Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola

ISSN 1516-635X 2022 / v.24 / n.2 / 001-008

http://dx.doi.org/10.1590/1806-9061-2021-1553

Original Article

Performance of Turkeys in Enrichment Environment with Perches and Outdoor Access under Tropical Conditions

■Author(s)

González-Zapata FA[I] https://orcid.org/0000-0003-0998-4424
Sanginés-García JR[I] https://orcid.org/0000-0002-1542-8072
Piñero-Vázquez ÁT[I] https://orcid.org/0000-0002-8400-4046
Velázquez-Madrazo PA[I] https://orcid.org/0000-0002-7993-0475
Itzá-Ortíz MF[III] https://orcid.org/0000-0003-0313-586X
Bello-Pérez EV[IV] https://orcid.org/0000-0001-7105-5752
Chay-Canul AJ[II] https://orcid.org/0000-0003-4412-4972
Aguilar-Urquizo E[I] https://orcid.org/0000-0003-4727-7894

[I] Tecnológico Nacional de México/ Campus Conkal, División de Estudios de Posgrado e Investigación. Km 16.3 antigua carretera Mérida-Motul, Conkal, Yucatán, México. C.P. 97345.
[II] División Académica de Ciencias Agropecuarias, Universidad Juárez Autónoma de Tabasco. Carretera Villahermosa-Teapa, km 25, R/A. La Huasteca 2ª Sección, Villahermosa, Tabasco, México. CP 86280. Tel. DACA: (993) 358-1585, 142-9151, Fax DACA: (993) 142-9150.
[III] Departamento de Ciencias Veterinarias, Universidad Autónoma de Ciudad Juárez, Ciudad Juárez, Chihuahua, México.
[IV] Department of Veterinary and Animal Sciences, Faculty of Health and Medical Sciences, University of Copenhagen, Grønnegårdsvej 3, DK-1870 Frederiksberg C, Denmark.

■Mail Address

Corresponding author e-mail address
Edgar Aguilar-Urquizo
Tecnológico Nacional de México/ Campus Conkal, División de Estudios de Posgrado e Investigación. Km 16.3 antigua carretera Mérida-Motul, Conkal, Yucatán, México. C.P. 97345.
Email: edgar.au@conkal.tecnm.mx

■Keywords

Heat stress, perches use, free range.

Submitted: 09/August/2021
Approved: 19/November/2021

ABSTRACT

Heat stress compromises turkey's productivity and increase mortality mainly in the final stages of growth. This study evaluated the effect of perches and its interaction with outdoor access on turkey performance in high environment temperature humidity index (THI). Turkeys were reared in 1.75 × 5 m indoor floor pens and were fed with a standard commercial diet, offered *ad libitum* according to the productive phase. All poults were housed indoors until 62 d of age. A free-range area for a replicate of 8.75 m², with natural shadow, was available from 07:00 to 19:00 h. Final density was 10.33 ± 0.22 kg/m². The treatments were a combination of a factorial arrangement (2 × 2) with or without perches and, with or without access to the outdoors. From 10:00 and 19:00 THI was above critical level of comfort (heat stress). In indoors turkeys, feed intake (FI) decreased, and water intake increased, panting was observed, and had a significantly lower final body weight (BW) and FI than turkeys allowed outdoors ($p<0.05$). Perch availability decreased final BW and FI ($p<0.05$). Differences in weight of breast meat, wings, or thighs between treatments were negligible. In conclusion turkeys with outdoor access from 62 d of age had better performance.

INTRODUCTION

Animals raised within the thermal neutral zone (TNZ) have optimal growth due to minimal energy cost of energy for basal and maintenance requirements (Mayes *et al.*, 2015). However, high environmental temperatures along with high relative humidity (THI higher than 28.9) induce heat stress with undesirable physiological responses and is linked to compromised productivity through a decline in growth rate and feed utilization (Yahav *et al.*, 1995). Birds are unable to sweat because they lack sweat glands, they have a limited ability to dissipate body heat by evaporation in tropical climate, they rely heavily on panting mechanism (Vandana *et al.*, 2021). Then heat dissipation at high ambient temperatures by non-evaporative means must happen through the unfeathered heads and necks, and possibly the fleshy structures on the head (Buchholz, 1996). Normally, under free range conditions, turkey's movement decreased by three-fold during peak heating of the hottest days (≥35 °C), while in cooler days (< 30 °C), movement was uniform (Rakowski *et al.*, 2019). During daylight hours with higher temperature and humidity index (THI), the turkeys attempt to cool their bodies by different means; for instance, by digging into the litter in order to be in contact with a cooler floor or surface (Farghly *et al.*, 2018). Also, they will try to take refuge in the coolest areas within the facilities, to avoid deleterious effects on feed intake and growth rate (Mendes *et al.*, 2020).

High ambient temperature and large stocking density (SD) are better tolerated in young turkeys than in birds older than five weeks (Jankowski *et al.*, 2015), which have a higher rate of water intake with deleterious effect on litter quality. High humidity in litter affects bird's health and welfare, especially footpad dermatitis (Martrenchar *et al.*, 1999; Krautwald-Junghanns *et al.*, 2011).

On the other hand, effects on mobility functions and a poorer skeletal quality were observed in birds exposed to heat stress and high SD during their life (Jankowski *et al.*, 2015). A management practice to reduce aggressiveness and mortality rates by heat stress during warm seasons is by reducing the SD (Buchwalder & Huber-Eicher, 2004; Marchewka *et al.*, 2013). In this regard, (Erasmus, 2017) reported that SD greater than 29.3 kg / m^2 is associated with various productive, health and behavioral problems such as less feed intake, footpad lesions and aggressive peaking. High SD increases the disturbance frequency and resting behavior is progressively disturbed (Hall, 2001; Ventura *et al.*, 2012). Heat stress and high SD decrease broiler performance with no interaction between effects (Goo *et al.*, 2019). Moreover, sudden death syndrome is significantly higher in greater stocking densities in the summer (Imaeda, 2000).

Under commercial conditions, turkeys' environment facilities include only feeders, water troughs, and litter management (Martrenchar *et al.*, 2001). Also, environmental conditions such as temperature and SD need to be considered, since these factors affect animal metabolism, bone tissue and skeletal properties in fast-growing turkeys (Jankowski *et al.*, 2015). It has been postulated that adding perches inside poultry facilities allow a natural behavior in birds and could be beneficial on their welfare (Martrenchar *et al.*, 2001). During daytime, only 10% of laying hens rest on the perches but at night all hens were resting on the perches (Blokhuis, 1984; Liu *et al.*, 2018). In turkeys, the percentage of perching birds peaked at week 5 and progressively decreased until they reached 10 weeks of age, when the birds were unable to stand on the perches (Martrenchar *et al.*, 2001). In broilers, the use of perches had clear benefits as it reduces disturbances and controls aggressive interactions, especially at higher rearing densities (Ventura *et al.*, 2012). Kiyma *et al.* (2016) has reported a 34% reduction of footpad lesions and further reported that reducing bird density at floor level litter quality could reduce lesions. Furthermore, access to an outdoor area can offer a wide variety of natural behavioral opportunities (Dawkins *et al.*, 2003). An outdoor area is preferred on relatively warm, cloudy days without rainfall or strong winds (Stadig *et al.*, 2017), with increasing number of birds coming outdoors during warm days on daylight hours (Dawkins *et al.*, 2003), resulting in higher locomotion and lower resting (Rodriguez-Aurrekoetxea *et al.*, 2015). Turkeys under outdoors conditions can select a diet based on insects and seeds which complement their requirements (Sarica *et al.*, 2009); food consumption is increased and consequently weight gain is improved (Tong *et al.*, 2015). The aim of this study was to evaluate perches use and its interaction with outdoor access on turkey performance in high environment temperature humidity index in tropical conditions.

MATERIAL AND METHODS

Experimental site and animals

Animals were managed according to guidelines and regulations for ethical animal experimentation of the División de Estudios de Posgrado e Investigación del Campus Conkal del Tecnológico Nacional de México.

The experiment was carried on a conventional turkey rearing farm in Yucatán (21° 6′ N, 89° 39′ W) in the summer, between June 11 and September 5. The climate of the region is AW_0 according to the Köppen classification, modified by (García, 2004), and is considered a sub-humid warm climate, with maximum and minimum temperatures of 36 °C and 16 °C respectively, rainfall average of 1100 mm per year. The rainy season comprises from June to December.

For this study, 240 male turkey poults line Nicholas 700, 20-day-old, were acquired in a commercial hatchery with initial body weight 500 ± 20 g. Poults were weighed and randomly allocated into four treatments with four replicates (n = 15). Every replicate was housed in concrete floor facilities (1.75 x 5 m). Wood shavings were used as bedding with approximately 5 cm of depth. All facilities were equipped with feeders (capacity 8 kg) and bell drinkers. Feeding was supplied *ad libitum* using a standard commercial (Lorgam®); turkey diet provided according to the corresponding productive phase (Table 1). One bird of each group was sacrificed by cervical dislocation every two weeks; then, initial, and final density were 1.7 and 1.02 birds/m^2, respectively (10.33 ± 0.22 kg/m^2).

Poults were vaccinated against chicken pox prior entering the farm; two days later were supplemented with commercial vitamins (Carosen®, Lab. PISA, Guadalajara, Jalisco, México) and copper sulphate in drinking water for seven days (1 and 0.18 g/L, respectively). Between 35 and 42 d of age, phosphomycin disodium (Fosfodica®, Lab. PISA, Guadalajara, Jalisco, México) were given in drinking water at a dose of 0.1 g/L. Finally, between 90 and 97 d of age, sulfamonomethoxine with trimethoprim (Daimetoprim L®, Lab. SANFER Ciudad de México, México) was provided in the daily drinking water at a dose of 0.11 g /kg of body weight.

Table 1 – Nutrient composition of diets in Lorgam® feed (Mérida, Yucatán, México).

Item	Starter (21 to 49 d)	Grower (50 to 77 d)	Finisher (78 to 105 d)
Dry Matter (%)	88.00	88.00	88.00
Crude Protein (%)	26.00	24.00	18.00
Eter Extract (%)	2.80	2.50	2.50
Crude Fiber (%)	4.50	4.80	5.00
Minerals (%)	10.00	9.00	8.00
Nitrogen Free Extract (%)	44.70	47.70	54.50

All poults were housed indoors until 62 d of age. Treatments were a combination of a 2 x 2 factorial arrangement with or without perches and, with or without access to outdoors. The 4 treatments were as follow: control (indoors without perches); indoors with perches; outdoors without perches and outdoors with perches. Perches where 3 m long metal square (3.75 x 3.75 cm), 40 cm above the floor, between feeders and bell drinkers. In outdoors system, free-range area for replicate was 8.75 m^2, with natural shadow. Feed and water were provided *ad libitum* indoors. Turkeys had access to the outdoor area from 07:00 to 19:00 h, shelter indoors at night. In each facility, the number of birds perching and use frequency was registered along with panting and drinker use frequency.

Data collection

Productive traits

Feed intake was daily recorded and calculated as the difference of offered and refused feed, between 7:30 and 8:00 h. Turkeys were weighed from each facility every 14 d, using a mechanical weighing scale (Nuevo León®, Monterrey, Nuevo León, México), capacity 220 kg. Food efficiency was determined by the ratio between the total body weight gain and the feed consumed by the facility, in each productive phase: start, growth and finish which correspond to the weight ranges: 0.50 – 2.70 kg, 2.70 – 6.50 kg, 6.50 – 10.50 kg, respectively.

Carcass traits

This analysis was performed by randomly selecting one turkey by replicate at ages of: 47, 77 and 105 d (16 turkeys per age and 48 in total). Prior to slaughter, an 8-hour fasting period was applied, weighing them after that. All birds were slaughtered by cervical dislocation (NOM-033-SAG/ZOO-2014, 2015), followed by scalding (1 min at 56 °C), plucking, cold-water chilling, vent opening, evisceration, and air chilling procedures. Feather's weight was estimated by the difference in carcasses after plucking. Carcasses were cut into parts according to standard methods, and leg (thigh and drumstick), back, breast and wing weights were recorded as percentages of hot-carcass weights.

Temperature and humidity

Weather conditions were recorded every three hours from 07:00 to 19:00 h using an anenometer Kestrel® 4000. The temperature-humidity index (THI) was calculated according to (LPHSI., 1990) using the modified formula:

$$THI = db\ °C - [0.31(1 - RH)(db°C\ - 14.4)]$$

Where db°C is the dry bulb temperature in Celsius and RH is the relative humidity percentage/100. A value for THI below 27.8 was taken to signify an absence of heat stress, while a value more than 28.9 was considered to represent severe heat stress.

Statistical Analysis

Data were analyzed using the GLM procedure (SAS 9.2). Live weight, feed intake, feed efficiency and carcass traits were studied by analysis of variance, including the effects of housing system and perching use and their interaction. Therefore, data were analyzed in a randomized complete design as factorial arrangements of treatments. When the F-test was significant ($p<0.05$), treatment means were compared using LSMEANS tests. To describe the turkey´s growth curve, the modified Gompertz function was used:

$$Y_{ij} = a_i exp\left[-b_i exp\left(-k_i\ t_j\right)\right] + \varepsilon_{ij}$$

Where Y_{ij} is the observed BW of individual ***i*** at age j; a_i, b_i, k_i are the parameters of the Gompertz function for the *i*-th animal, which have a biological interpretation. Then a_i can be interpreted as the mature BW, maintained independently of short-term fluctuations; b_i is a timescale parameter related to the initial BW; k_i is a parameter related to the rate of maturing (growth rate); and ε_{ij} is the residual error, independently and normally distributed among individuals. The Gompertz function was fitted by using ORIGIN LAB® (2020) software.

RESULTS AND DISCUSSION

The average of the observed temperature-humidity index was 26.58 ± 0.83 at 7:00 h and greater than 28.7 between 10:00 and 19:00 h (severe heat stress) during the experimental period (Table 2). This condition was maintained throughout the whole experimental period (Figure 1).

Table 2 – Effect of daytime on temperature (°C), relative humidity (%) and the temperature-humidity index (THI) averages, between June 11th and September 5th , 2019.

Hour	Temperature	humidity	THI
07:00	27.41 ± 0.98	79.60 ± 4.01	26.58 ± 0.83
10:00	31.35 ± 1.28	67.53 ± 7.32	29.62 ± 0.86
13:00	34.18 ± 1.66	54.23 ± 8.62	31.34 ± 1.01
16:00	33.37 ± 2.72	57.78 ± 12.41	30.80 ± 1.78
19:00	30.35 ± 2.06	68.14 ± 9.53	28.72 ± 1.47

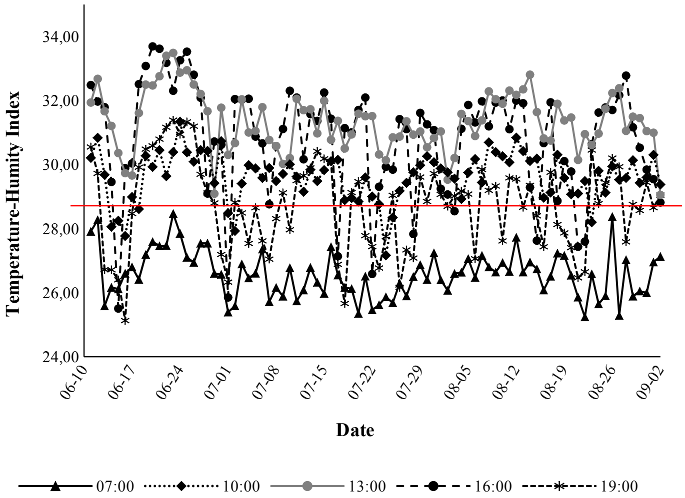

Figure 1 – Effect of daytime on Temperature-Humidity Index between June 11th and September 5th, 2019. Red line indicates the limit of the comfort zone, where a higher THI indicates that heat stress is manifested.

Productivity and Growth

Results are summarized in Table 3. Final body weight and feed intake (105 d) were greater ($p<0.05$) in turkeys with outdoors access, without affecting ($p>0.05$) feed efficiency. On the other hand, final weight, feed intake and feed efficiency were affected negatively ($p<0.05$) in perch housing system. Stocking density and thermal environment change with age and should be optimal to ensure proper growth, development and rearing of birds. Turkey poults, especially heavy fast-growing males, are susceptible to heat stress (Jankowski *et al.*, 2015); then, the ability to maintain normothermia under heat load conditions is a result of efficient cooling mechanisms and/or reduced heat production; where relative humidity plays a role in the performance male turkeys respond to RH only at ambient temperature >30°C (Yahav, 2000). There were not observed significant differences ($p>0.05$) in growth curve (Figure 2). Parameters for the Gompertz function fitted to the average growth curve were:

$$Observed\ BW = 18.91\ exp[-0.021\ exp(-81.79\ age)],\ R^2 = 0.999$$

Table 3 – Effects of perch use or free range on body weight (BW), feed intake (FI), feed efficiency (FE) in turkeys at several stages of the experiment.

	Free Range		Perch Use		EE	*p* value	FR	PU	FR*PU
	Yes	No	Yes	No					
Body Weigth (kg)									
Initial	0.47	0.48	0.48	0.47					
49 d	2.71	2.70	2.69	2.72	0.022	0.117	0.589	0.489	0.026
77 d	6.49ᵃ	6.21ᵇ	6.24b	6.45ᵃ	0.043	0.001	0.001	0.005	0.122
105 d	10.61ᵃ	10.05ᵇ	10.15ᵇ	10.51ᵃ	0.107	0.006	0.003	0.031	0.397
Weigth gain (kg)									
21-49 d	2.24	2.22	2.22	2.24	0.022	0.060	0.482	0.393	0.013
50-77 d	3.77ᵃ	3.51ᵇ	3.55ᵇ	3.74ᵃ	0.041	0.001	0.001	0.007	0.706
78-105 d	4.12	3.84	3.90	4.06	0.110	0.278	0.095	0.332	0.851
21-105 d	10.14ᵃ	9.57ᵇ	9.67ᵇ	10.04ᵃ	0.108	0.006	0.003	0.031	0.364
Feed Intake (kg feed/bird)									
21-49 d	3.69ᵃ	3.67ᵃ	3.59ᵇ	3.76ᵃ	0.030	0.008	0.622	0.002	0.116
50-77 d	8.14ᵃ	7.81ᵇ	7.61ᵇ	8.33ᵃ	0.071	0.001	0.006	0.001	0.492
78-105 d	13.16ᵃ	11.95ᵇ	11.86ᵇ	13.25ᵃ	0.132	0.001	0.001	0.001	0.016
21-105 d	24.98ᵃ	23.43ᵇ	23.06ᵇ	25.34ᵃ	0.199	0.001	0.001	0.001	0.089
Feed Efficiency (kg)									
21-49 d	0.61	0.61	0.62ᵃ	0.60ᵇ	0.005	0.037	0.716	0.015	0.089
50-77 d	0.46	0.45	0.47	0.45	0.007	0.164	0.165	0.093	0.466
78-105 d	0.31	0.32	0.33	0.31	0.010	0.322	0.632	0.136	0.318
21-105 d	0.41	0.41	0.42ᵃ	0.40ᵇ	0.005	0.016	0.786	0.006	0.061

[a, b] Means in column having different superscripts differ significantly at $p<0.05$

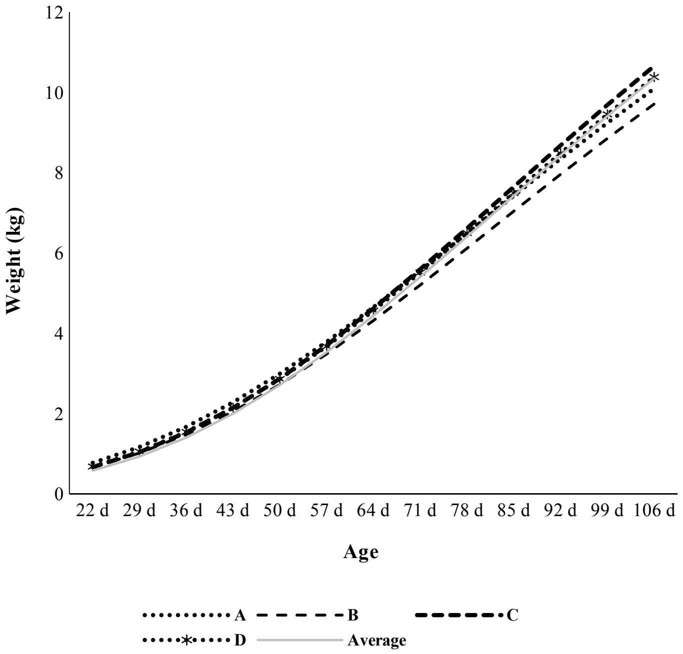

Figure 2 – Growth curve of male Nicholas 700 turkeys adjusted by a Gompertz function in average were:

BW = 18.91 exp [– 0.021 exp (– 81.79 *age*)], R^2 = 0.999

A = Indoors without perches: *BW* = 18.19 exp [– 0.02 exp (– 79.52 *age*)

B = Indoors without perches: *BW* = 17.98 exp [– 0.02 exp (– 81.77 *age*)

A = Indoors without perches: *BW* = 20.12 exp [– 0.02 exp (– 83.33 *age*)

A = Indoors without perches: *BW* = 19.38 exp [– 0.02 exp (- 82.44 *age*)

Carcass Traits

Carcass weight and yields of breast, wings, back, thighs and legs are presented in Table 4. These traits were similar (p>0.1) between ages and housing systems.

Turkeys' production welfare standards state that floor space for each production phase must be enough so birds can freely move and rest without perturbations. Allocated area should be sufficient so birds can stretch, turn around, preen, grow, and produce normally (Erasmus, 2017). High SD has a negative effect on the number of turkeys walking and standing while increasing the incidence of total disturbances; furthermore, poor mobility affects the bird's ability to access food and water as well as to escape from dominant males which cause injuries and higher seizure rates. Then mobility is a relevant aspect concerning welfare and bird's health (Beaulac & Schwean-Lardner, 2018). On the contrary, by decreasing SD, aggressiveness and the number of pecks and threats are reduced (Buchwalder & Huber-Eicher, 2004). Perch availability allows birds to develop a natural behavior and could be beneficial for turkeys' performance to decrease crowding at floor level (Martrenchar *et al.*, 2001). High density production of broiler chicken influences perches' use, suggesting that social factors also influence perch use (Pettit-Riley & Estevez, 2001). However, perching decrease as turkeys get heavier and when BW is above 6 kg or from 70 d of age, they were clearly unable to stand on the perches (Martrenchar *et al.*, 2001).

On the other hand, in this work, aggressive behaviors were not observed, probably due to the low density which, at the end of the growth period, was 10.65 ± 0.46 kg/m^2. The incidence of skin injuries had a quadratic relationship with SD. (Beaulac *et al.*,

Table 4 – Effects of perch use or free range on carcass traits in turkeys slaughter at different ages.

	Free Range		Perch Use		EE	*p* value	FR	PU	FR*PU
	Yes	No	Yes	No					
Body Weigth (kg)									
49 d	2.62	2.64	2.55	2.71	0.057	0.221	0.843	0.060	0.408
77 d	6.17	5.96	5.86	6.27	0.125	0.143	0.270	0.042	0.934
105 d	9.83	9.60	9.35	10.08	0.228	0.181	0.463	0.050	0.539
Hot Carcass (kg)									
49 d	1.78	1.80	1.73	1.85	0.042	0.258	0.857	0.072	0.436
77 d	4.42	4.27	4.18	4.51	0.102	0.160	0.336	0.044	0.743
105 d	7.22	7.09	6.84	7.47	0.189	0.198	0.627	0.045	0.690
Breast and wings (kg)									
49 d	1.05	1.07	1.02	1.10	0.026	0.166	0.694	0.051	0.302
77 d	2.56	2.55	2.45	2.65	0.059	0.136	0.854	0.034	0.342
105 d	4.35	4.24	4.11	4.48	0.119	0.214	0.537	0.053	0.686
Back, Thigs and Legs (kg)									
49 d	0.73	0.72	0.71	0.75	0.018	0.457	0.722	0.138	0.736
77 d	1.83	1.72	1.73	1.82	0.047	0.230	0.124	0.167	0.824
105 d	2.87	2.85	2.73	2.99	0.082	0.250	0.844	0.056	0.721

[a, b] Means in column having different superscripts differ significantly at p<0.05.

2019) observed that total mortality was not affected by SD and aggression and infectious diseases were two principal mortalitiy categories that are impacted differently by increasing SD. In this work, the observed variation of the turkey behavior throughout the day and early morning might be related to daytime and THI.

Temperature, photoperiod, and light intensity in turkeys with outdoor access are inherently variable and are not controlled (Sarica *et al.*, 2009). (Rodriguez-Aurrekoetxea *et al.*, 2015) observed a positive relationship between temperature and outdoor access in slow growing meat chicken. Chickens prefer grazing areas with trees, to avoid bright sun, they either stay close to the facilities or in tree covered areas which are used approximately 60% of their time pecking at the soil, walking, dust bathing and scratching (Dawkins *et al.*, 2003).

Birds access to perches affected negatively the final BW, feed intake and feed efficiency (Table 4); contrary to what it is observed by (Kiyma *et al.*, 2016) and (Akşit *et al.*, 2017) where the use of perches in broilers have no effect on feed consumption, feed efficiency and body weight. Martrenchar *et al.* (2001) concluded adding perches in turkey´s production did not give the expected results and have not beneficial effects in reducing injuries, in this sense, only 2.9% of turkey's farmers in Canada provided perches (van Staaveren *et al.*, 2020). Offering traditional perches to broilers in commercial farms, might be a suboptimal use of the farmer's resources, because their use was negligent (Norring *et al.*, 2016).

On the other hand, outdoor access has a positive effect on feed efficiency and weight in turkeys. Poultry BW increase linearly with outdoor access from 56 d of age. Birds would be more active because they had more space to move around due to low stocking density (Tong *et al.*, 2015). In contrast, (Sarica *et al.*, 2009) in turkeys and (Moyle *et al.*, 2014) in fast-growing broilers did not observe effects on feed intake, feed efficiency and weight gain with outdoor access; while (Wang *et al.*, 2009) found that an outdoor system could reduce growth performance significantly in slow-growing chickens. There are many factors that affect production systems with outdoor access, including relative humidity and ambient temperature, which are inherently variable and are not controlled. Although birds can have access to insects, worms, seeds and forages (Fanatico *et al.*, 2005). Turkeys reared in outdoor systems spent more time walking and feeding, indicators of good health and welfare, therefore it is recommended over confinement rearing systems (Irfan *et al.*, 2016).

Organic turkey production include access to outdoors and free-range turkey, however, information on types of housing and production systems on the growth and carcass traits are limited (Moyle *et al.*, 2014). Nevertheless, free-range access can be benefical, by allowing birds to develop natural behaviors which are not reachable in indoor systems (Stadig *et al.*, 2017). Effects of treatments and slaughter age on hot carcass, breast and wings, back, thighs and legs was not observed, which was consistent with other authors in studies on turkeys (Sarica *et al.*, 2009) or poultry broilers (Fanatico *et al.*, 2005; Wang *et al.*, 2009; Chen *et al.*, 2013). Carcass yield and meat sensory quality attributes are influenced by the rearing systems and consumers preferred meat from birds reared under free-range system due to better sensory attributes (Irfan *et al.*, 2016). On the other hand, perches use can potentially improve health status and welfare of the birds without effect on carcass quality and proportions of carcass (Kiyma *et al.*, 2016).

CONCLUSIONS

Overall, perch availability and their use were negligent, during the first weeks of rearing. They were frequently used in turkeys under 6.05 ± 0.10 kg and had a negative impact on performance. On the other hand, outdoor access system decreases effects of heat stress and improve turkey performance, while improving animal welfare. There was no effect on carcass traits. However, more studies are needed to determine which factors affect consumer preferences and welfare concerns, which impact the development of housing and management alternative systems in fast-growing turkeys.

COMPLIANCE WITH ETHICAL STANDARDS

Legal statement of the experiment

Under Mexican law, published in the Official Standard NOM-062-ZOO-1999, it has been complied with animal care throughout the development of this research in animal owned by the Instituto Tecnológico de Conkal.

STATEMENT OF ANIMAL RIGHTS

All applicable international, national and/or institutional guidelines for the care and use of animals were followed.

CONFLICT OF INTEREST

Through this manuscript, the authors of this article express that they have no conflict of interest from an economical point of view with this research.

ACKNOWLEDGMENTS

The first author is grateful for the research grant (893920) provided by the National Council of Science and Technology of Mexico (CONACYT) for his postgraduate studies at the Tecnológico Nacional de México, Campus Conkal.

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