Poultry rearing on perforated plastic floors and the effect on air quality, growth performance, and carcass injuries – Experiment 2: Heat stress situation

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ABSTRACT Previously, we reported the effect of rearing conditions (plastic floors and air quality) on carcass injury development of broiler chickens at thermal comfort. In this study, the same rearing conditions were tested at thermal stress. The birds were reared in 2 climatic chambers, and the experiment followed a completely randomized design with one factor, flooring material: wood shaving or perforated plastic. The birds were divided into 16 experimental pens, being 8 females and 8 males. The studied parameters were the same as the previous study (ammonia concentration, carbon dioxide, performance, carcass yield, and variability, and scores of hygiene, gait and chest, and hocks and footpad lesions). Higher ammonia (15 ppm vs. 4 ppm) and carbon dioxide (1,000 ppm vs. 850 ppm) concentration was seen at d 42 for the wood shavings floor as compared to the perforated plastic floor, respectively. Regarding gender, males had better performance than females at 42 d of age on both floor types. Males reared on wood shavings showed a higher meat production (29.049 kg/m^2) than females (24.700 kg/m^2). There were observed breast lesion incidences of 10.4% (score 1) in males reared on the plastic floor, as well higher incidence of hock injury and footpad dermatitis. Chickens reared on plastic flooring showed better hygiene than chickens reared on wood shavings. Our findings revealed that the use of perforated plastic flooring in a heat stress situation can improve the air quality (less CO_2 and NH_3 concentration) and bird cleanliness. On the other hand, chickens are more susceptible to develop lesions in the breast, hock, and footpad. We conclude that the use of plastic flooring in heat stress conditions needs more attention, since chickens are more susceptible to develop lesions on the carcass, being a source of pain, impairing bird wellbeing and causing losses in meat production.

Key words: plastic floor, ammonia concentration, carcass injury, poultry litter, animal welfare

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INTRODUCTION

Heat stress is an important environmental stressor in worldwide poultry production (Lara and Rostagno, 2013). According to some studies, heat stress can negatively affect production traits, including meat yield, egg yield, meat and egg quality, reproductive performance, intestinal functions, and the immune response (Fouad et al.,2016, Tan et al., 2010; Song et al., 2014; Wang et al. 2016). It is important to understand how heat stress can influence the bird's development under a wide variety of rearing conditions.

Typically, broilers are floor reared, generally on soft organic materials, such as wood shavings, rice husks, and peanut shells (Miles et al., 2011). These practices raise several concerns about waste management and environmental impacts. Poultry litter is a serious environmental problem. As shown by Benites et al. (2010), a huge quantity of litter is produced (7.8 million tons only in Brazil), and the producers are reusing it due to production costs (Lopes et al., 2013).

Litter management is crucial for a better environment in the poultry house, since it can increase ammonia concentrations affecting birds' performance (Miles et al., 2004; de Jong et al., 2014), immunological responses, and susceptibility to diseases (Beker et al., 2004; Wei et al., 2015). It also can impair barn workers' health due to daily contact with the gas (Rylander and Carvalheiro, 2006).

Although litter is classically used in poultry production, especially for broilers, the birds' management could be changed to improve environmental conditions and birds' welfare. However, producers resist this change, because there are not enough data in the literature. One of the alternatives is to use elevated plastic flooring as used in swine barns (Almeida et al., 2017 and Li et al., 2016 for broilers; Heerkens et al., 2015 for laying hens; Fraley et al., 2013, Rice et al.,2014 and Xie et al., 2014 for ducks). We previously reported that perforated plastic flooring could be used for

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broilers without affecting performance when reared at thermoneutral conditions (Almeida et al., 2017). Because heat stress in tropical and subtropical countries is an atypical condition in broiler production, this study investigated whether perforated plastic flooring could be used in these environmental conditions without affecting performance.

MATERIALS AND METHODS

Experimental Design Rearing Temperature And Management

This research is a continuation of the previously published study (Almeida et al., 2017). Thus, the procedures were almost identical to those reported in the previous article. Briefly, the study was conducted using male and female Cobb500® broiler chickens to 42 d of age with birds assigned to 2 climate-controlled chambers (one with wood shavings as litter material and the other with perforated plastic flooring).

The birds were raised in a heat-stress situation with the following air temperature schedule: 35°C d 1 to 7, 34°C d 8 to 16, and 33°C d 17 to 42. The diet composition, feed management, and vaccination were described by Almeida et al. (2017).

The experimental design was the same as before, i.e., the birds (males and females) were randomly assigned to one of 2 climate-controlled chambers, with one chamber having perforated plastic flooring and the other wood shavings (each chamber contained 16 pens, 8 with males and 8 with females). The perforated plastic floor and wood-shaving characteristics were the same as earlier described. Manure was removed from below the perforated plastic flooring, avoiding excrement decomposition, and the wood-shaving floor had the traditional management.

Ammonia and carbon dioxide were measured, and performance, gait, injuries, plumage cleanliness, and parts yield parameters also followed the same standard as previously described.

Statistical Analysis

The data were submitted to analysis of variance, using Tukey's test at 5% probability, except for ammonia, carbon dioxide concentration, breast blister, hock burn, footpad dermatitis, and gate scores, which were submitted to a chi-squared test at 5% probablility.

RESULTS ANS DISCUSSION

Nh$_3$ and CO$_2$ concentrations

In tropical countries, animals are always susceptible to heat stress due to high ambient air temperatures. Environmental conditions within poultry facilities are important for the growth of animals and working conditions for barn laborers. Knowing the effects of extreme air temperatures on bird development supports management decisions for achieving optimal production.

Comparing the environmental gas concentrations between treatments revealed that ammonia levels were significantly higher ($P < 0.05$) in the wood-shavings than perforated plastic flooring at 32 to 42 d (from 9 ppm vs. 2 ppm at 28 d to 13 ppm vs. 4 ppm at 39 d, and 15 ppm vs. 4 ppm at 42 d for wood-shaving and perforated plastic flooring, respectively) (Figure 1a).

The airborne NH_3 over wood shavings on d 42 (15 ppm) was less than the maximum level (20 ppm) recommended by the GLOBAL G.A.P (2016). Ammonia concentrations were lower than those reported previously in a similar experiment conducted under thermoneutral conditions (Almeida et al., 2017), where NH_3 concentrations reached 25 ppm on the wood-shavings treatment. The lower NH_3 concentrations in this study compared to those observed under thermoneutral conditions (Almeida et al., 2017) may be due to the lower feed intake under heat stress conditions (4.021 kg for males and 3.732 kg for females) compared with those observed under thermoneutral conditions (5.082 kg for males and 4.665 kg for females), considering that the lower feed intake will result in less organic matter deposition inside the barn, consequently decreasing the NH_3 production.

Bianchi (2013) reported that elevated NH_3 concentrations in the environment can cause adverse health effects, decrease animal comfort, and impair the safety and efficiency of the productive activity. In the environment where wood shavings were used, the NH_3 concentration in the air was below the safe working threshold (20 ppm with exposure duration of 8 h per d) established by MTE (2008). However, according to Carvalho et al. (2011), ammonia concentrations above 10 ppm tend to cause discomfort and irritability in the eyes and nostrils. The air quality with plastic flooring had lower levels of NH_3, reaching a maximum of 4 ppm on d 42.

Li et al. (2017) observed higher concentrations of airborne NH_3 when using a perforated floor (15.02 ppm), compared to wood shavings (10.44 ppm), but, contrary to the methodology used in this paper, they did not remove the manure from below the elevated flooring. Poultry litter absorbs excess moisture. Thus, if the manure was not removed from below the plastic floor, NH_3 volatilization may be aided, due to the excess of moisture.

Carbon dioxide concentrations also increased according to birds' age (Figure 1b), reaching values significantly higher on the wood-shavings treatment than plastic-floor treatment from 32 to 42 days. At 32 d, the CO_2 concentration was 900 ppm on the wood shavings and 800 ppm on the plastic floor. The CO_2 concentrations remained stable until d 42, when there was a CO_2 concentration of 1,000 ppm in the environment with wood shavings, and 850 ppm where the plastic floor was used.

Concentrations of CO_2 tended to increase with bird age (Henn et al., 2015) where greater feed intake and

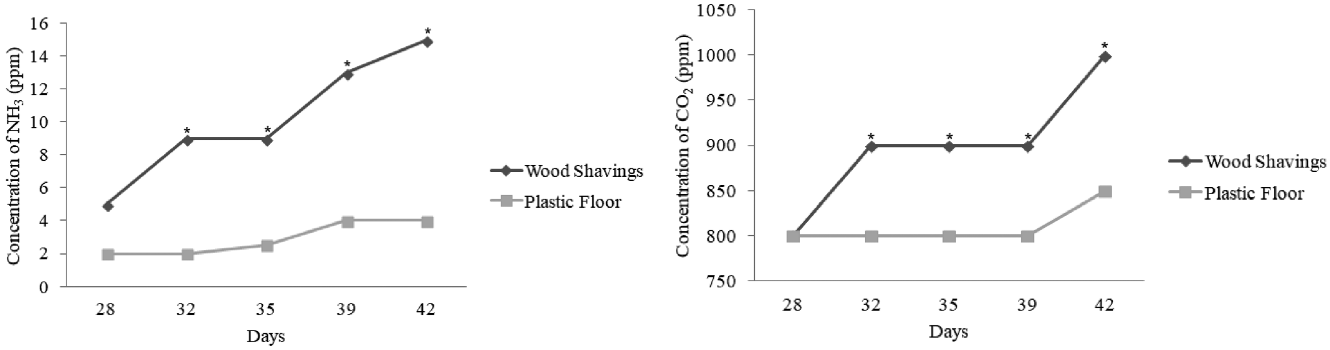

Figure 1. (a) Ammonia Concentration (ppm) and (b) Carbon dioxide concentration (ppm) under heat stress condition. ∗An asterisk indicates significant difference (P<0.05), between wood shavings and plastic floor, according chi-squared tests.

Table 1. Production performance of chickens raised under heat stress conditions.

	Wood Shavings			Plastic Floor		
	Male	Female	*P*-value	Male	Female	*P*-value
Weight Gain 7days (kg)	0.084 ± 0.003	0.081 ± 0.002	0.4013	0.090 ± 0.002	0.091 ± 0.003	0.8102
Feed Intake 7days (kg)	0.101 ± 0.002	0.103 ± 0.003	0.646	0.100 ± 0.001	0.100 ± 0.003	0.7774
Feed Conversion 7days	1.211 ± 0.028	1.264 ± 0.015	0.09	1.107 ± 0.024	1.106 ± 0.025	0.9926
Weight Gain 21days (kg)	0.683 ± 0.015	0.652 ± 0.009	0.1027	0.669 ± 0.010^{a}	0.642 ± 0.008^{b}	0.0067
Feed Intake 21days (kg)	0.967 ± 0.020	0.939 ± 0.028	0.3753	0.887 ± 0.020	0.849 ± 0.014	0.1822
Feed Conversion 21 days	1.419 ± 0.035	1.443 ± 0.052	0.5317	1.325 ± 0.029	1.323 ± 0.021	0.9322
Weight Gain 42days (kg)	2.402 ± 0.039^{a}	2.138 ± 0.030^{b}	0.0002	2.594 ± 0.058^{a}	2.259 ± 0.036^{b}	0.002
Feed Intake 42days (kg)	4.021 ± 0.076^{a}	3.732 ± 0.103^{b}	0.0173	4.120 ± 0.079^{a}	3.727 ± 0.025^{b}	0.0014
Feed Conversion 42 days	1.674 ± 0.015	1.745 ± 0.039	0.0735	1.589 ± 0.013^{a}	1.652 ± 0.025^{b}	0.0435
Viability (%)	98.810 ± 1.190	94.047 ± 2.996	0.103	92.857 ± 2.174	92.857 ± 4.611	0.9976
Meat Production (kg/m^2)	29.049 ± 0.503^{a}	24.700 ± 0.916^{b}	0.0007	29.431 ± 0.800	25.837 ± 1.623	0.0701

∗Different lower case letters indicate significant differences in the row, within each floor type treatment, using Tukey's test at 5% significance.

live weight were associated with greater CO_2 production. From d 32 to 42, airborne CO_2 concentrations in the chamber where wood shavings were used were higher than those observed in the chamber with plastic floors, similar to those observed by Almeida et al. (2017) in thermoneutral conditions, with the microbial degradation of organic matter in the wood shavings a possible explanation for this case (Henn, 2013). According to GlobalG.A.P. (2016), CO_2 concentrations must be below 5,000 ppm, because concentrations higher than this are harmful for the animals. The CO_2 concentrations reported in this study remained well below this threshold.

Productive Traits

The production data are shown in Table 1. Significant difference ($P < 0.05$) among males and females reared on wood shavings was found only on d 42 for weight gain (**WG**) ($P < 0.01$) and Feed Intake (**FI**) ($P < 0.05$). There were higher WG and FI for males (2.402 kg WG and 4.021 kg FI) than for females (2.138 kg WG and 3.732 kg FI). Regarding the animals reared on plastic flooring, males and females differed significantly in their WG ($P < 0.01$) on d 21 and WG ($P < 0.01$), FI ($P < 0.01$), and feed conversion (*FC*) ($P < 0.05$) on d 42, with higher WG (0.669 kg) for males than for females (0.642 kg) on d 21. There were also higher WG (2.594 kg) and FI (4.120 kg) and better FC (1.59) in males than females (2.259 kg, 3.727 kg, and 1.65 for WG, FI, and FC, respectively) on d 42.

The viability for males (98.81%) and females (94.05%) was not different ($P > 0.05$) in the wood-shaving treatment. Regarding meat production, males showed higher values than females (29.049 kg·m^{-2} for males vs. 24.700 kg·m^{-2} for females, $P < 0.05$). Viability and meat production data did not differ ($P > 0.05$) between males and females raised on the plastic flooring.

Similar results were obtained for chickens reared in thermoneutral conditions (Almeida et al., 2017). Andrews et al. (1990), verified higher WG for males than females when they studied the influence of different surface materials on the chickens' performance. Passini et al. (2012), when investigating the role of the environment on the performance of broiler chickens, also verified higher WG for males than females.

We observed that broilers reared on plastic flooring had relatively higher WG and better FC than observed for chickens reared on wood shavings. There was observed greater numerical values of WG for chickens reared on plastic flooring. Specifically, WG was 192 g greater for male chickens reared on plastic flooring than male chickens reared on wood shavings, and females reared on plastic flooring were 121 g heavier than females reared on wood shavings. These findings are relevant for practical and economic perspectives. Moreover, males reared on plastic flooring showed 0.382

kg·m^{-2} more meat production than males reared on wood shavings, and females reared on plastic flooring produced 1.137kg·m^{-2} more meat than females reared on wood shavings. These differences among treatments are important due the expressive numeric values. When we consider a poultry shed with a floor area of 1,500 m^2, we could expect production increases of 573 kg or 1,705.5 kg if males or females, respectively, were grown on plastic flooring rather than on wood shavings.

Conversely, chickens (males and females) reared on wood shavings showed higher viability than chickens reared on plastic flooring. This result differs from those found under thermoneutral conditions, published in Almeida et al. (2017), in which male chickens reared on plastic flooring had higher viability (100%) than males reared on wood shavings (94.14%). The lower viability observed in chickens reared on plastic flooring compared with wood shavings in heat stress situations may have been due to the negative effect of the plastic floor on the chickens' thermal exchange, increasing the susceptibility to death.

Gait And Injury Scores

Gait and injury scores are seen in Table 2. Males (9.5%) reared on wood shavings had the lowest gait score of 1. With the group that was assigned a gait score 2, 21.4% of females from both treatments (wood shavings and plastic floor) presented this level of mobility. For males, a difference was seen depending on flooring, as 67% reared on wood shavings and 2.4% reared on plastic flooring had a score of 2. A gait score of 3 was observed for a majority of females on wood shavings (71.4%) and plastic flooring (64.3%), with fewer males reared on wood shavings (19%) or plastic flooring (50%) presenting the same gait score (3).

A gait score of 4 was observed in more birds reared on the plastic flooring (28.6% of males and 14.3% of females) compared to birds raised on wood shavings (0.0 and 4.8% for males and females, respectively), and a gait score 5 was observed only in males (19%) reared on plastic flooring, whereas in the wood-shavings treatment, a low frequency of score 5 was found for both sexes (4.8% of males and 2.4% of females).

None of the birds was assigned a gait score of 0, associated with the absence of walking disability. A majority of the animals was assigned gait scores of 2 or 3, considered typical for the rapid-growing lineages. Animals assigned a gait score of 2 presented an irregularity in their gait, but their walking ability was not seriously impaired, whereas chickens assigned a score of 3 or higher expressed a wellbeing concern, because their walking ability was severely compromised (Knowles et al., 2008; de Jong et al., 2014, 2016; Almeida et al., 2017). The greater frequency of gait score 3 or above observed in chickens reared on plastic flooring suggests that animals in this treatment tended to have more locomotor issues than those reared on wood shavings. When birds were reared under thermoneutral conditions, similar results were found (Almeida et al., 2017), indicating that regardless of the air temperature, the plastic floor tends to impair the locomotor system.

A plausible cause for these findings is the low absorption of impacts on the plastic flooring and the animals' general aversion to the surface. When wood shavings are utilized, the animals are on a softer substrate that is capable of absorbing impact and gives more support to the animal, promoting better development of the locomotor system (Lensink et al., 2013). Another possible explanation is the greater weight of the birds in the plastic-floor treatment, since according to Naas et al. (2010), the limited mobility of broilers is directly linked to the weight of the animal, where heavier animals tend to show higher incidence of locomotor issues than lighter animals. Fernandes et al. (2012) reported proportionality between the degree of difficulty of movement and birds' weight, where animals with higher locomotion scores (greater difficulty in locomotion) showed a weight numerically greater than animals with less limited mobility. Li et al. (2017) also found that broilers' walking ability tended to decrease with increasing age and weight.

Table 2. Distributions (%) for the gait scores, injuries and cleanliness as a function of both floor types and sex.

	Wood Shavings		Plastic Floor	
	Male	Female	Male	Female
Gait Score				
0	0.0	0.0	0.0	0.0
1	9.5[a]	0.0[b]	0.0	0.0
2	66.7[a]	21.4[b]	2.4[b]	21.4[a]
3	19.0[b]	71.4[a]	50.0[b]	64.3[a]
4	0.0[b]	4.8[a]	28.6[a]	14.3[b]
5	4.8	2.4	19.0[a]	0.0[b]
Hock Burn Score				
0	21.4	31.0	38.1	47.6
1	71.4[a]	47.6[b]	35.7	40.5
2	7.1[b]	21.4[a]	21.4	11.9
3	0.0	0.0	4.8[a]	0.0[b]
4	0.0	0.0	0.0	0.0
Footpad Dermatitis Score				
0	42.9[b]	71.4[a]	59.5	71.4
1	50.0[a]	16.7[b]	26.2[a]	11.9[b]
2	7.1	11.9	11.9	14.3
3	0.0	0.0	2.4	2.4
4	0.0	0.0	0.0	0.0
Breast Blister				
0	100	100	89.6[b]	100.0[a]
1	0.0	0.0	10.4	0.0
2	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0
Cleanliness Score				
0	0.0	2.4	0.0	2.4
1	14.3	19.0	54.8	47.6
2	66.7	64.3	40.5	47.6
3	19.0	14.3	4.8	2.4

*Different lower case letters indicate significant differences in the row, within each floor type treatment, using chi-squared test at 5% significance.

**The values of gait score vary from 0 (normal, dexterous and agile) to 5 (incapable of walking). Hock burn and footpad dermatitis scores range from 0 (absence of lesion) to 4 (severe damage). Cleanliness score range from 0 (dry and clean) to 3 (entirely wet or soiled with litter material, feces or dirt) (Welfare Quality, 2009).

Breast blisters were not observed in birds raised on wood shavings, but 10.4% of males on plastic flooring showed a score of 1. This is similar to the results reported by Li et al. (2017), who found a higher incidence of breast lesions in chickens reared on perforated flooring, compared to wood shavings. According to Li et al. (2017), birds reared on plastic flooring spent more time lying on the floor than birds reared on wood shavings, because there was air movement from below the perforated floor. Thus, air movement tended to reduce heat stress of the broilers. Almeida et al. (2017) observed no incidence of breast injury in chickens reared on wood shavings or plastic flooring under thermoneutral conditions. It is likely that the higher incidence of breast lesions found in the present study, for chickens reared in hot conditions, is due to the fact that birds increased the time lying on the floor in an attempt to facilitate heat transfer by convection due to the air movement between the perforations.

For hock burn, 47.6% of females and 38.1% of males reared on plastic flooring, and 31.0% of females and 21.4% of males reared on wood shavings did not show any lesion. The proportion of birds with a score of 1 was higher for males (71.4%) and females (47.6%) reared on wood shavings, compared to males (35.7%) and females (40.5%) reared on plastic flooring.

Hock lesions were assigned a score of 3 in 4.8% of male birds grown on plastic flooring only. Almeida et al. (2017) and Li et al. (2017) reported a lower incidence of hock burn in chickens reared on wood shavings in thermoneutral conditions. It is likely that the higher incidence of hock burn in chickens reared on plastic flooring in this research was the higher temperature (heat stress). In their research, Almeida et al. (2017) and Li et al. (2017) reared the birds under thermoneutral conditions, while in this research, the birds were reared in heat-stress conditions. According to Mack et al. (2013), birds in a heat-stress situation spent more time lying, with the hock in contact with the floor, raising the risk of hock burns. For Kjaer et al. (2006), the body weight can be related to increases in hock lesions, where heavier chickens tend to show more incidences of hock lesions than light animals. In this sense, the behavior of the chicken in a heat-stress situation and the higher chicken weight when reared on a plastic floor may work together to raise the incidence of hock injuries.

Most of the animals were not affected by footpad dermatitis; 71.4% of females had a score of 0 in both treatments. Higher proportions of males (50.0 and 26.2% on wood shavings and plastic floor, respectively), compared to females (16.7 and 11.9% on wood shavings and plastic floor, respectively) had a score of 1. There were observed higher incidences of scores 2 and 3 in chickens reared on the plastic floor.

Our results on the occurrence of footpad dermatitis differed from those reported by Karcher et al. (2013), who studied the consequences of plastic flooring used in duck production in thermoneutral conditions. They reported a lower incidence of footpad dermatitis in birds reared on plastic flooring than wood shavings. In this research, no birds were observed with a score of 4 (severe footpad dermatitis), while a score of 3 was observed in 2.4% of all birds (male and female) reared on plastic flooring. A large majority of birds reared on wood shavings (92.9% of males and 88.1% of females) was assigned a score of 0 or 1 (none or only a minimal lesion), compared with 85.7% of males and 83.3% of females grown on the plastic flooring. This demonstrates that the wood shavings helped to reduce the occurrence of footpad dermatitis in these hot conditions.

According to Nascimento et al. (2014), an animal in a heat-stress situation prompts an increase in peripheral blood flow, in an attempt to increase the heat loss from featherless areas (e.g., legs). For Song (1984), when a tissue is exposed to heat, the veins in the peripheral areas are dilated, and excessive exposure of tissues to heat results in a breakdown of vasculature followed by necrosis of these tissues. In this sense, we can infer that the higher air temperature may contribute to a greater susceptibility to suffer lesions, and the chicken foot being in contact with a hard surface (plastic floor) promotes a higher incidence of footpad dermatitis.

Plumage Cleanliness Scores

Only 2.4% of females with 0 cleanliness score were identified in both treatments, with most of the birds showing scores between 1 and 2. The data also showed that 19% of males and 14.3% of females raised on wood shavings had a score of 3 compared with 4.8% of males and 2.4% of females reared on plastic flooring.

Broilers reared on plastic flooring showed better hygiene than birds reared on wood shavings, because the broilers would have had less contact with feces. Some previous studies had already reported that perforated flooring improved the cleanliness of feathers in broilers (Akpobome and Fanguy, 1992; Almeida et al., 2017; Li et al., 2017). Likewise, better hygiene was reported for ducks reared on plastic floors, compared with conventional litter (Karcher et al., 2013). Better hygiene is very important in the production process, because the presence of waste on the chickens' bodies can cause carcass contamination at slaughter and impair bird health, being a source of contamination.

Carcass Performance

Males had better performance than females regarding live body weight (2.461 vs. 2.064 kg, respectively; Table 3) when reared on wood shavings. By consequence, eviscerated carcass and parts followed the same pattern comparing males and females, as follows: carcass (1.809 vs. 1.518 kg), chest weight (0.725 vs. 0.617 kg), thigh (0.519 vs. 0.433), back (0.343 vs. 0.298 kg), and wing (0.186 vs. 0.160 kg).

The same trend was observed for animals reared on plastic flooring, in which males showed higher live

Table 3. Absolute and relative carcass yield and parts of broiler chickens raised under heat stress conditions at 42 days of age.

	Wood Shavings			Plastic Floor		
	Male	Female	*P*-value	Male	Female	*P*-value
Live weight (kg)	2.461 ± 0.039[a]	2.064 ± 0.021[b]	0.0001	2.502 ± 0.032[a]	2.148 ± 0.018[b]	0.0001
Carcass weight eviscerated (kg)	1.809 ± 0.030[a]	1.518 ± 0.013[b]	0.0001	1.827 ± 0.028[a]	1.641 ± 0.026[b]	0.0003
RW of eviscerated carcass	0.734 ± 0.002	0.733 ± 0.002	0.6814	0.737 ± 0.003	0.736 ± 0.004	0.9217
Chest weight (kg)	0.725 ± 0.014[a]	0.617 ± 0.010[b]	0.0001	0.744 ± 0.013[a]	0.659 ± 0.012[b]	0.0007
RW of Chest	0.408 ± 0.003	0.405 ± 0.004	0.4678	0.405 ± 0.004	0.407 ± 0.005	0.7423
Thigh Weight (kg)	0.519 ± 0.010[a]	0.433 ± 0.005[b]	0.0001	0.525 ± 0.008[a]	0.469 ± 0.009[b]	0.0001
RW of Thigh	0.291 ± 0.003	0.289 ± 0.002	0.5827	0.289 ± 0.003	0.292 ± 0.002	0.5442
Back Weight (kg)	0.343 ± 0.008[a]	0.298 ± 0.004[b]	0.0001	0.367 ± 0.007	0.327 ± 0.007	0.0021
RW of back	0.194 ± 0.002	0.194 ± 0.002	0.9176	0.199 ± 0.003	0.196 ± 0.003	0.4522
Wing Weight (kg)	0.186 ± 0.002[a]	0.160 ± 0.002[b]	0.0001	0.190 ± 0.004[a]	0.174 ± 0.003[b]	0.0035
RW of wing	0.105 ± 0.001	0.105 ± 0.001	0.855	0.104 ± 0.001	0.108 ± 0.001	0.1024

∗Different lower case letters indicate significant differences in the row, within each floor type treatment, using Tukey's test at 5% significance.
∗∗RW = Relative Weight (%).

weight than females (2.502 vs. 2.148 kg, respectively), as well as higher eviscerated carcass weight (1.827 vs. 1.641 kg), chest weight (0.744 vs. 0.659 kg), thigh weight (0.525 vs. 0.469 kg), back weight (0.367 vs. 0.327 kg), and wing weight (0.190 vs. 0.174 kg) than females. Relative weights (**RW**) of body parts for males and females were not different ($P > 0.05$) in either treatment.

The carcass and part yield difference between males and females was reported by Almeida et al. (2017), who verified a higher weight of carcass and parts for chickens reared on plastic flooring than wood shavings. Passini et al. (2012) also verified higher carcass yield for male broiler chickens than females.

Plastic Floor Costs

The cost associated with the use of plastic flooring is very expensive compared to wood shavings, if we consider just a few production cycles. The price of the plastic flooring used in this research was about $70.00 per square meter, considering just the plastic floors and not other costs, such as the support structure and system of feces removal.

It is very important to remember the higher durability of the plastic flooring (lifespan of 25 years or more, according to the supplier). Thus, the plastic flooring system can be more attractive to producers if the cost per year goes down because of better durability and good productivity results.

CONCLUSION

The use of plastic flooring in heat stress situations requires careful attention, since, despite the good performance and high meat production, the incidence of lesions on the breast, hock, and footpad represents a severe concern from a welfare point of view.

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