KW	3.67	10.67	17.67	12.67^{ab}	8.00^{ab}	14.67^{b}	4.00	12.67	61.00
Intensive	CF	3.40	11.67	16.83	12.00^{ab}	8.00^{ab}	13.23^{c}	3.83	13.17	59.33
	25 % KW	3.33	10.67	15.83	12.00^{ab}	8.17^{ab}	12.83^{c}	3.93	13.33	56.00
	50 % KW	3.57	11.17	15.83	13.17^{ab}	7.33^{ab}	13.33^{c}	4.17	13.33	57.00
	75 % KW	3.83	10.67	17.33	12.67^{ab}	6.17^{b}	13.33^{c}	4.00	13.50	60.00
	100% KW	3.83	11.00	16.83	12.33^{ab}	7.50^{ab}	13.67^{c}	4.00	13.83	63.00
SEM		0.091	0.383	0.263	0.160	0.335	0.236	0.060	0.263	0.753
Source of variation						ANOVA				
PS		0.5788	0.2367	0.0310	0.7711	0.1354	0.0001	1.5790	0.7989	0.0205
FR		0.2783	0.2303	0.0213	0.9978	0.9824	0.0001	0.9237	0.3801	0.0089
PS × FR		0.6581	0.3199	0.4381	0.0201	0.0496	0.0001	0.4470	0.0882	0.1407

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

BL= Beak length; KL= Keel length; DL=Drumstick length; DC= Drumstick circumference; NL= Neck length; SL=Shank Length; SC =shank Circumference; WS=Wing spread; BDL= body length; BW=Body weight; KW = Kitchen Waste; CF= Commercial feed.

Behavioral response

Male birds in free range system spent most of their time feeding (%) (25.53 ± 1.49vs.20.71 ± 0.84%; p=0.0011), walking (%) (40.67 ± 1.27 vs.30.23 ± 0.79%; p=0.0001) and pecking (%) (32.24 ± 1.72vs.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), 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 + 50% kitchen waste 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 ($p \leq 0.05$) 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 ± 0.98vs. 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

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		25.53^{a}	40.67^{a}	12.56^{b}	32.24^{a}	23.68^{a}	45.04^{a}	10.34^{b}	37.90^{a}
Intensive		20.71^{b}	30.23^{b}	14.92^{a}	28.52^{b}	19.35^{b}	25.86^{b}	21.97^{a}	26.24^{b}
	CF	21.71^{bc}	32.96	10.75^{c}	33.27^{a}	23.51^{a}	32.40^{d}	16.16	30.67
	25 % KW	27.92^{a}	36.94	13.96^{b}	24.35^{b}	22.34^{b}	34.54^{c}	17.60	32.05
	50 % KW	19.15^{c}	35.46	11.35^{c}	26.85^{b}	21.53^{c}	36.02^{b}	13.87	33.13
	75 % KW	24.69^{ab}	37.52	12.27^{bc}	32.75^{a}	20.71^{d}	36.82^{ab}	19.21	33.16
	100% KW	22.15^{bc}	34.38	20.35^{a}	34.67^{a}	19.49^{e}	37.48^{a}	13.92	31.34
Free range	CF	25.17^{bc}	34.38	8.13^{e}	30.83	25.88^{a}	35.79^{e}	10.35^{c}	34.19
	25 % KW	34.25^{a}	41.46	15.38^{bc}	25.67	24.93^{b}	41.80^{d}	10.58^{c}	38.82
	50 % KW	21.08^{bcd}	41.67	10.83^{ed}	30.17	23.76^{c}	46.14^{c}	10.37^{c}	40.75
	75 % KW	23.92^{bcd}	44.13	8.08^{e}	37.88	22.75^{d}	49.12^{b}	9.91^{c}	39.81
	100% KW	23.25^{bcd}	41.71	20.38^{a}	36.67	21.10^{e}	52.37^{a}	10.48^{c}	35.95
Intensive	CF	18.25^{d}	31.54	13.38^{d}	35.71	21.15^{e}	29.00^{f}	21.97^{ab}	27.15
	25 % KW	21.58^{bcd}	32.42	12.54^{d}	23.04	19.76^{f}	27.27^{fg}	24.62^{ab}	25.29
	50 % KW	17.21^{bcd}	29.25	11.88^{b}	23.54	19.30^{f}	25.90^{gh}	17.38^{bc}	25.52
	75 % KW	25.46^{b}	30.92	16.46^{b}	27.63	18.67^{g}	24.53^{ih}	28.52^{a}	26.51
	100% KW	21.04^{bcd}	27.04	20.33^{a}	32.67	17.88^{h}	22.59^{i}	17.37^{bc}	26.74
SEM		0.929	1.114	0.733	1.135	0.418	1.699	1.416	1.070
Source of variation					ANOVA				
PS		0.0011	0.0001	0.0017	0.0032	0.0001	0.0001	0.0001	0.0001
FR		0.0033	0.2289	0.0001	0.0470	0.0001	0.0001	0.4621	0.4344
PS × FR		0.0258	0.0716	0.0001	0.1276	0.0005	0.0001	0.0001	0.0763

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

PS = Production System; FR = Feeding Regimen; FD = Feeding; WK = Walking; ST = Sitting; PK = Pecking; KW = Kitchen Waste; CF= Commercial feed.

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

as compare 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, feed 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 regimes.

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.

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