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Effect of Litter Material and Elevated Platform Enrichment on Behaviour and Welfare of Broiler Chickens in Closed-House System

Research Article

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ABSTRACT

The present study assessed the effect of litter materials (paddy husk and sawdust) and elevated platform enrichment on welfare (foot pad dermatitis (FPD), hock burns, plumage cleanliness, behaviours, litter quality, and body weight of the broiler chickens living in the cooling pad area of a closed house. A total of 320 Indian River broiler chicks were randomly allocated to four treatments: paddy husk with an elevated platform, paddy husk with no elevated platform, sawdust with an elevated platform, and sawdust with no elevated platform with four replicates for each treatment (n=20). Behaviour of the birds was assessed by scan sampling methods. Welfare indicators were assessed by using a scoring system. Data were analyzed using a generalized linear mixed model and Kruskal-Wallis tests. There was no effect of litter material on the prevalence of FPD ($P>0.05$). Elevated platforms reduced the severity of FPD in the birds in both litters ($P<0.05$). The birds reared in sawdust regardless of elevated platforms, showed higher ($P<0.05$) scores for hock burns. Litter quality was lower in sawdust, irrespective of the elevated platforms ($P<0.05$). There was no effect of the elevated platform on litter quality, hock burns, plumage cleanliness, and behaviours of the birds. A higher frequency of dust bathing was observed in paddy husks ($P=0.014$). Litter material or elevated platform did not affect body weight of the birds. Results revealed that the provision of elevated platforms and paddy husk litter material enhanced the welfare of broiler chickens in the closed-house system.

KEY WORDS body weight, foot pad dermatitis, hock burns, paddy husk, sawdust.

INTRODUCTION

Even though broilers have high genetic and nutritional potential to maximize the efficiency of production, the targets cannot be achieved without providing environmental parameters; temperature, relative humidity, and ventilation in the broiler houses. As a solution for that, more intensive closed-house systems for broiler production have become a trend worldwide to obtain quality and safe meat production for human consumption. The closed house systems are typically 40-50 ft. in width, 400-600 ft. in length and 8-10 ft. in height that are built by concrete and steel structures by providing bedding material; wood shavings, paddy husk, sawdust in the floor. When compared to intensive systems, a tunnel ventilation system is used in closed-house systems to keep birds cool during the hot climatic condition in tropical climatic conditions. Furthermore, recirculating evaporate cooling system is used in the closed house system when tunnel ventilation is insufficient to cool the entire broiler house. The inside area where cooling pads are placed in the closed house, contains high moisture content in the surrounding air. As a result of that, this condition may lead to poor quality litter, Foot Pad Dermatitis (FPD), hock burns, poor feather cleanliness and abnormal behav-

iours which can be identified as welfare issues of the broiler chickens living in the cooling pad area of the closed house system (Turner *et al.* 2005). The FPD can be identified as leg lesions of the broilers in the region of foot and ankle area (Shepherd and Fairchild, 2010) which can be directly affected on animal welfare; difficulties in walking by a pain, reduce accessibility to feed and water, reduce the body weight and infections in other tissues (Škrbić *et al.* 2015). Incidence of dermatitis on footpads is a major issue in the broiler industry because it directly affects on the production of quality chicken feet which has a remarkable market value (Shepherd and Fairchild, 2010). Hock burns and breast blisters are two more types of contact dermatitis that aren't usually connected with bacterial infections (Shepherd and Fairchild, 2010).

Natural behaviour in animal is defined as behaviour that animals have a tendency to perform under natural conditions because these behaviours are pleasurable and because they promote biological functioning. It includes behaviours such as foraging, grooming, exploration, playing etc. Thus, prevention of performance of certain behavioural patterns may cause distress or even suffering in animals. Broilers in large-scale production tend to be reared in environments of low complexity resulting in limited movements, activity, and foraging (Estevez and Christman, 2006). In such environment, restriction of natural behaviour is most likely to occur (SCAHAW, 2000). In broiler chickens promoting of their natural behaviour is important even in the farming condition to enhance positive affective state (mental condition) and proper biological functions. Providing enrichment tactics and management of housing conditions for the broilers is the best remedy in order to facilitate the welfare of the birds. Both jungle fowl and their domesticated relatives have a natural desire to rest on elevated structures; trees or perches. Therefore, providing perching structures is an apparent way to enrich the environment of broilers, and improve the behaviour and frequency of species-specific behaviours (Riber *et al.* 2018). This may lead to low incidence of contact dermatitis and improved welfare of the broilers reared in closed house systems. Malchow *et al.* (2019a) and Malchow *et al.* (2019b) found that the broilers prefer elevated platform-type grids for perching over traditional bar perches. As well as, litter type and quality of litter are the most significant factor that affected on FPD of the broilers among numerous risk factors; flock health, nutrition, feeding and management practices (De Jong *et al.* 2014). The type of litter material, size, thickness and moisture content of the litter are strongly affected on the occurrence of FPD (Grimes *et al.* 2006; Meluzzi *et al.* 2008; Bilgili *et al.* 2009).

The present study was aimed to evaluate the effect of two types of litter materials (sawdust, paddy husk) and the elevated platform enrichment on the prevalence of FPD, body weight and welfare characteristics; behaviours, plumage cleanliness and hock burns of the broiler chickens residing in the cooling pad area of closed house system.

MATERIALS AND METHODS

Housing

The present study was carried out in a closed house system (122 m×15 m) featuring a semi-automated system with negative pressure ventilation using ten (10) exhaust fans and two (2) fiber evaporative panels. Temperature is controlled inside the closed house according to the age of the broilers. The temperature of brooding period (7-8 days) was adjusted around 33.5 ± 0.5 ˚C and the temperature was manually adjusted according to the environmental temperature after the brooding period. During this current study, the minimum temperature was maintained at 28 ˚C and minimum ventilation was 5 min cycles which controlled until end of the first 10 days of the broiler chicks. Moreover, relative humidity (RH) level of the closed house system wasn't maintained because of the operating system was semi-automated.

Tunnel ventilation system of the closed house consisted of exhaust fans at one end of the broiler house and large air inlet panels (cooling pads) at the two sides of the cage. The exhaust fans pulled air from the entire closed house at a velocity about 500 ft. per minute facilitating removal of heat from the building rapidly and to create a wind chill in order to provide additional cooling for the broilers. When the birds grew up exhaust fans alone, it wasn't sufficient to cool the broiler house. As a solution for that, an evaporative cooling system is activated. The automated cooling pads are turned on after 21st day of the broilers and controlled according to environmental temperature. Lighting was provided for 24 h in the closed house.

Animals

Indian River commercial broiler strain (both male and female chicks) was used for the experiment. Day-old-broiler chicks (DOCs) were reared in a brooder inside the closed house during 7-8 days within the allocated space area; 60 × 15 m area per 30000 chicks. During the brooding period, the provided litter material was sawdust for all the chicks. The length of the brooding period was 9 days. From 0-21 days, the broiler chicks were provided with *ad libitum* feeding of broiler booster feed (crude protein: 21%, crude fat: 3.5%, crude fiber: 5%, ash content: 7% and calcium content: 0.9%). From the 22nd day onwards, the broilers were provided with commercially available broiler finisher feed in *ad libitum* (crude protein: 19%, crude fat: 2.6%, crude fiber: 2.6%, ash: 5% and calcium: 0.7%) until slaughtering of the broilers. Furthermore, drinking water was provided

in *ad libitum* by using a nipple drinking system to the broilers until slaughtering. Broiler chickens were vaccinated for infectious bronchitis, Newcastle disease and infectious bursal disease.

Experimental design

The present study was conducted as a 2 × 2 factorial arrangement where there were four (4) treatments; paddy husk litter with elevated platform (T1), sawdust litter with elevated platform (T2), paddy husk litter without elevated platform (T3) and sawdust litter without elevated platform (T4) with four replicates per each treatment. Paddy husk is commonly used as a litter material in Asian countries due to its higher availability as a byproduct of rice production. Sawdust is also commonly used in commercial broiler farms due to higher availability and its lower price. Two consecutive broiler chicken batches were observed where two replicates per treatment in each batch resulting in four replicates per treatment in overall. The experimental pens were prepared in the same house where the brooding was practiced. The experimental pens (150 cm×150 cm per each pen) were prepared in the middle area of the cooling pad of the closed-house. The pens were separated longitudinally into a single row by using steel frames. The fresh litter materials (sawdust and paddy husk) were added to the experimental pens up to the height of 8 cm. The elevated platform for T1 and T2 treatments was prepared from wood, and the dimensions were based on of a previous study: length, width, and height as 150 cm, 30 cm and 20 cm, respectively (Malchow *et al.* 2019a). The plastic ramp (width: 30 cm) was installed as 45% inclination angle in each of the elevated platforms to provide easy access to the platforms. Two feeding troughs and a single row of nipple drinkers were provided to each pen with 30 cm^2 space per bird. Twenty birds were accommodated in each pen (n=20). A total of 320 (20 birds×16 pens) broiler chickens were used in the study. Figure 1 shows the arrangement of four treatments in the cooling pad area of the closed house. Chicks were introduced to the experimental pens at the age of 10^{th} day (just after the brooding period).

Method

Behaviour observations of the broiler chickens

Five days were provided for the acclimatization after introducing the chicks into the experimental pens, and on the 15^{th} day of age behaviour observations of the birds were started. The behaviours (feeding, drinking, moving, resting, foraging, preening, dust bathing and perching) were observed three consecutive days per week in a weekly basis until the end of production (35 days old) by using five point scan sampling technique (Lehner, 1992). Data were gathered during the three time periods per day (8:00-10:00 a.m., 12:00-13:00 p.m. and 15:00-16:00 p.m.) by using an ethogram (Table 1). Climbing to the provided elevated platforms was observed in three (3) additional timeslots within a particular day (6.00 a.m., 7.00 a.m., and 9.00 p.m.) by using scanned sampling techniques. These three time slots were selected in accordance with the natural time of perching behaviour in chickens.

Welfare indices of the broiler chickens

At the age of 32 days, the welfare indices; severity of foot pad dermatitis and hock burns, and degree of plumage cleanliness were assessed in individual bird according to the following criteria.

Foot pad dermatitis

Severity of foot pad dermatitis (FPD) of individual bird was assessed by using four points scale system as mentioned in Table 2 and Figure 2 as described by Hunter *et al.* (2017). The foot pad dermatitis of left and right feet was scored separately. The FPD scores of both feet were averaged for statistical analysis.

Hock burns assessment

As shown in Table 2 and Figure 3, the severity of hock burns of each bird was assessed by a modified version of the lesion scoring system as described by Kaukonen *et al.* (2016b). The hock burns scores of both feet were averaged for statistical analysis.

Plumage cleanliness assessment

The plumage cleanliness of the birds was scored based on the scoring system as described by Malchow *et al.* (2019b). The categories were assessed on four (4) different body parts of the bird including head and neck, back, tail, and wings using 0-3 scale system (Table 2). Scores of all four (4) categories were later averaged for statistical analysis.

Plumage cleanliness in abdomen area of the broiler chickens

The plumage cleanliness in the abdomen area of the broiler chickens was assessed by using self-developed scoring system as described in Table 2.

Litter quality assessment in the cooling pad area of the closed house

The litter quality (moisture content) of the cooling pad area of the broiler house was assessed by using a modified hand sampling quality assessment protocol (Butterworth *et al.* 2009; Hunter *et al.* 2017). For this study, four (4) locations were sampled in each replicate pen; under drinker line, in between two feeders, middle of the pen and in one corner of the pen.

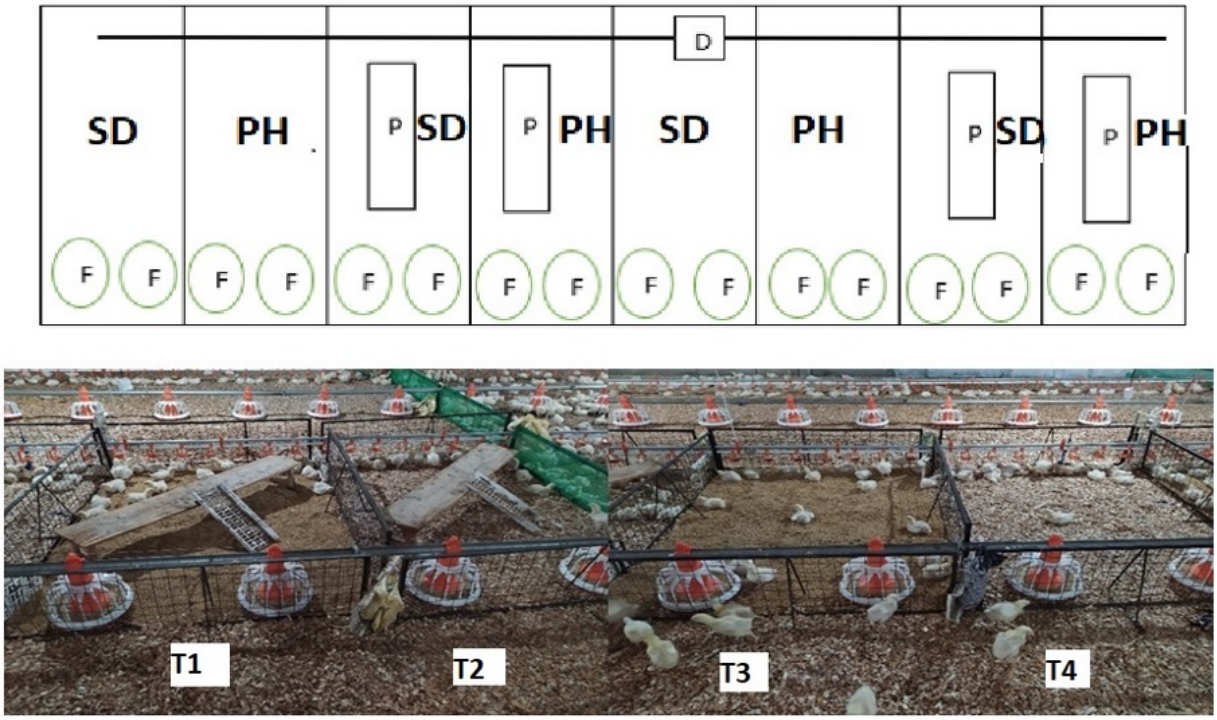

Figure 1 Distribution of four treatments in cooling pad area of the closed house in one broiler chicken batch (two replicates per treatment per batch)
SD: sawdust; PH: paddy husk; F: feeders; D: drinker line and P: elevated platform
T1: paddy husk litter with elevated platform; T2: sawdust litter with elevated platform; T3: paddy husk litter without elevated platform and T4: sawdust litter without elevated platform

Table 1 Ethogram used to observe the behaviours of the broiler chickens in the cooling pad area of the closed house system

No	Behaviour	Description
1	Dust-bathing	Bath performed by the bird using the litter as a substrate. bird forced the litter into the plumage by squatting on the ground and making appropriate movements with the body, wings and legs and scratching (bird moved the litter backwards with its feet)
2	Preening	The beak is moving whilst touching another part of the body of the birds (cleaning its body by beak)
3	Moving	Walking or running (minimum of two steps) without any other behaviours
4	Resting	Lying down being still and not performing any other activities with open or closed eyes.
5	Scratching and foraging	When the bird moved the litter backward with its feet
6	Feeding	At the feeder with head into the lip of the feeder. When the bird ate, regardless of whether it was standing, sitting, or resting
7	Drinking	The action of standing in front of the drinker and drinking (standing with head directly under the drinker line)
8	Climbing	Climbing on the perch/elevated platform

The litter collected from the selected area of the pen was distributed by hand to mix the top and bottom layers in order to assess the quality of litter throughout the layers in the litter. A handful of litter was picked up, compressed and assessed by the given scoring system as mentioned in Table 2 and Figure 4. The obtained scores from the four locations in a pen were averaged to attain one score per replicate pen for statistical analysis.

Weighing of the broiler chickens

Randomly selected five birds per replicate were placed in side a pre-weighed polythene bags and weighed by using a digital electronic hanging scale (Shimaru (by Budry) Model OSC-F Top-of-the-Line Electronic Hanging Crane Scales, capacity=50 kg×20 g).

Data collection

All welfare indices and the body weight were assessed on a separate day apart from the dates of behaviour observation to avoid the effect of handling stress on behaviour of the birds. All observations were recorded by two trained persons to ensure the consistency of the study.

Table 2 Scoring system for Foot pad dermatitis assessment, hock burns assessment, plumage and abdomen cleanliness assessment, and litter quality assessment in cooling pad area of the closed-house system

Score	Definition
	Foot pad dermatitis (Hunter *et al*. 2017)
0	No blemish or discoloration of foot pad
1	Small black lesion (<25% of foot pad) or keratosis of foot pad
2	Moderate lesion (25-50% of foot pad) with black coloration
3	Severe lesion (>50% of foot pad) Black coloration may extend to toes
	Hock burns assessment (Kaukonen *et al*. 2016a)
0	Healthy skin
1	Signs of superficial hock burn on less than half area of hock. (Slight reddish color also included)
2	Dark scabby skin covering more than half area of hock
	Plumage cleanliness assessment (Malchow *et al*. 2019b)
0	No contamination
1	Light contamination
2	Moderate contamination
3	High contamination with litter glued to feathers
	Abdomen area assessment
0	Abdomen has feathers without contamination
1	Abdomen has feathers but contaminated with glued litter
2	No feathers present
	Litter quality assessment (Butterworth *et al*. 2009; Hunter *et al*. 2017)
0	Litter is dry, moves easily when touched in the hand
1	Litter moves less easily in the hand, but doesn't form a ball
2	Litter forms a ball when compressed, but it easily falls apart
3	Litter stays in a ball when compressed, wet litter
4	Wet and sticky under hard crust

Figure 2 Scoring system for foot pad dermatitis assessment in broiler chickens
Scores; 0: no blemish or discoloration; 1: small black lesion (<25% of foot pad) or keratosis; 2: moderate lesion (25-50% of foot pad) with back coloration and 3: severe lesion (>50% of foot pad) with black coloration in extended toes

Statistical analysis

Data collected from the evaluating the effect of litter material and elevated platform enrichment on FPD, hock burns, plumage cleanliness, abdominal cleanliness and litter quality were analyzed by Kruskal-Wallis test using IBM SPSS Statistics 25 software.

As well as, the data collected from evaluating the effect of litter material and elevated platform enrichment on behaviours the broiler chickens were analyzed by using generalized linear mixed model (GLI MIX) procedure in SAS statistical software version 9.4 (SAS, 2004). The least significant mean separation was conducted by using Tukey's test.

Main effects and differences between least squares means were considered as statistically significant and the probability of the null hypothesis being true was less than 0.05. The trend of this study was defined as $0.05 \leq P \leq 0.10$. P-values were greater than $P > 0.1$, there was not considered significant. The graphical illustration of the present study was done by using Microsoft Excel 2019.

Figure 3 Scoring system for hock burns assessment in broiler chickens
Scores; 0: healthy skin; 1: signs of superficial hock burn on less than half area of hock; 2: dark scabby skin covering more than half area of hock

Figure 4 Scoring system for litter quality assessment
Scores; 0: litter is dry, moves easily when touched in the hand; 1: litter moves less easily in the hand, but doesn't form a ball; 2: litter forms a ball when compressed, but it easily falls apart; 3: litter stays in a ball when compressed, wet litter and 4: wet and sticky under hard crust

RESULTS AND DISCUSSION

The effect of litter material and elevated platforms on several behaviours of the broilers; dust bathing, preening, moving, resting, feeding, drinking, scratching/foraging, and climbing/ roosting is illustrated in Table 3. Results revealed that the litter material did not affect behaviours of the broiler chickens except the dust bathing behaviour. However, previous studies reported behaviour differences of broiler chickens in different litter materials. Villagrá *et al.* (2014) studied four litter materials on behaviour of broiler chickens and stated that they performed a higher frequency of resting on wood shavings and straw; a higher frequency of dust bathing on sand; and higher frequency of pecking and scratching on rice hulls. In the present study birds reared in the paddy husk litter material showed a higher frequency (P=0.0014) for dust bathing than the broilers reared in the saw dust. When litter is loose and friable, it enables birds to display natural behaviours such as scratching and dust bathing.

Zikic *et al.* (2017) and Baxter *et al.* (2018) stated that the domestic fowl showed higher preference for dust bathing in consistently loose materials or friable substrates and they spend more time for dust bathing on the loosest litter. Therefore, the results of this study suggest that, paddy husk was better than sawdust in facilitating the dust bathing behaviour in broiler chickens, and may be a better external stimuli for the dust bathing behaviour. However, some other studies reported that Hy-Line White and Brown layers preferred sawdust to dust bath over the sand (Wall *et al.* 2008). According to the findings of Baxter *et al.* (2018), peat showed high frequency as well as wood shavings showed the least frequency for dust bathing among other substrates; oat hulls, and straw pellets. Bessei, (2006) stated that sand is one of the most preferred litter materials of broiler chickens for performing their natural behaviours; walking, foraging and dust bathing.

Table 3 Effect of litter material and elevated platform on behaviours of the broilers in cooling pad area of the closed-house system

Behaviours	Effect of litter		P-value	Effect of elevated platform		P-value
	Paddy husk- no elevated	Sawdust- no elevated		Paddy husk-elevated	Sawdust-elevated	
Dust bathing	0.377±0.132[a]	0.034±0.132[b]	0.0014	0.293±0.132	0.117±0.132	0.096
Preening	2.246±0.234	2.267±0.234	0.913	2.394±0.234	2.121±0.234	0.201
Moving	3.838±0.378	3.574±0.378	0.622	3.843±0.378	3.569±0.378	0.609
Resting	81.120±0.752	82.111±0.752	0.353	81.495±0.752	81.736±0.752	0.821
Feeding	8.099±0.637	7.799±0.637	0.585	7.813±0.637	8.086±0.637	0.620
Drinking	3.458±0.201	3.412±0.201	0.871	0.293±0.132	0.117±0.132	0.096
Scratching and foraging	0.532±0.064	0.565±0.064	0.722	3.602±0.201	3.269±0.201	0.244
Climbing/roosting	0.421±0.099	0.394±0.099	0.842	0.569±0.064	0.528±0.064	0.648

In the contrary, Shields *et al*. (2004) reported that there was no difference in dust bathing frequency of the broiler chickens among four substrates; pinewood shavings, rice husks, granulated sand and recycled paper. Thus, it seems that the preference of broiler chickens for a litter material is greatly varied based on the quality and availability of combinations.

With respect to the provision of platform enrichment, there was no significant difference on behaviours of the broiler chickens reared in elevated platform *vs*. no-elevated platform treatments in this study. Similar results were reported by Norring *et al*. (2016) and they concluded that the presence of elevated platforms had no effect on general activity of broiler chickens. Bessei (2006) reported that barren environment may contribute to the low behavioural activities of broiler chickens. However, provision of elevated structures as the environmental enrichment did not alter the frequency of behaviours in broiler chickens in comparison to the control.

There was no significant difference (P=0.777) in climbing behaviours of the broilers between the two types of litter material; paddy husk and sawdust used in the cooling pad area of the closed-house. This scenario indicated that, there was no effect of litter material in morning and night time climbing behaviours of the broilers.

There was a treatment (paddy husk-no elevated platform, paddy husk-elevated platform, sawdust no-elevated platform, sawdust-elevated platform) effect on food pad dermatitis (FPD) (P<0.0001). With regard to the elevated platform on FPD of the broiler chickens on paddy husk litter material, higher scores for FPD (P<0.0001) were observed of the birds reared on paddy husk-no elevated platform than the paddy husk-elevated platform treatment. Thus, the results indicated that providing of elevated platform in paddy husk reduced the prevalence of FPD in broilers. Moreover, there was a significant difference in prevalence of FPD in between sawdust-no elevated platform and sawdust-elevated platform treatments (P=0.033) where lower scores were found in sawdust-elevated platform treatment.

When providing the elevated platform, the prevalence of FPD was reduces in both litter materials. Therefore, results revealed that, the providing of elevated platforms reduced the prevalence of FPD of the broiler chickens in the cooling pad area of the closed-house system. Table 4 shows the effect of elevated plat forms on the prevalence of FPD in broiler chickens reared in each litter material. The literature revealed that fast growing broiler chickens usually spend much of their life in contact with litter due to heavy body weight and higher frequency of resting/lying (Meluzzi and Sirri, 2009; Çavuşoglu and Petek, 2019). Gouveia *et al*. (2009) explained that high concentrations of ammonia within litter are the primary source of chemical burns of the birds' skin which led to lesions on foot pad and the hock area. Previous studies suggested that providing of environmental enrichments including elevated structures increase activity and reduce the time spent lying down. Promoting perching and roosting behaviour in broilers in commercial farming environments may decrease the contact between foot pads and the litter, as well as increase the use of available space (Bizeray *et al*. 2002; Ventura *et al*. 2012). Therefore, that decreases the duration of the foot pad in contact with the bedding thus reducing the risk of foot pad dermatitis (Riber *et al*. 2018). This might be the reason of having a lower prevalence of foot pad dermatitis in the birds reared in the elevated structures in this study.

According to the analysis in between paddy husk-no elevated platform *vs*. sawdust no-elevated platform (P=0.188), and paddy husk-elevated platform *vs*. sawdust-elevated platform (P=0.317) revealed that there was no effect of litter material on FPD of the broiler chickens. According to Shepherd and Fairchild, (2010), the birds reared in fine particles had significantly lower FPD than coarse particle litter material.

Even though, paddy husk had fine particles than sawdust, prevalence of FPD wasn't significantly different from each other in this study. Some other previous studies also reported the effect of litter material on PFD in broiler chickens.

Table 4 Effect of elevated platform on severity of foot pad dermatitis of the broiler chickens reared in paddy husk and saw dust litter material (at the age of 35 days)

Treatments	No. of birds	Score				P-value
		0	1	2	3	
Paddy husk-no platform	80	68	11	1	-	< 0.0001
Paddy husk-platform	80	80	-	-	-	
Sawdust-no platform	80	73	7	-	-	0.033
Sawdust-platform	80	79	-	1	-	

Statistical analysis: paddy husk-no platform *vs*. paddy husk-platform; sawdust-no platform *vs*. sawdust-platform.

According to the findings of Škrbić *et al*. (2015), a lower incidence of FPD was found on wood shavings over to the straw litter. According to the findings of Meluzzi *et al*. (2008), the broiler birds reared in wheat straw showed a significantly higher incidence of FPD than those on wood shavings. Bilgili *et al*. (2009) studied different litter materials and explained the positive relationship in high litter moisture and caking scores with the higher severity score of FPD in broiler chickens. They have found that chipped pine, chopped straw, cotton-gin trash, and pine shavings showed the highest severity scores for FPD and mortar sand and ground door filler showed the lowest. De Jong *et al*. (2014) also suggested that the high moisture content in the litter material positively affected on the incidence of footpad lesions. At the end of the production period of the current study, results revealed that paddy husk had higher litter quality than sawdust litter material. However, the current results described that there was no effect of litter material on the prevalence of FPD of the broiler chickens in the cooling pad area of the closed-house system.

Table 5 shows the effect of litter material and elevated platform on hock burns of the broilers in cooling pad area of the closed-house system. According to the findings of this study, higher scores (P=0.046) were observed in the birds reared on sawdust no-elevated platform treatment than in the paddy husk no-elevated platform treatment. As well as, birds reared on sawdust-elevated platform treatment showed higher scores for hock burns (P=0.043) than the birds reared on paddy husk-elevated treatment. Therefore, results revealed that there was an effect of litter material on the prevalence of hock burns in broiler chickens, where the prevalence of hock burns was higher in sawdust litter material than in paddy husk. Previous studies also revealed that litter materials affected on the prevalence of hock burns in broiler chickens. Wood shavings has showed lower incidence of hock burns in broiler chickens compared to straw litter (Škrbić *et al*. (2015), and wheat straw (Meluzzi *et al*. (2008)). Studies suggested that the conditions of the litter material; type, size and thickness directly related to hock burns (Haslam *et al*. 2006; Allain *et al*. 2009). Broiler chickens rest most of their time and increase it with age (Weeks *et al*. 2000).

When broilers lying down hock skin is placed on the litter instead of foot pads (De Jong *et al*. 2014) increasing the risk for hock skin lesions. Several studies have shown a positive correlation in between impaired walking ability and hock burns where more resting time duration facilitate more time for hock skin in contact with litter (Kestin *et al*. 1999; Sørensen *et al*. 2000; Haslam *et al*. 2006).

When considering the effect of elevated platform, there was no difference between paddy husk-no elevated and paddy husk-elevated treatments (P=0.185) as well as in sawdust-no-elevated and sawdust-elevated treatments (P=0.175). Thus, the results revealed that there was not effect of elevated platforms on the prevalence of hock burns in broiler chickens.

As shown in Table 6, higher score values were observed in sawdust-no elevated platform treatment than paddy husk-no elevated platform treatment (P=0.004) indicating better plumage cleanliness in the birds reared in paddy husk litter with no elevated structures. Bessei (2006) stated that, humidity and ammonia concentration of the litter affected soiled, dirty plumage of the broilers. In the present study, we also suggest poor plumage cleanliness of the birds reared in sawdust was due to poor litter quality of the sawdust in comparison to the paddy husk. However, when providing elevated structures the litter effect did not observe (P=0.130). Providing of elevated structures did not affect plumage cleanliness of the birds reared in paddy husk litter (paddy husk-no elevated *vs*. paddy husk-elevated; P=0.337).

However, there was a trend (P=0.094) of having higher plumage cleanliness when the broilers were kept in sawdust litter material with elevated platforms. According to Kestin *et al*. (1999) platforms provide more chance for locomotion and reduce the prevalence of disturbances such as pushing and trampling. Thus, it supports to keep the plumage cleaner. This could be the reason to see a trend in better plumage cleanliness in the birds reared in sawdust with elevated platforms than in no-elevated platforms.

Plumage cleanliness in abdomen area of the broilers: In this study, all four (4) treatments obtained a score 1 (P=1.00) at the end of production period of broiler chickens.

Table 5 Effect of litter material and elevated platform on hock burns of the broiler chickens in cooling pad area of the closed-house system

Treatments	No. of birds	Score				P-value
		0	1	2	3	
Paddy husk-no platform	80	48	32	-	-	0.046
Sawdust-no platform	80	32	48	-	-	
Paddy husk-platform	80	54	26	-	-	0.043
Sawdust-platform	80	43	36	1	-	

Table 6 Effect of litter material and elevated platform on plumage cleanliness of the broiler chickens in cooling pad area of the closed-house system

Treatments	No. of birds	Score									P-value
		0	1	2	3	4	5	6	7	8	
Paddy husk-no platform	80	-	-	1	14	27	24	8	5	1	0.014
Sawdust-no platform	80	-	-	1	5	20	32	20	2	-	
Paddy husk-platform	80	-	-	1	5	20	32	20	2	-	0.014
Sawdust-platform	80			10	12	18	26	18	1	-	

Thus, there was no effect of litter material or elevated platform on the abdominal cleanliness of the broiler chickens in cooling pad area of the closed-house system.

Higher scores were found in sawdust-no elevated platform treatment than paddy husk-no elevated platform treatment and there was a trend (P=0.058) of having higher litter quality in paddy husk no-platform treatment than sawdust no-platform treatment. Higher scores were also found in sawdust-elevated platform treatment than paddy husk-elevated platform treatment (P=0.020). Thus, the results revealed that paddy husk was better in litter quality than the sawdust irrespective of the elevated structures. Paddy husk litter material can be identified as more porous material than saw dust and it may have higher moisture evaporation ability in comparison to sawdust. Thus, it can be turned by the broiler chickens easily and it cause to emit toxic gasses from the litter. Saw dust litter create a strong crust due to small particle size and high moisture content in surface area and the rate of deterioration is high. Therefore, these qualities could be the possible reasons for the better litter quality observed in paddy husk over the saw dust in the present study. Dawkins *et al*. (2004), reported that poor litter quality conditions positively affected on prevalence of hock burns and FPD of the broilers. In accordance with this, the reason for higher prevalence of FPD in the birds reared on sawdust could be the poor litter quality of the sawdust in the present study.

Providing of elevated platform did not affect the quality of paddy husk litter material (paddy husk-no platform treatment *vs*. paddy husk-platform treatment: P=0.549) and sawdust litter material (sawdust-no platform treatment *vs*. sawdust-platform treatment: P=0.655).

Results revealed that there was no effect of litter material or elevated platforms on the body weight of the broilers (P=0.683) at the end of production (paddy husk-no platform treatment: 1925.5±26.9, paddy husk-platform treatment: 1952.5±26.9, sawdust-no platform treatment: 1925.7±26.9, sawdust-platform treatment: 1924.7±26.9). Thus, elevated structures can be introduced to the broiler chickens with no effect on the body weight. Similar results were reported by Estevez *et al*. (2002) where authors reported that there was no significant effect of providing elevated structures on the final body weights of the broiler chickens at 6 weeks of age.

CONCLUSION

In conclusion, paddy husk is better than sawdust as a litter material to enhance the welfare of broiler chickens in cooling pad areas which resulted in lower hock burns, a higher degree of plumage cleanliness, and facilitated higher frequency of dust bathing in broiler chickens with maintaining better litter quality at the end of production. Providing of the elevated platform also enhanced the welfare of broiler chickens by resulting in lower food pad dermatitis, and resulting a trend in higher plumage cleanliness of the broiler chickens in sawdust. Litter material (paddy husk or sawdust) or elevated platform enrichment did not affect the body weight of broiler chickens.

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