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Effects of production system and feeding regimen on carcass and meat quality traits of Naked Neck chicken

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Abstract

To evaluate the effect of a production system and feeding regimen on meat quality attributes of Naked Neck chickens, a total of 150 cockerels at 18 weeks old (1625 ± 70 g) were collected from 10 treatment groups with five replicates of three birds. The factorial arrangement of treatments consisted of two production systems (intensive and free-range) and five nutritional regimens, namely 100% commercial feed; 75% commercial feed plus 25% kitchen waste; 50% commercial feed plus 50% kitchen waste; 25% commercial feed plus 75% kitchen waste; and 100% kitchen waste. Carcass traits, meat quality, and meat organoleptic were found to differ significantly among production systems, feeding regimens, and their interaction. Higher liver weight was observed in birds reared under an intensive system. Higher gizzard weight was noted in birds fed with 100% kitchen waste, whereas lower gizzard weight was observed in birds fed the commercial diet. The meat from cockerels fed with 75% kitchen waste was most yellow, whereas the meat from the birds fed with 100% kitchen waste was least yellow. At two hours after slaughter, pH of the meat was highest in birds fed 50% kitchen waste and lowest in birds fed 100% kitchen waste. The interaction of production system and feeding regimen was significant for overall acceptability score. In conclusion, Naked Neck chickens performed equally well under intensive and free-range systems, irrespective of the level of kitchen waste that they were fed.

Keywords: carcass, kitchen waste, nutritional regimes, sensory attributes

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Introduction

Food security is a challenge globally because of the increasing human population and decreasing nutritional resources. Meat and eggs from chickens are considered the cheapest, most readily available source of quality protein for sustaining health and nutrition for this ever-increasing population (Ajayi, 2010; Sow & Grongnet, 2010; Shahzad *et al.*, 2011; Rahman *et al.*, 2013; Mueller *et al.*, 2018). In Pakistan, poultry production plays an essential role in bridging the divide between the demand for animal protein and its supply, and is a dynamic contributor to animal agriculture. Poultry meat accounted for 35 per cent (1657 thousand tons) of the meat produced in Pakistan in 2019 - 2020 (ESOP, 2020). The rural and commercial poultry sectors contributed about 124.72 and 1,531.60 million metric tons to the total production of meat (ESOP, 2020).

Indigenous chickens that are well adapted to local environmental conditions with excellent resistance to endemic diseases play a significant role in food security and socio-cultural activities in the rural population (Yousif & Eltayeb, 2011; Zhao *et al.*, 2015; Padhi, 2016; Rajkumar *et al.*, 2017). A wide variation of choice is observed, especially among urban populations, where some segments of society prefer meat from organic backyard-type chickens, whereas others prefer meat from commercial meat-type chicken genotypes, because less time is required for preparation and cooking. Such variation in preferences may serve as a threat to the local backyard-type chickens or as an opportunity for these chickens to be used more widely.

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The preference of consumers for meat products is affected strongly by sensory characteristics such as juiciness, flavour, and aroma (Chulayo *et al.*, 2011; Jin *et al.*, 2019). Carcass, physicochemical and sensory attributes of meat are affected significantly by diet in both commercial and indigenous chickens (Youssao *et al.*, 2012). The nutritional profile of meat varies in different feeding and housing systems (Ying *et al.*, 2011), live body and carcass weights, physicochemical traits, and sensory attributes (Wattanachant, 2008; Yousif & Eltayeb, 2011; Olaniyi *et al.*, 2012; Ojedapo, 2013; Ahmad *et al.*, 2019). Recent findings supported free-range housing systems, which lead to more cooking and drip loss, which result in healthier food with less fat in comparison with meat from birds reared in the cage system (Xiang *et al.*, 2018). Free-range rearing affects the birds' welfare, health, and production efficiency. Consumers prefer free-range products and are willing to pay a premium for them (Zhang *et al.*, 2018). Products from free-range systems are generally healthier and have had higher welfare standards from a consumer standpoint than those from the conventional intensive systems (Rehman *et al.*, 2017; Jin *et al.*, 2019).

Backyard chickens are considered slow growing with relatively low carcass weight (Tougan *et al.*, 2013a,b). However, they can provide a local means to recycle kitchen waste as a replacement for a portion of corn and soy in the diet, resulting in more sustainable and lower cost production of eggs and meat (Georganas *et al*., 2020; Truong *et al*., 2019; Zu Ermgassen *et al*., 2016). Thus, there is a need to evaluate the performance of backyard-type native chickens whose diet is composed in part or entirely of kitchen waste. The local Naked Neck breed was superior when reared under various systems of feeding and housing (Garces *et al*., 2001). Keeping this in view, the present experiment was undertaken to explore the carcass traits, meat quality, and sensory attributes of Naked Neck chickens under two production systems and five nutritional regimens.

Materials and Methods

The care and use of the experimental birds were in accordance with the laws and regulations of Pakistan as affirmed by the Committee of Ethical Handling of Experimental Birds, University of Veterinary and Animal Sciences, Lahore, Pakistan (No. DR/758). 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 at an elevation of 186 m. The climate is hot and muggy with temperatures extending from 13 °C in winter to 45 °C in summer.

A total of 900 Naked Neck chicks (400 ± 27 g) were picked from stock at random at the age of six weeks and divided into 10 treatment groups with 5 replicates of 18 birds each. A 2 × 5 factorial arrangement of treatments was applied according to a completely randomized design. Treatments consisted of two production systems (intensive and free-range) and five nutritional regimens, namely i) 100% commercial feed, ii) 75% commercial feed plus 25% kitchen waste, iii) 50% commercial feed plus kitchen waste, iv) 25% commercial feed plus 75% kitchen waste, and v) 100% kitchen waste.

The experimental birds were labelled individually and kept in a well-ventilated open-sided poultry house (6.1 m × 6.1 m × 3.66 m), oriented east to west, and were fed commercial grower ration according to the recommendations of the NRC (1994). Their weekly feed allowance was increased in correlation with their growing pattern. A stocking density of 0.06 m^2 per bird and nipple drinking system at 10 birds per nipple were used as an intensive system till six weeks old. With the progression in age, stocking density was adjusted to a maximum of 0.14 m^2 per bird.

For a free-range system, a pen measuring 11 m^2 indoor area and 19 m^2 for outdoor access were provided to 20 birds at 2 m^2/bird (Ghayas *et al.*, 2020). Drinking water was provided with a nipple drinking system in the indoor area and supplementary feeders and drinkers were placed at 10 birds per feeder and 15 birds per drinker in the outdoor area.

The birds in both systems were fed kitchen waste and commercial poultry feed (Table 2) in a measured amount to calculate feed intake. The kitchen waste was collected from university student hostels and cafeterias of A and C Block of UVAS Ravi Campus Pattoki, Pakistan. The restaurants in the vicinity of Ravi Campus were also utilized to obtain free kitchen waste. The kitchen waste was 35.6% dry matter with a proximate analysis (as fed) of 16.5% crude protein, 18.0% ether extract, and 6.0% ash. The commercial poultry feed is described in Table 1.

At eighteen weeks old, three Naked Neck cockerels (1625 ± 70 g) were randomly selected from each replicate (total 150 cockerels) and slaughtered. These birds were weighed individually with an electrical balance (Wei Heng, Guangdong, China). All birds fasted for five hours before slaughter to keep their intestines and crop free of undigested feed (feed withdrawal period). The birds were slaughtered manually and humanely following the Halal method to ensure complete bleeding. Birds were de-feathered manually after slaughter, then eviscerated. After that, carcasses were soaked in cold water for one hour. Then the carcasses were hung to drain, and cut up into parts for further examination. The calculations of the yield of parameters were based on the percentage of live bodyweight at the time of slaughter (Raphulu *et al.*, 2015).

Table 1 Ingredient and nutrient composition of commercial feed for Naked Neck chickens between 7 and 18 weeks old

Ingredients	%	Nutrients	
Corn	61.55	Dry matter, %	89.50
Soybean meal	31.70	Crude protein, %	20.02
Soybean oil	3.00	Metabolizable energy, Kcal/kg	3020
Di-calcium phosphate	1.70	Calcium, %	0.91
NaCl	0.30	Phosphorus, %	0.35
Methionine	0.12	Lysine, %	1.09
		Methionine, %	0.43

The hot carcass (without skin and giblets) was weighed before complete bleeding, de-feathering, and eviscerating to record dressed weight, which was then used to calculate carcass yield as:

$$\text{Carcass yield \%} = \frac{\text{Dressed weight(g)}}{\text{Live weight (g)}} \times 100$$

Each carcass was cut into prime parts (breast, thigh, drumstick, wings ribs & back and their relative weight was worked out using this equation:

$$\text{Carcass part \%} = \frac{\text{carcass part weight(g)}}{\text{carcass weight (g)}} \times 100$$

Meat pH values were recorded after 15 minutes, 2 hours, and then 24 hours (ultimate pH) of slaughter using a German pH meter (Thermo Fisher Scientific, Inc., Göteborg, Sweden). Approximately four hours after slaughter, the breast and thigh meat samples were separated and colour values (lightness, redness, yellowness) (L*, a*, b*) were recorded with a chromameter. The samples were kept in plastic bags for 24 hours at 8 - 10 ºC while hung up to dry, and then again weighed to estimate drip loss (Honikel, 1987). At that point samples were put away for 24 hours at 5 ºC, then two cylindrical samples were taken from each breast, parallel to the grain, 12 mm broad, and at least 03 cm long to test shear force with a Warner-Bratzler (TAXT Plus, USA) shear force texture analyser (Stadig *et al.*, 2016).

A sensory panel test was performed to evaluate the colour, aroma, taste, flavour, juiciness, tenderness, and overall acceptability of the samples. For sensory evaluation, samples of breast meat (n = 150) were cooked to 72 ºC without salt or spices (Castellini *et al.*, 2002). Immediately after cooking, the samples were cut into pieces and presented to ten faculty staff, postgraduate students, and industry-linked personnel, who served as panellists. The panellists were taught how to assess each sensory attribute before the samples were served. Then, a consumer acceptance test was conducted based on a nine-point hedonic scale (Table 2).

Table 2 Description of hedonic scale used to evaluate meat from Naked Neck chickens fed varying levels of kitchen waste

Score	Description	Score	Description	Score	Description
1	Dislike extremely	4	Dislike slightly	7	Like moderately
2	Dislike very much	5	Neither like nor dislike	8	Like very much
3	Dislike moderately	6	Like slightly	9	Like extremely

Source: Wichchukit & O'Mahony, 2014

Effects of production system and feeding regimen on carcass and meat quality characteristics and sensory attributes were determined through factorial ANOVA (SAS Institute Inc., Cary, North Carolina, USA). Treatment means for the significant effects were compared through Duncan's (1955) procedure for multiple comparisons, considering the difference to be real at probability *P* =0.05.

Results and Discussion

Meat quality attributes of the Naked Neck chickens were not influenced by kitchen waste, and the birds performed equally well in the free-range and intensive rearing systems. The effects of production system and dietary treatment on carcass and meat quality traits are shown in Tables 3, 4, 5, 6, and 7. Liver weight was higher in intensively reared birds than in free-range birds. A possible explanation for larger liver mass in birds reared under an intensive housing system is lack of exercise with fewer nutrients being expended for energy and thus the high energy diet stimulated hepatic lipogenesis. These findings are consistent with those of Hanyani (2012) and Zhao *et al.* (2012, 2015), who reported that chickens raised in cages had heavier carcasses and livers than those reared on the floor. In addition, Hrncar *et al.* (2014) reported higher liver weights in ducks reared in cages than those of deep litter floor systems. However, Ahmad *et al.* (2019) reported a contradictory result in which liver weight in Naked Neck chicken increased when the bids were reared under a semi-intensive system.

The birds fed on 100% kitchen waste had a remarkably high gizzard weight compared with those fed 75%, 50%, 25%, and 0%. The gizzard is the principal physical food processing organ of food in avian species and the relative size of the gizzard has been reported to increase with increased particle size in the diet (Amerah *et al.*, 2007). The birds fed 100% kitchen waste had more variation in the particle sizes of their foodstuffs, which was theorized to have increased the volume of gizzard and caused its walls to become thicker. This corresponded with the findings of de Verdal *et al.* (2010) that the gizzard became heavier with more forage in the diet. Likewise, Batkowska *et al.* (2015) observed increased gizzard weight in three chicken genotypes when they were fed a high-fibre diet containing wheat bran, crushed wheat, and green fodder. However, Farghly *et al.* (2019) did not detect differences in gizzard weight of commercial broilers that were fed ad libitum, were feed restricted, or were fed intermittently.

The meat from birds fed 100% kitchen waste was more yellow than meat from birds in the other treatment groups. This yellowness might result from the kitchen waste containing more carotenoids, xanthophyll, or related pigments. Da Silva *et al.* (2017) reported higher yellowness in the meat of slow-growing chickens reared in the free-range system and provided with forages rich in carotenoids. More generally, a change of nutritional strategies has been reported to ultimately affect the colour of chicken meat (Batool *et al.*, 2018). Hoffman *et al.* (2010) reported that nutrient quantity and quality, scavenging, and alternative feed resources may influence the meat colour of the chickens. Likewise, Fanatico *et al.* (2005) and Wattanachant (2008) observed that the colour of meat from indigenous chickens depended on the feeds that were provided.

Significant interactions between the rearing system and percentage of dietary kitchen waste were found for carcass yield, muscle pH at two hours post mortem, and overall acceptability. The birds reared intensively with a diet composed of 100% kitchen waste and those reared under a free-range system with commercial feed had the highest carcass yield, however, birds fed on 25% and 75% kitchen waste and reared under free-range system had the moderate carcass yield. Moreover, free-range birds fed with 50% or 100% kitchen waste and intensive birds fed 0% or 25% kitchen waste were the lowest in terms of carcass yield. These inconsistent results might be seen as being somewhat similar to the variation observed among other studies. Ying *et al.* (2011) reported that eviscerated carcass yield and proportions of breast and leg muscles were influenced by production system. Darwish *et al.* (2017) noted a higher percentage of carcass yield of broiler birds reared on the floor system. Sogunle *et al.* (2008) reported that the birds raised on the floor had higher dressing percentage than those raised in battery cages. Moreover, Hanyani (2012) reported that birds reared under semi-scavenging systems had higher slaughter and carcass weights than those of full-time scavenging birds (Kondombo, 2005; Mekonnen *et al.* 2010; da Silva *et al.,* 2017). However, Połtowicz and Doktor (2011) indicated that carcass yield was unaffected by rearing system.

Breast meat from birds fed on 50% and 75% kitchen waste had high pH at two hours post mortem, whereas birds reared intensively with 25% kitchen waste and free-range birds without kitchen waste had lower pH values. Apparently, birds that received a diet with 50% commercial feed and 50% kitchen waste had better post-slaughter properties and their carcasses achieved the ideal ultimate pH quicker than other treatment groups. Ying *et al.* (2011) and Stadig *et al.* (2016) observed that meat pH depended largely on the feeding habits of the birds. Hanyani (2012) reported that chickens reared under semi-scavenging systems had better meat ultimate pH because their diet was rich in carotenoids.

Table 3 Effect of production system and level of dietary kitchen waste on carcass characteristics of male Naked Neck chickens

Production system	Feeding regimen	Live weight, g	Carcass weight, g	Carcass yield,%	Breast meat yield, g	Thigh yield, g	Drumstick yield, g
Free-range		1630.00	1045.25	64.21	159.60	158.00	112.00
Intensive		1617.50	1058.75	65.63	161.60	154.00	103.00
	0% KW	1653.75	1097.13	66.55	160.75	168.75	116.25
	25% KW	1736.25	1101.25	63.49	183.25	183.75	120.00
	50% KW	1605.00	985.63	61.63	147.00	147.50	108.75
	75% KW	1535.00	1034.75	67.33	153.75	128.75	92.50
	100% KW	1588.75	1041.25	65.60	158.25	151.25	151.25
Free-range	0% KW	1632.50	1149.25	70.51[a]	164.00	165.00	130.00
	25% KW	1732.50	1122.50	64.97[abc]	169.00	187.50	130.00
	50% KW	1710.00	1035.00	60.60[c]	152.50	160.00	102.50
	75% KW	1475.00	952.00	64.58[abc]	156.00	127.50	82.50
	100% KW	1600.00	967.50	60.38[c]	156.50	150.00	115.00
Intensive	0% KW	1675.00	1045.00	62.59[c]	157.50	172.50	102.50
	25% KW	1740.00	1080.00	62.00[c]	197.50	180.00	110.00
	50% KW	1500.00	936.25	62.66[bc]	141.50	135.00	115.00
	75% KW	1595.00	1117.50	70.07[ab]	151.50	130.00	102.50
	100% KW	1577.50	1115.00	70.81[a]	160.00	152.50	85.00
Source of variation				Probability effect ≠ 0			
Production system		0.8211	0.7272	0.3728	0.7963	0.7962	0.2158
Feeding regimen		0.2181	0.3065	0.1601	0.0599	0.2266	0.1146
Production system × feeding regimen		0.4228	0.0718	0.0084	0.5120	0.9651	0.0955
RMSE		27.82	20.55	0.93	4.06	7.44	3.96

[a,b,c] Within a column, means with a common superscript were not different with probability P =0.05
RMSE: root mean square error, KW: kitchen waste

Table 4 Effect of production system and level of dietary kitchen waste on cut-up parts of male Naked Neck chickens

Production system	Feeding regimen	Heart, g	Wings, g	Ribs & Back, g	Liver, g	Gizzard, g	Abdominal fat, g
Free-range		9.30	106.50	255.00	24.25[b]	26.60	2.65
Intensive		9.45	107.00	242.00	27.70[a]	28.95	2.95
	0% KW	9.00	108.75	260.00	23.25	25.88[b]	2.88
	25% KW	9.88	112.50	257.50	28.75	27.50[b]	2.88
	50% KW	9.00	101.25	255.00	26.38	25.13[b]	2.75
	75% KW	9.13	97.50	240.00	25.75	27.25[b]	2.88
	100% KW	9.88	113.75	230.00	25.75	33.13[a]	2.63
Free-range	0% KW	9.75	105.00	265.00	21.75	24.75	2.75
	25% KW	8.25	105.00	285.00	25.75	25.50	2.25
	50% KW	9.50	112.50	265.00	26.25	25.25	2.75
	75% KW	8.75	100.00	225.00	24.00	25.25	3.25
	100% KW	10.25	110.00	235.00	23.50	32.25	2.25
Intensive	0% KW	8.25	112.50	255.00	24.75	27.00	3.00
	25% KW	11.50	120.00	230.00	31.75	29.50	3.50
	50% KW	8.50	90.00	245.00	26.50	25.00	2.75
	75% KW	9.50	95.00	255.00	27.50	29.25	2.50
	100% KW	9.50	117.50	225.00	28.00	34.00	3.00
Source of variation				Probability effect ≠ 0			
Production system		0.8328	0.9424	0.1623	0.0391	0.0889	0.2602
Feeding regimen		0.8486	0.5005	0.1931	0.3295	0.0062	0.9632
Production system × feeding regimen		0.2286	0.4646	0.0889	0.8398	0.8405	0.1799
RMSE		0.34	3.35	5.02	0.82	0.77	0.13

[a,b,c] Within a column, means with a common superscript were not different with probability P =0.05
RMSE: root mean square error, KW: kitchen waste

Table 5 Effect of production system and level of dietary kitchen waste regimen on meat colour of male Naked Neck chickens

Production system	Feeding regimen	Lightness, L*	Redness, a*	Yellowness, b*	Chroma, *c*	Hue angle, *h*
Free-range		51.03	13.59	8.67	16.39	31.66
Intensive		51.91	12.78	7.80	15.30	30.60
	0% KW	50.95	13.80	9.52[b]	16.67	34.53
	25% KW	52.13	13.63	8.50[abc]	18.26	32.55
	50% KW	50.28	12.80	7.04[bc]	14.63	28.64
	75% KW	51.92	12.25	10.54[a]	16.38	38.19
	100% KW	52.05	13.44	5.57[c]	15.29	21.77
Free-range	0% KW	49.47	13.55	9.60	16.37	34.89
	25% KW	48.59	16.49	8.85	18.76	27.56
	50% KW	52.06	12.44	7.53	14.56	31.17
	75% KW	51.87	12.22	10.76	16.46	38.37
	100% KW	53.15	13.24	6.63	15.82	26.34
Intensive	0% KW	52.44	14.06	9.45	16.97	34.17
	25% KW	55.68	10.77	8.16	13.76	37.53
	50% KW	48.50	13.15	6.55	14.70	26.10
	75% KW	51.98	12.27	10.33	16.30	38.02
	100% KW	50.94	13.65	4.51	14.76	17.19
Source of variation				Probability effect ≠ 0		
Production system		0.5919	0.2728	0.3375	0.1493	0.7499
Feeding regimen		0.9263	0.6168	0.0309	0.3729	0.0725
Production system × feeding regimen		0.2904	0.0661	0.9566	0.1581	0.4653
RMSE		0.75	0.41	0.53	0.41	1.89

[a,b,c] Within a column, means with a common superscript were not different with probability *P* =0.05
RMSE: root mean square error, KW: kitchen waste

Table 6 Effect of production system and level of dietary kitchen waste on meat quality attributes of male Naked Neck chickens

Production system	Feeding regimen	Cooking Loss,%	Drip Loss,%	Shear force, N	pH, 15 min	pH, 2 hr	pH, 24 hr
Free-range		33.32	3.27	28.35	6.92	6.74	6.11
Intensive		31.32	3.44	23.67	6.95	6.73	6.12
	0% KW	33.93	2.48	28.95	6.82	6.55[b]	6.11
	25% KW	30.75	3.71	24.21	6.96	6.96[ab]	6.12
	50% KW	30.75	4.40	21.90	7.09	6.90[a]	6.06
	75% KW	33.26	2.61	28.12	6.98	6.87[a]	6.12
	100% KW	33.04	3.57	26.88	6.82	6.67[ab]	6.16
Free-range	0% KW	33.94	2.44	30.68	6.75	6.51[c]	6.19
	25% KW	33.57	3.15	24.92	6.95	6.93[ab]	6.15
	50% KW	33.00	3.96	19.09	7.10	6.56[bc]	5.89
	75% KW	33.05	3.48	35.52	6.97	6.95[ab]	6.05
	100% KW	33.06	3.33	31.55	6.84	6.74[bc]	6.26
Intensive	0% KW	33.93	2.53	27.22	6.90	6.58[bc]	6.03
	25% KW	27.93	4.28	23.50	6.97	6.45[c]	6.10
	50% KW	33.53	4.85	24.72	7.09	7.24[a]	6.24
	75% KW	28.19	1.73	20.73	6.98	6.79[bc]	6.19
	100% KW	33.03	3.81	22.20	6.81	6.61[bc]	6.07
Source of variation				Probability effect ≠ 0			
Production system		0.1063	0.8144	0.1196	0.7285	0.9747	0.8568
Feeding regimen		0.2830	0.4278	0.5273	0.1637	0.0411	0.9772
Production system × feeding regimen		0.3034	0.7146	0.2501	0.9532	0.0012	0.3622
RMSE		0.64	0.33	1.51	0.04	0.05	0.04

[a,b,c] Within a column, means with a common superscript were not different with probability *P* =0.05
RMSE: root mean square error, KW: kitchen waste

Table 7 Effect of production system and level of dietary kitchen waste on meat sensory attributes of male Naked Neckchicken

Production system	Feeding regimen	Colour	Aroma	Taste	Flavour	Juiciness	Tenderness	Overall acceptability
Free-range		6.11	5.63	6.00	6.60	5.74	5.71	6.26
Intensive		5.97	5.26	5.80	6.57	6.57	5.34	6.00
	0% KW	5.53	5.26	6.00	6.21	5.47	5.74	6.00
	25% KW	6.11	5.67	5.44	6.78	5.89	5.11	5.67
	50% KW	6.64	5.36	6.57	6.29	5.50	5.43	6.14
	75% KW	5.79	5.07	5.79	6.36	5.36	5.14	6.43
	100% KW	6.36	6.00	5.50	7.50	6.36	6.00	6.29
Free-range	0% KW	5.71	4.71	5.29	6.14	5.71	5.29	7.14[a]
	25% KW	5.71	6.14	6.29	6.29	5.43	5.86	4.86[b]
	50% KW	7.14	5.43	7.14	6.14	6.00	6.00	7.14[a]
	75% KW	5.71	5.57	5.29	6.57	5.43	5.43	5.57[ab]
	100% KW	6.29	6.29	6.00	7.86	6.14	6.00	6.57[ab]
Intensive	0% KW	5.00	5.14	6.14	5.86	5.43	5.86	6.00[ab]
	25% KW	6.43	5.57	5.57	7.29	5.86	5.14	5.57[ab]
	50% KW	6.14	5.29	6.00	6.43	5.00	4.86	5.14[b]
	75% KW	5.86	4.57	6.29	6.14	5.29	4.86	7.29[a]
	100% KW	6.43	5.71	5.00	7.14	6.57	6.00	6.00[ab]
Source of variation					Probability effect ≠ 0			
Production system		0.9508	0.3155	0.8762	0.6869	0.6535	0.5526	0.5186
Feeding regimen		0.1578	0.6375	0.4104	0.1637	0.4299	0.6557	0.8887
Production system × feeding regimen		0.3928	0.9662	0.3808	0.3534	0.8237	0.8379	0.0367
RMSE		0.18	0.20	0.20	0.20	0.18	0.20	0.19

[a,b,c] Within a column, means with a common superscript were not different with probability *P* =0.05
RMSE: root mean square error, KW: kitchen waste

Meat from birds fed 75% kitchen waste in the intensive system and free-range birds fed on 0% and 25% kitchen waste were deemed by the panellists to have higher overall meat acceptability, whereas meat from the free-range birds fed 25% kitchen waste had the lowest score for overall acceptability. Similarly, Hanyani (2012) reported that consumers preferred meat from birds reared under a semi-scavenging system to that from full scavenging chickens. Furthermore, these consumers noted significant differences between the two systems in meat juiciness, impression on the first bite, and typical taste and flavour intensity. Mikulski *et al.* (2011) reported that the colour of thigh and breast muscles was significantly darker when birds were reared in an open house system compared with those reared indoors. Farghly *et al.* (2019) did not detect differences in the sensory attributes of meat from commercial broilers that were fed ad-libitum, feed restricted, or intermittently.

Conclusions

Naked Neck chickens produced meat of equivalent value, whether produced under the intensive or the free-range system and irrespective of the level of kitchen waste that was fed. Adopting the practice of feeding kitchen waste to backyard chickens may lead to improved food security.

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Author's Contributions

EB conducted this study as part of his Ph.D. research under the supervision of JH, AM, and AK. AM and KH helped in reviewing the manuscript. JH helped in the statistical analysis and formatting the manuscript.

Conflict of Interest Declaration

The authors have no potential conflicts of interest.

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