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Carcass traits, meat quality, and sensory attributes of fast-growing broilers given outdoor access at different ages

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Abstract: This study evaluated the effect of outdoor access offered to fast-growing broilers at different ages and its impact on meat quality attributes. A total of 200 straight-run broilers were arranged according to the completed randomized design and distributed into 4 treatment groups. The treatments were replicated 5 times; each replicate consisted of 10 birds. The treatment included age at exposure to outdoor access including day 21, day 28, and day 35, and a control group in which the birds were reared at an indoor facility for up to 56 days. Taste, flavor, juiciness, and overall acceptability of breast meat were highest for broilers given outdoor access on day 21 followed by day 28, day 21 and lowest for broilers without outdoor access. Tenderness of breast meat was highest in broilers without outdoor access followed by broilers given outdoor access on day 35 and day28 and lowest for broilers given outdoor access on day 21 of age. It can be concluded that giving outdoor access to fast-growing broilers at the age of day 21 improves carcass and meat quality traits.

Key words: Broiler chicken, outdoor access, different ages, meat quality

1. Introduction

Poultry producers started to raise their commercial chickens indoors as of the 1950s for better disease control, protection from predators, and to integrate their management measures for the production of uniform products [1]. Modern breeding plans and conventional raising systems have enabled mankind to produce broiler chickens with more than 2kg body weight in 35 days [2]. Although the selection for higher growth rate and slaughter yield has dramatically increased the size of muscle fiber to maximize its functionality, it also has impaired the sensory attributes and quality of the final product [3]. Another concern regarding meat from the conventional raising system is the amount of fat deposition in the breast, thigh, and drum muscles [4].

In recent years, consumers have been increasingly concerned about the quality of food products and the term "natural/healthy food" has become more popular. To this end, poultry industry is growing rapidly, and the producers are looking forward to alternative production systems to minimize the welfare concerns of birds as well as to ensure the quality of final product [5]. From consumers' point of view, today's broilers should not only have higher carcass yields and conformation, but also have better sensory and nutritional composition [6]. In the rural, urban, and peri-urban areas of Pakistan, the demand for indigenous chicken meat is gradually increasing [7].The reason behind this tendency is the belief of general masses that nutritional profile as well as meat quality is better in local birds reared under free-range production system [8]. Consumers also share their views about such production systems for broiler chickens, saying that at least these are more conducive to natural, cleaner, and well-balanced environment [9].

There are several alternative systems for broiler production. Of these, organic and free-range production systems are very popular in the developed countries of the world. Outdoor access is a common feature in both production systems mentioned above along with an indoor housing facility [10], which is provided to exploit natural behavior of chickens for better welfare aspects. Outdoor access may or may not include a vegetative area, depending upon the availability of forages. There are numerous factors that influence the meat quality such as the type of

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forages, breed/strain, the age of the bird, sex, and climatic conditions [11,12[1]]. There are some demerits of outdoor access including exposure to infectious diseases, predators as well as extreme climatic conditions [13]. However, there are numerous advantages of outdoor access including the bird's exploratory behaviors like running, wing flapping, jumping, scratching, dust bathing, and foraging [14]. Lower stocking density in alternative production systems with outdoor access gives broiler chickens more freedom to express their innate response as compared with indoor systems. In European countries, such types of production systems are quite evident especially where slow- and medium-growing genotypes are maintained in outdoor access [15]. Although fast-growing birds are used to rear in conventional production systems, scientists are keen to maintain them with outdoor access to exploit their genetic potential for growth more [16]. Fast-growing broilers show the least interest in ranging when compared with medium- and slow-growing genotypes due to their higher body weights [17]. However, there are certain advantages of providing outdoor access to fast-growing broilers. The exposure to outdoor access gives an opportunity to move freely, resulting in improved musculoskeletal development and reduced leg deformities [18]. Furthermore, it also reduces stress levels in fast-growing broilers with higher metabolic rates and improves their welfare. The carcass quality increases in broilers with outdoor access as they have more locomotor activity, which reduces the percentages of their abdominal fat contents. Scientists believe when broiler chickens are given outdoor access to paddock areas, increased levels of omega-3 and omega-6 fatty acids become available for the consumers. This is one of the reasons why consumers are more motivated to buy poultry products from alternative production systems for lower risks of health issues [19]. Unfortunately, the adaptability and acceptability of fast-growing genotypes with inferior development of their thermoregulatory, cardiovascular, and respiratory systems to fluctuating climatic conditions outdoors is a big question mark. The best age to expose such birds to outdoor access is still unclear. The present study is an effort to answer such questions as well as to understand the dynamics of growth performance and meat quality attributes of broilers given outdoor access at different ages.

2. Materials and methods

The present study was conducted at the Department of Poultry Production, the University of Veterinary and Animal Sciences (UVAS), Ravi Campus, Pattoki for a duration of 8 weeks. The geographical coordinates of Pattoki are 31°1′0″N and 73°50′60″E in the northeastern part of Pakistan, with a height of 186 m above sea level and a maximum temperature ranging from 13 °C to 48 °C.

2.1. Experimental birds and ethics

A total of 200 straight-run day old broilers (Ross-308) were collected from a local hatchery and maintained at the Poultry Research and Training Centre. The birds were distributed into 4 treatment groups and placed in 5 replicates (per treatment) of 10 birds each according to Completely Randomized Design (CRD). The treatment groups were based on the age of exposure to outdoor access. The treatment 1 included the birds reared for 21 days in indoor house and then exposed to outdoor access till 56 day of age. Similarly, the treatment 2 and 3 comprised of birds reared up till 28 and 35 days in indoor facility and then subjected to outdoors up till 56 days of age. All these treatments were compared with a control group comprising of birds kept for 56 days in indoor facility without any kind of outdoor access. The study was performed in compliance with the guidelines and code of practices of the Ethical Review Committee, the University of Veterinary and Animal Sciences, Lahore, Pakistan and ethical approval was obtained before experimentation.

2.2. Bird's husbandry

2.2.1. Indoor facility

The indoor facility for experimental birds comprised of environmentally controlled experimental broiler house of 60-ft length and 40-ft width. During the initial 3 days of their life, 23-h light and 1-h dark periods were given to the birds. Then, a photoperiod of 20-h light and 4-h dark periods were continued till the end of this trial. A maximum stocking density of 12 bird/m^2 were maintained in the indoor house while the birds had outdoor access. The birds were fed with commercially available broiler ration (Table 1); strain-specific guidelines were followed for brooding and nutritional management. Drinking water was provided in manual drinkers (10 birds per drinker). Experimental birds were vaccinated against Newcastle disease (ND), infectious bronchitis (IB), and infectious bursal disease (IBD) following the vaccination schedule of the Pakistan Poultry Association.

2.2.2. Outdoor access

The birds were individually tagged and maintained in an open-sided housing facility with 10-ft length, 10-ft width, and 10-ft height located north to south for each treatment. An area measuring 6 birds/m^2 located adjacent to the open-sided shed was used as outdoor access. The availability of fresh water was assured by using manual drinkers in the range area. For protection against predators, fishnet was used around the range area. The birds had access to the range area [enriched with grasses and plant (Lucerne; *Medicago sativa* L.)] from sunrise to sunset during the research trial.

[1] http://www.sare.org/content/download/73280/1060790/PasturedPoultryNutritionandForages.pdf.

Table 1. Ingredient and nutrient composition of experimental ration for broilers.

Ingredients (%)		Nutrients	
Maize	54.85	ME (Kcal/kg)	2800
Rice polish	5.00	CP (%)	20.0
Wheat Bran	3.00	Fat (%)	4.11
Canola Meal	6.05	Fiber (%)	4.31
Rapeseed Meal	4.00	Calcium (%)	0.82
Soybean Meal	16.00	Available Phosphorus (%)	0.4
Corn Gluten Meal	1.60	Lysine dig. (%)	1.05
Poultry By product meal	2.00	Meth dig. (%)	0.49
Fish Meal	2.50	M+C dig. (%)	0.77
Marble Chips	0.55	Arginine dig (%)	1.1
DCP	0.53	Threonine dig. (%)	0.66
Lysine sulphate	0.48	Tryptophan dig. (%)	0.18
DL Methionine	0.18	Isoleucine dig. (%)	0.68
Threonine	0.05	Valine dig. (%)	0.76
Molasses	2.50		
Premix*	0.43		
Salt	0.23		
Phyzyme	0.05		
Rice Broken	0.00		
Total	100		

*Vitamin-mineral premix supplied per Kg of diet: vitamin A, 11,000 IU; vitamin D3, 2,560 IU; vitamin E, 44 IU; vitamin K, 4.2 mg; riboflavin, 8.5 mg; niacin, 48.5 mg; thiamine, 3.5 mg; d-pantothenic, 27 mg; choline, 150 mg; vitamin B12, 33 µg; copper, 8 mg; zinc, 75 mg; manganese, 55 mg; iodine, 0.35 mg; selenium, 0.15 mg.

2.3. Parameters Evaluated

2.3.1. Growth performance

Feed Intake (g): Daily feed intake was calculated by extracting feed refusal from feed offered.

Body weight (g): Weekly body weight was recorded by electronic weighing balance.

Weight gain (g): Weekly weight gain was determined by extracting the final body weight from the initial body weight.

Feed Conversion Ratio: It was derived from its total feed intake and total body weight gain using the following formula:

$$\mathrm{FCR} = \frac{\text{Feed consumed (g)}}{\text{Body weight gain (g)}}$$

Mortality %: It was recorded on a daily basis if any.

2.3.2. Carcass traits

At the age of 56 days, a total of 60 birds (15 from each treatment group)were randomly selected and after halal slaughtering, the following parameters were recorded:

Live Body Weight (g): It was recorded by using electrical weighing balance with a least count of 1g.

Dressed Weight (g): Dressed weight was considered as hot (eviscerated) carcass weight measured without skin with the help of electrical weighing balance with a least count of 0.1g.

Carcass cut-ups %: Breast, thigh, drumstick, neck, wings, ribs and back, liver, gizzard, and heart were calculated as weight recorded for the respective cut-up parts divided by the dressed weight and multiplied by 100.

Abdominal fat%: It was calculated by dividing the weight (g) of abdominal fat by the weight of the carcass (g) and multiplying by100.

2.3.3. Meat Quality Attributes

pH: The pH of the breast meat samples was measured 2 h and 24 h after slaughtering with the help of a digital pH meter and a probe. Shortly, the probe was inserted into the breast meat sample individually and reading was noted after it became still at pH meter display.

Color: The color of the breast meat samples was evaluated using a Minolta CR-410 colorimeter 2 h and 24 h after slaughtering for redness (a*), yellowness (b*), and lightness (L*).

Drip loss: It was determined by following the method adopted by Downs et al. [20]. The breast meat samples were hung in a sealed plastic bag at 4 °C for 12h. Moisture oozing out of the meat samples were weighed by using an electronic weighing balance with a least count of 0.01g which was used to calculate drip loss as percentage.

Cooking loss: 24 h after slaughtering, the breast meat samples were weighed and sealed in a plastic bag separately and placed in water bath till the core temperature of the breast meat reached 75 °C for 10min [21]. After careful cooling (10 minutes) and drying off the cooked meat samples, cooking losses for each sample were extracted by using the weight loss divided by the initial weight.

2.3.4. Sensory Evaluation

Sensory panel tests were performed on the breast samples after boiling the meat samples without spice and salt [19]. The cooked samples were immediately sliced into pieces and was offered to the panelists (n = 25). For each sensory parameter, the intensity of evaluation was scored on a 9-point Hedonic scale (1 being extremely dislike and 9 extremely like). The parameters included taste, aroma, flavor, juiciness, tenderness, and overall acceptability in the sensory analysis lab at the Central Laboratory Complex (CLC), UVAS, Ravi Campus, Pattoki.

2.4. Statistical Analysis

The data obtained from growth performance and meat quality traits were analyzed through one-way ANOVA technique [22] using GLM procedures in SAS software. Duncan's Multiple Range test was used to compare significant treatment means [23]. The following mathematical model was applied:

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$$

where,

Y_{ij} = Dependent variable recorded on i^{th} treatment

μ = Overall population mean

τ_i = Effect of i^{th} treatment (i = 1, 2, 3, 4)

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

3. Results and Discussion

3.1. Growth performance

The present study aimed to increase the performance of fast-growing broilers by providing them outdoor access in later stages of their life. This was successful as the birds acclimatized to outdoor access very quickly, which influenced their performance as well as meat quality. The mean daily feed intake was higher in birds without outdoor access than those with outdoor access on day 21, day 28, and day 35 of age (Table 2).The most likely explanation of higher feed intake in birds without outdoor access is the provision of *ad libitum* feed which is easier for birds to eat when desired. However, the birds given outdoor access at different ages spent some of their time in natural behaviors like foraging, walking, running, and wing flapping. Without doubt, they have more opportunities to eat grass or even small invertebrates, but due to more exercise, they burn more calories. Similar findings were also observed by Li et al. [24] and Branciari et al. [25], who found higher feed intake of commercial broilers reared in indoor housing systems as compared to outdoor access birds. However, contradictory studies [19,21] also reported higher feed intake in commercial broilers when given outdoor access for 56 days. In the current study, chickens without outdoor access who were given access on day 35 were heavier on day 56 than chickens given outdoor access on day 21 of age. Higher body weight of these birds could be attributed to their lifestyle as in the first group, the birds remained in the indoor housing system. Due to less movement, all the nutrients are converted into muscle mass. In the second group, the birds were given outdoor access on day 35 when they already attained their maximum body weight (2400g). The findings of the present study are in line with the study of Castellini et al. [19] and Dou et al. [26], who found a higher body weight gain of commercial broilers without outdoor access. The feed conversion ratio was better in chickens without outdoor access and the birds given access on day 21 of age. It is quite logical that the

Table 2. Growth performance of commercial broilers subjected to outdoor access at different ages.

Parameter	Outdoor Access				P -Value
	21 d	28 d	35 d	No Access	
ADFI (g)	$99.30^b \pm 1.06$	$99.52^b \pm 0.99$	$101.37^b \pm 0.66$	$104.90^a \pm 1.34$	0.0053
AWG(g)	$353.94^b \pm 8.19$	$397.53^{ab} \pm 26.25$	$432.03^a \pm 13.92$	$437.42^a \pm 18.10$	0.0162
BW (g)	$2477.56^b \pm 57.32$	$2782.72^{ab} \pm 183.75$	$3024.18^a \pm 97.46$	$3061.96^a \pm 126.71$	0.0162
FCR	$2.25^a \pm 0.03$	$2.03^b \pm 0.11$	$1.88^b \pm 0.05$	$1.93^b \pm 0.06$	0.0085
Mortality %	2.30 ± 0.28	2.70 ± 0.25	2.79 ± 0.45	2.59 ± 0.35	0.7671

ADFI: Average daily feed intake; AWG: Average weekly gain; BW: Body weight; FCR: Feed conversion ratio; Superscript on different means within a row differ significantly (P ≤ 0.05) birds which remained indoors and ate more feed had the best feed conversion. The birds with outdoor access at different ages had the opportunity to explore the range area and spent most of their time in exercise, burning more calories and utilizing maximum energy. This corresponds to the findings of Fanatico et al. [27] and Li et al. [24], who reported a better feed conversion ratio of commercial broilers reared in indoor housing systems than those with outdoor access. The mortality percentage did not differ between the treatments groups; however, another study [28] reported higher mortality rates in intensive system as compared to broilers given access to outdoor area.

3.2. Carcass traits

There were no differences in live weight, dressing, breast, thigh, drumstick, neck, wings, abdominal fat, liver, heart, gizzard percentages as well as intestinal weight and intestinal length among the treatments. Ribs and back, and abdominal fat percentages differed among the treatments (Table 3). It is possible that the difference among different treatment groups may not have been sufficient to cause considerable differences between indoor and outdoor access, also because the birds specially given outdoor access on day 35 of age remained close to their house. In another study by Wang et al. [29], it was also reported that the rearing system did not affect carcass, breast, thigh, and wing yields of commercial slow-growing broilers. However, in another study, Poltowocz and Doktor [30] reported that indoor rearing of broilers showed a tendency of more muscularity on carcass parts than outdoor systems whereas non-significant results were reported for giblets percentages.

Abdominal fat percentages were lower in chickens given outdoor access on day 21, day 35, and day 28 than the chickens without outdoor access. It is also likely that the birds with outdoor access utilized their energies efficiently to fulfill their natural behaviors like wing flapping, walking, running, scratching, and dust bathing. Similar findings were reported by Castellini et al. [19], Dou et al. [26], Wang et al. [29], and Poltowocz and Doktor [30], who reported lower abdominal fat percentages for free-range broilers. However, contradictory studies [21,31] reported lower abdominal fat percentages for intensive broiler chickens.

3.3. Meat Quality

The pH of breast meat differed between chickens with and without outdoor access. The level of pH at 2 h was lower in chickens with outdoor access on day 21 and without outdoor access than chickens with outdoor access on day 35 (Table 4). On the contrary, Comert et al. [31] reported lower pH at 2 h for conventional broilers than outdoor

Table 3. Carcass traits of commercial broilers subjected to outdoor access at different ages.

Item	Outdoor Access				P -Value
	21 d	28 d	35 d	No Access	
LW	2598.40 ± 97.37	2662.80 ± 112.17	2852.20 ± 68.65	2932.50 ± 214.37	0.2414
CY	65.20 ± 0.66	66.45 ± 0.69	65.40 ± 0.57	66.95 ± 0.50	0.2017
BP	33.84 ± 0.64	33.22 ± 0.77	33.42 ± 0.95	34.55 ± 0.63	0.6744
TP	15.88 ± 0.58	16.00 ± 0.46	16.68 ± 0.76	16.33 ± 0.46	0.6405
DP	13.80 ± 0.19	13.95 ± 0.48	13.00 ± 0.33	13.06 ± 0.39	0.1790
RB	24.24^{bc} ± 0.62	25.23^{ab} ± 0.35	26.09^{a} ± 0.61	23.61^{c} ± 0.18	0.0177
NK	3.36 ± 0.11	3.51 ± 0.16	3.09 ± 0.21	3.28 ± 0.13	0.3361
WG	9.53 ± 0.18	9.60 ± 0.13	9.22 ± 0.27	9.09 ± 0.21	0.2905
AFP	1.14^{b} ± 0.18	1.19^{b} ± 0.10	0.91^{b} ± 0.17	1.80^{a} ± 0.09	0.0062
LP	1.93 ± 0.12	1.96 ± 0.07	1.88 ± 0.10	1.95 ± 0.13	0.9489
HP	0.35 ± 0.02	0.38 ± 0.01	0.38 ± 0.02	0.36 ± 0.02	0.6020
GP	1.25 ± 0.06	1.28 ± 0.08	1.12 ± 0.04	1.20 ± 0.06	0.2418
IW	13.27 ± 8.92	4.03 ± 0.33	3.45 ± 0.21	3.40 ± 0.51	0.3900
IL	197.00 ± 11.92	213.00 ± 12.10	197.20 ± 2.22	196.75 ± 10.26	0.5883

Superscript on different means within a row differ significantly ($P \leq 0.05$)
LW: Live weight (g); CY: Carcass yield (%); BP: Breast percentage; TP: Thigh percentage; DP: Drumstick percentage; RB: Ribs and Back percentage; NK: Neck percentage; WG: Wings percentage; AFP: Abdominal fat percentage; LP: Liver percentage; HP: Heart percentage; GP= Gizzard percentage; IW: Intestinal weight; IL: Intestinal length (cm)

treatment groups. The ultimate pH was higher in chickens with no outdoor access as compared to the chickens with outdoor access on day 21. As the body weight of broilers with outdoor access on day 21 was lower, the most likely explanation of differences in pH is that a low pH is generally related to poor water holding capacity, reflected in higher drip loss and cooking loss. This corresponds to the findings of Chen et al. [21], who found a higher ultimate pH of commercial broilers in indoor system than that of outdoor access birds. However, Funaro et al. [32] reported that the ultimate pH of broiler meat tends to be lower in free-range broilers as compared to conventional broilers. There were no differences found in yellowness, lightness, drip loss, and cooking loss among the 4 treatments. Contrary to the present study, Castellini et al. [19] and Fanatico et al. [27] reported a higher water holding capacity of broiler meat from indoor treatment than outdoor. However, Fanatico et al. [27] reported a higher cooking loss of broiler meat from indoor treatment than broilers given outdoor access.

3.4. Sensory Evaluation

The breast meat of broiler chickens with and without outdoor access showed several differences, as scored by the taste panel on a scale of 0 to 9. Regarding taste, birds given outdoor access on day 21 scored higher, meaning that their meat was tastier than those of other treatments. Flavor and juiciness were also scored to be higher in birds with outdoor access on day 21, followed by the birds with outdoor access on day 28 and day 35 and those without outdoor access. Furthermore, meat form the birds without outdoor access was scored as more tender than those with access on day

Table 4. Meat quality of commercial broilers subjected to outdoor access at different ages.

Item	Outdoor Access				P -Value
	21 d	28 d	35 d	No Access	
At 2 hours					
pH	$6.10^{b} \pm 0.01$	$6.21^{ab} \pm 0.06$	$6.40^{a} \pm 0.10$	$6.15^{b} \pm 0.06$	0.0350
a*	11.37 ± 0.39	12.26 ± 0.77	11.77 ± 0.42	10.43 ± 0.75	0.2926
b*	$9.24^{b} \pm 0.03$	$11.79^{a} \pm 1.02$	$12.02^{a} \pm 0.65$	$13.29^{a} \pm 0.58$	0.0504
L*	53.71 ± 2.09	55.51 ± 2.01	54.77 ± 0.55	55.61 ± 0.14	0.7843
At 24 hours					
pH	$5.51^{c} \pm 0.05$	$5.63^{bc} \pm 0.02$	$5.75^{ab} \pm 0.06$	$5.95^{a} \pm 0.10$	0.0027
a*	10.75 ± 0.57	11.20 ± 0.29	12.18 ± 0.70	12.04 ± 0.58	0.3398
b*	16.53 ± 1.01	11.16 ± 1.17	12.37 ± 1.53	12.14 ± 1.16	0.0759
L*	59.34 ± 1.45	58.71 ± 0.47	57.49 ± 2.92	56.83 ± 0.90	0.7686
Drip loss %	2.28 ± 0.26	1.83 ± 0.24	2.95 ± 0.47	2.17 ± 0.23	0.1666
Cooking loss %	10.09 ± 0.70	11.85 ± 1.23	11.43 ± 0.79	11.82 ± 0.83	0.5150

Superscript on different means within a row differ significantly ($P \leq 0.05$)
a*: Redness; b*: Yellowness; L*: Lightness

Table 5. Sensory evaluation of commercial broilers subjected to outdoor access at different ages. Superscript on different means within a row differ significantly ($P \leq 0.05$).

Item	Outdoor Access				P -Value
	21 d	28 d	35 d	No Access	
Taste	$3.00^{c} \pm 0.00$	$4.40^{b} \pm 0.24$	$5.20^{a} \pm 0.20$	$2.80^{c} \pm 0.20$	0.0001
Aroma	5.00 ± 0.32	5.40 ± 0.24	5.60 ± 0.24	6.00 ± 0.45	0.2174
Flavor	$5.00^{c} \pm 0.00$	$6.00^{b} \pm 0.00$	$6.80^{a} \pm 0.37$	$4.20^{d} \pm 0.20$	0.0001
Juiciness	$6.00^{c} \pm 0.32$	$7.00^{b} \pm 0.00$	$7.80^{a} \pm 0.20$	$4.20^{d} \pm 0.37$	0.0001
Tenderness	$6.00^{b} \pm 0.00$	$5.40^{c} \pm 0.24$	$5.00^{c} \pm 0.00$	$6.60^{a} \pm 0.24$	0.0001
Overall Acceptability	$5.60^{b} \pm 0.24$	$6.40^{a} \pm 0.24$	$7.00^{a} \pm 0.00$	$4.20^{c} \pm 0.47$	0.0001

35, day 28, and day 21. The overall acceptability was higher in meat from the outdoor access birds on day 21 and day 28, followed by the birds with access on day 35 and those without access (Table 5). It is possible that the birds with outdoor access on day 21 and day 35 of age acclimatized better and spent most of their time in foraging or food searching, because the consumption of grass and forage like Lucerne alters the sensory attributes of their meat. Nevertheless, meat is ultimately intended for consumers and their opinion is probably better reflected. The findings of the present study are in line with the findings of Husak et al. [33], who found differences in the sensory evaluation of commercial and free-range broilers. Aroma, chewiness, moistness, and flavor were more intense in free-range broiler meat than meat from conventional birds.

Conclusions: From the above discussion, it can be concluded that giving outdoor access to fast-growing broilers improves overall performance, carcass characteristics, and meat sensory attributes.

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