Effect of different flooring types on performance, gut microbiota, and biochemical parameters in broiler chickens

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ABSTRACT:

Broiler production is a critical component of global meat production, yet the impact of flooring types on broiler performance, health, and biochemical parameters remains underexplored. This study aimed to investigate the effect of five flooring types including wood shavings, sun-dried tree leaves, compact metal cages, cages transferred to perforated plastic slats, and perforated plastic slats on broiler performance, serum biochemical parameters, and oxidative stress. A total of 300 Ross 308 broiler chicks were randomly allocated to five experimental groups, each with three replicates of 20 birds. Broilers reared on plastic slats exhibited the highest body weight, weight gain, and European Production Efficiency Factor (EPEF), along with optimal FCR. However, plastic slats were associated with elevated liver enzymes (ALT, AST) and kidney stress markers (uric acid, creatinine), indicating potential metabolic strain. Wood shavings and tree leaves showed higher oxidative stress (elevated MDA and NO levels) but supported greater protein synthesis. Cages-to-plastic slats had the highest microbial counts, while plastic slats maintained the lowest microbial load. The study concludes that plastic slats and wood shavings are optimal for broiler performance, but synthetic flooring may induce liver and kidney stress, whereas organic materials enhance protein synthesis but may increase oxidative stress. Future research should explore long-term effects on broiler health and the interaction between flooring type and dietary interventions.

Keywords: Broiler performance; Flooring types; Biochemical parameters; Microbial profile.

INTRODUCTION

Broiler chickens are a significant poultry species raised for meat production. Globally, the economic value of broiler production is substantial, making it crucial to understand the factors influencing their growth and health (Erdaw and Beyene, 2022). Understanding how different factors affect broiler performance and health parameters is crucial for optimizing their growth (George and George, 2023). In addition to an adequate feeding regime, housing, and environmental factors, the floor also plays an important role in broiler chicken husbandry (Legge et al., 2023).

Although, the litter-based rearing system is the most common way of broiler production (Panel et al., 2023), precision farming in poultry production requires a detailed understanding of floor design in interaction with the animals (Dunlop and Pepper, 2023). Flooring types have played an essential role in animal farming practices. Floor types are one of the most important items in management from day old birds until the culling day in poultry farm management (Topal and Petek, 2021). These types play a very critical role in overall management of poultry farms, especially in broiler production systems. As a management item, the choice of materials to be used in the floor directly affects the welfare of broiler chickens and the operators in the poultry farm (Honig et al., 2024). Moreover, the selection of floor type conditions affects the efficiency of the poultry facilities, particularly they have effects on the humidity, hygiene, transmission of infectious diseases and comfort of the broiler chickens and decreases the convenience to broiler chickens (Panel et al., 2023). Consequently, the selection of different flooring materials influence the performance and health parameters (Costantino et al., 2021).

Former studies have evaluated specific types of flooring. For instance, Abd El-Wahab et al. (2020) investigated wooden shavings and concrete surfaces. Also, Abdel-Azeem (2019), compared litter floors with cage systems. Abreu et al. (2011) conducted a study on dirt and concrete flooring, whereas Adler et al. (2020) examined partially perforated flooring and wood shavings. In a similar vein, Almeida et al. (2018) investigated the use of perforated plastic flooring in conjunction with wood shavings, while Al-Nasseri et al. (2021) conducted an examination of perforated plastic flooring positioned at different elevations. Limited comprehensive investigations are available about the effects of different flooring types on the performance, serum biochemical, and health status of broilers.

We hypothesized that different floor types can significantly influence the overall performance and health parameters of broiler chickens. This impact may be attributed to factors such as the animal's comfort, hygiene levels, and the ability to express natural behaviors (Sonnabend et al., 2022).

This study aims to investigate the impact of common different floor types on the performance, and health parameters of broiler chickens. These types include wood shavings; sun-dried tree leaves; compact metal cages; compact metal cages till 14 days of age, then transferred to perforated plastic slats; and perforated plastic slats. Understanding how these variables interact could optimize poultry management practices.

MATERIAL AND METHODS

Site of the study

The experiment was started on 6th of August 2022, at the Experimental Farm of Animal Production Department, Faculty of Agriculture at Al-Azhar University, Nasr City, Cairo, Egypt

Birds' management and experimental design

The practical experiment was conducted using Ross 308 broiler chicks, which were unsexed and observed from one d age until reaching the appropriate age for marketing (42 d). which were randomly allocated to five distinct experimental treatments. Each treatment comprises three replications, with each replicate consisting of twenty chicks. The avian species were categorized across five distinct flooring types including commercial litter from wood shavings (WSL, control); sun-dried tree leaves, 5 cm depth (STL); commercial broiler compact metal cages (CMC); compact metal cages till 14 d age, then transferred to perforated plastic slats (CM14-PS); and perforated plastic slats till 42 d age (PPS).

All perforated plastic slats were installed at a height of 10 cm, with a thin layer of limestone covering the ground below to facilitate humidity absorption. Table 1 presents the maximum, minimum, and mean values of temperature (°C), relative humidity (%), and air pressure (mbar) recorded at the experimental location and over the specified period.

The feeding method employed was *ad libitum*, utilizing a commercial broiler formula as detailed in Table 2. Drinking water was supplied manually two times per day. During the initial week of life, illumination was maintained continuously, followed by a regimen of 22 h of light and 2 h of darkness commencing from the seventh day.

Vaccination programs and medical care

The flocks received vaccinations targeted at prevalent diseases as outlined in the vaccination protocols, including Newcastle disease virus (NDV), infectious bronchitis (IB), and Gumboro disease (IBD), administered at the recommended age, as advised by veterinarians, as depicted in Table 3.

Also, some medications were given according to medical care from 1 d till the end (42 d) as shown in (Table 4).

Besides the environmental measurements, this study involved comparative analysis of the productive performance, behavioral observations, biochemical blood and histological responses of broiler chickens that are housed either on the floor or in cage systems.

Live body weight and body weight gain

The chicks were weighed individually at the commencement of the experiment (day 1) to the nearest gram within each group, ensuring that there were no disparities in weight at the initiation of the study. The weight was measured weekly in the early morning prior to the administration of any feed or water until the conclusion of the experimental period, which lasted for 42 d. The total live body weight for each group was calculated and subsequently divided by the number of chicks in order to determine the average live body weight. The increase in weight was determined by taking the difference between the average initial live body weight recorded over a specified duration and the average final live body weight observed during that same time frame. The calculation of body weight gain was conducted utilizing the subsequent equation:

$$W_G=W_X-W_0$$

Where: W_G, weight gain; W_X, weight at any age; W_0, weight at the pervious age.

Feed intake (FI)

Throughout the course of the experimental period, diets were provided ad libitum for all groups and their respective replicates. Residual feed was gathered on a weekly basis, measured, and then deducted from the amount provided to determine the feed intake on a group level, utilizing the subsequent formula for the calculation of feed intake:

$$\text{Feed intake } (\text{g. bird. d}^{-1}) = \frac{\text{Feed intake for replicate}}{\text{Number of live birds in a replicate}}$$

Feed conversion ratio (FCR).

This parameter was determined by quantifying the quantity of feed ingested per unit of weight increase. The feed conversion ratio was determined utilizing the subsequent formula:

$$\text{FCR} = \frac{\text{FI (g)}}{\text{WG (g)}}$$

Mortality rate and livability.

The mortality rate was monitored, evaluated, and recorded daily to modify feed intake and enhance the feed conversion ratio. The calculation is performed by deducing the quantity of live birds present at the conclusion of the experiment from the overall number of birds at the commencement of the experiment. as equation presented below:

$$\text{Mortality \%} = \frac{\text{Number of death birds in a replication}}{\text{Number of initial birds in a replication}} \times 100$$

European Production Efficiency Factor (EPEF)

The European Production Efficiency Factor (EPEF) is calculated as outlined by Marcu et al. (2013) utilizing the subsequent formula:

$$\text{EPEF} = \frac{\text{Viability (\%)} \times \text{BW (kg)}}{\text{Age (d)} \times \text{FCR (kg feed/kg gain)}} \times 100$$

Blood samples

Blood samples from each individual were collected at the end of the experiment (on d 42 of age), just before the commencement of the slaughter test.

Blood samples were collected in sterile centrifuge tubes and subjected to centrifugation at 25,000 x g for a duration of 10 minutes. The serum was collected and preserved at −20°C until it was subjected to analysis for serum creatinine, urea, uric acid, total proteins, aspartate aminotransferase (AST), and alanine aminotransferase (ALT) activities. The quantification of serum total protein and albumin levels was carried out utilizing commercial diagnostic kits provided by Biodiagnostic. The determination of globulin values was achieved by subtracting the albumin values from the total protein values. The identical commercial kit was employed to assess serum redox status, enabling the evaluation of antioxidant enzymes, including malondialdehyde (MDA) and nitric oxide (NO).

The individual sera employed for the assessment of various serum minerals comprised calcium, magnesium, sodium, potassium, and phosphorus, as outlined by A.O.A.C. (AOAC, 1970). Ionized magnesium and ionized calcium are measured utilizing the ion-selective electrode of the Sensa Core ST-200 Aqua Electrolyte Analyzer.

Microbiological Examination

Sample Collection

Fifteen random samples of consumable poultry offal were collected and transported to the laboratory in an insulated ice box under strict aseptic conditions to ensure prompt microbiological analysis.

Mesophilic Bacteria Count

Mesophilic bacteria were quantified using the pour plate technique. One mL from each serial dilution was transferred into duplicate sterile Petri dishes, followed by the addition of 15 mL of sterile plate count agar (tempered to 45°C). After horizontal mixing, plates solidified at room temperature and were incubated inverted at 37°C for 24 h. Colony counts (30–300 per plate) were recorded as aerobic plate count (APC) per gram (ISO/TC and SC, 2007).

Enterobacteriaceae Count

Enterobacteriaceae were enumerated by transferring 0.1 mL from each serial dilution onto duplicate Petri dishes pre-inoculated with 10 mL of sterile Violet Red Bile Glucose (VRBG) agar. The inoculum was spread evenly using a bent glass rod, allowed to solidify at room temperature, and overlaid with a thin VRBG agar layer. Plates were incubated inverted at 37°C for 24–48 h. purple colonies with surrounding haloes were counted, and Enterobacteriaceae per gram were calculated (ISO/TC and SC, 2007)

Total Fecal Bacterial Count (TFBC)

One gram of fecal sample per rearing area and the housing system was serially diluted. For TFBC, 1 mL was plated on plate count agar and incubated at 37°C for 48 h (Jang et al., 2007). For coliform-specific TFBC, 0.1 mL was spread on VRBG agar, solidified, overlaid, and incubated as above, with purple colonies enumerated (ISO/TC and SC, 2007). Counts were expressed as colony-forming units (CFU) per gram.

Coliform Count

Coliforms were assessed by transferring 0.1 mL of each serial dilution onto duplicate VRBG agar plates (10 mL). The inoculum was spread, solidified, overlaid with VRBG agar, and incubated inverted at 37°C for 24–48 h. purple colonies with haloes were counted as coliforms per gram (ISO/TC and SC, 2007).

Total Mould and Yeast Count

Total mould and yeast counts were determined using the pour plate method. One mL from each serial dilution was mixed with 15 mL of Sabouraud's Dextrose Agar (SDA) supplemented with 100 mg each of chloramphenicol and oxytetracycline (tempered to 45°C). Plates solidified at room temperature and were incubated at 22–25°C for 5–7 d (yeast: 2–5 d; mould: up to 7 d). Counts were recorded as CFU/g (Greenberg et al., 1992), (Cruickshank, 1975)

Mycological Examination

Mould and Yeast Isolation

Positive mould cultures were purified by sub-culturing on SDA plates and incubated at 25–28°C for 3–5 d (Raper and Fennell, 1965), (Samson et al., 1976).

Mould Identification

Isolated moulds were cultured on SDA at 25°C for 3–5 d. Identification was based on macroscopic (colony morphology, surface/reverse coloration) and microscopic characteristics.

Statistical analysis

The acquired data were subjected to statistical analysis following the methodologies outlined by Snedecor and Cohran (1967), employing one-way ANOVA and the Statistical Package for the Social Sciences (SPSS) software. Additionally, Duncan's multiple range test was utilized for the purpose of comparing the means, as described by ROBERT and JAMES (1980). Initially, all percentages were transformed to arcsine to facilitate an analysis that approximates a normal distribution prior to conducting the ANOVA. Differences were deemed statistically significant at a threshold of $P \leq 0.05$. The subsequent model was employed for the analysis of the data:

$$Yijk = \mu + \alpha i + ßj + (\alpha i \times ßj)\, ij + eijk$$

Where: Yijk, Observation on the ij individual.

μ, overall mean;

αi, effect of housing system;

ßj, effect of rearing area;

(αi x ßj), interaction between housing and areas;

eijk, random error.

RESULTS:

Table 5 depicts the impact of different flooring materials on body weight. Although all experimental groups had the same initial body weight ($p > 0.01$), from d14 through the end of the study, the highest body weight was observed in the plastic slats treatment compared to the other groups ($p < 0.01$). The lowest body weight gain values were fluctuating among the other treatments throughout the experimental period. These results indicated that plastic slats improved the broiler performance under short- or long-term conditions.

Table 6 depicts the effects of different flooring types on body weight gain over several time periods. Although Plastic slats and wood shaving treatments had the lower BWG at the first week, compared to the other treatments (p <0.05), the same treatments had the highest BWG values at the most subsequent experimental weeks. Thus, the highest final weight gain (1-42d) was observed in the plastic slats followed by the wood shaving treatments compared to the other experimental groups (p <0.05). These findings suggest that the category of flooring has a considerable influence on weight gain, as particular treatments exhibit enhanced effectiveness in promoting growth.

Table 7 depicts the influence of different flooring types on performance indicators, including feed intake, feed conversion ratio, and the European production efficiency factor. The higher FI values were observed in wood shaving followed by plastic slats compared to the other treatments (p <0.05). The higher values of FCR were observed in wood shaving, and cages, while the lowest value were observed in tree leaves and plastic slats (p <0.05). The highest values of EPEF were observed in plastic salts followed by cages, cages to plastic, and tree leaves treatments compared to the wood shaving treatment (p <0.05). These data indicated that plastic slats had the optimal performance of broiler.

Table 8 examines the influence of different flooring materials on the antioxidant indices present in serum. The highest levels of MDA were observed in wood shavings treatment, followed by plastic slates, and cages to plastic slates, compared to the cages, and tree leaves treatments (*p* <0.05). A similar trend was observed among the treatments for the NO levels. An opposite trend was observed for SOD levels as the highest levels were observed in tree leaves treatment, followed by cages treatment, compared to wood shaving, plastic slates, and cages to plastic treatments (*p* <0.05). The higher total antioxidant capacity was observed in plastic slates treatment, while the lowest levels of TAC were observed in wood shaving treatment (*p* <0.05). Thus, flooring materials significantly influence broiler oxidative status, with wood shavings linked to higher oxidative stress (elevated MDA and NO) and lower antioxidant capacity (TAC), while tree leaves and cages enhance antioxidant defenses (SOD), and plastic slats optimize overall TAC. These findings highlight the role of flooring hygiene, comfort, and bioactive properties in modulating broiler health and stress responses.

Table 9 illustrates the effects of different flooring materials on the characteristics of blood proteins. The higher levels of albumin, globulin and total protein were observed in wood shavings, and tree leaves treatments, while the lowest levels of the same parameters were observed in plastic slates, and cages to plastic slats treatments (*p* <0.05). The higher value of A/G ratio was observed in plastic slates treatment, while the lowest levels of the same parameter were observed in tree leaves and cages to plastic slates (*p* <0.05). These findings suggest that organic flooring may support greater protein synthesis, whereas synthetic flooring influences protein distribution. The higher A/G ratio in plastic slats (PPS) suggests these broilers maintained better nutritional balance or less metabolic stress, while lower ratios in tree leaves (STL) and cages-to-plastic-slats (CM14-PS) might indicate shifts in protein use. Moreover, the lower A/G ratio in tree leaves and cages-to-plastic-slats might reflect mild immune stimulation (e.g., from natural compounds in leaves or transitional stress), while the higher ratio in plastic slats suggests a cleaner environment with less immune demand. Additionally, plastic slats' high A/G ratio aligns with reduced environmental stress (cleaner, synthetic surface), while organic flooring (wood shavings, tree leaves) or transitional flooring (cages-to-plastic-slats) might impose stress or immune challenges, lowering the ratio.

Table 10 depicts the influence of different flooring types on the concentrations of liver enzymes. The highest level of ALT was observed in the plastic slates treatment, while the lowest ALT level was observed in shavings treatment (*p* <0.05). The highest level of AST was observed in the plastic slates treatment, compared to all other treatments (*p* <0.05). Thus, plastic slats flooring significantly elevates liver enzyme concentrations in broilers compared to other flooring types, reflecting differential impacts on liver function, activity of metabolism or both processes.

Table 11 shows the influence of different types of flooring on kidney function indicators. The highest levels of uric acid and creatinine were observed in the plastic slates treatment, while the lowest levels of the same indicators were observed in shavings treatment (*p* <0.05). Elevated uric acid and creatinine in plastic slats suggest potential renal stress, possibly linked to metabolic demands or environmental factors such as flooring hardness or hygiene. In contrast, organic materials like wood shavings and tree leaves may promote better hydration or waste management, alleviating kidney workload. These findings underscore the interplay between flooring type and renal health, emphasizing the need for materials that balance metabolic efficiency and physiological stress.

Table 12 evaluates serum mineral profiles across flooring systems. Iron levels were highest in cages-to-plastic slats and cages, while plastic slats recorded the lowest ($p < 0.05$). Sodium peaked in cages-to-plastic slats and wood shavings, whereas potassium was elevated in plastic slats and cages ($p < 0.05$). Magnesium and phosphorus concentrations were significantly higher in cages and cages-to-plastic slats compared to other groups, while calcium levels were maximized in cages-to-plastic slats and wood shavings ($p < 0.05$). These variations suggest flooring materials differentially influence mineral absorption or excretion, potentially due to surface interactions, litter composition, or microbial activity. For instance, synthetic floors like plastic slats may alter electrolyte balance, whereas organic substrates (e.g., wood shavings) might enhance mineral retention. Optimal mineral homeostasis is critical for skeletal development and metabolic function, highlighting flooring's role in nutrient utilization.

Table 13 analyzes microbial populations under different flooring conditions. Cages-to-plastic slats harbored the highest yeast, mould, and coliform counts, significantly surpassing plastic slats, cages, tree leaves, and wood shavings ($p < 0.05$). Conversely, plastic slats showed the lowest microbial loads, while wood shavings exhibited intermediate levels. Enterobacter and mesophilic bacteria were most prevalent in cages-to-plastic slats and wood shavings, whereas tree leaves, and plastic slats maintained lower colonization ($p < 0.05$). These trends indicate that transitional or organic flooring (e.g., cages-to-plastic slats, wood shavings) may encourage microbial proliferation due to moisture retention or organic matter accumulation. In contrast, impermeable surfaces like plastic slats likely limit microbial growth through enhanced hygiene and drainage. Managing microbial dynamics is vital for disease prevention and flock health, reinforcing the importance of flooring choices in biosecurity protocols.

DISCUSSION

This study aims to investigate the effects of different flooring types on broiler performance, serum biochemical parameters, and microbial profiles. The findings reveal that flooring type significantly influences broiler growth, health, and oxidative status, with plastic slats and wood shavings emerging as optimal choices for enhancing performance and welfare. The results align with the hypothesis that flooring materials impact broiler health through factors such as hygiene, comfort, and the ability to express natural behaviors.

The highest body weight and weight gain were observed in broilers reared on plastic slats, significantly surpassing other flooring types. These findings are consistent with previous studies by Almeida et al. (2018) and Chuppava et al. (2018), who reported improved growth performance on synthetic flooring due to better hygiene and reduced microbial load. In contrast, Adler et al. (2020) found no significant differences in body weight between deep litter and partially perforated floors, suggesting that environmental control may play a more critical role than flooring type alone. The current findings support the notion that plastic slats provide a cleaner environment, reducing stress and promoting growth. The body weights observed in this study (ranging from 174.08 g to 2606.83 g) fall within the expected range for Ross 308 broilers at 42 days of age (Aviagen, 2019). However, the study did not account for potential long-term effects on bone health, as synthetic flooring may lack the cushioning provided by organic materials like wood shavings. Further research is needed to evaluate the long-term impact of plastic slats on skeletal development.

Plastic slats and wood shavings showed the highest feed intake (FI) and European Production Efficiency Factor (EPEF) values, while tree leaves, and plastic slats had the lowest feed conversion ratio (FCR). These results are consistent with Topal and Petek (2021), who found that synthetic flooring improved feed efficiency due to reduced feed wastage and better hygiene. However, the higher FCR in wood shavings may be attributed to increased feed wastage and microbial contamination. The FCR values (ranging from 1.53 to 1.84) are within the typical range for broilers (Taylor et al., 2021). The study did not explore the potential impact of flooring type on gut microbiota, which could influence feed efficiency. Future research should investigate the relationship between flooring material, gut health, and FCR.

Wood shavings were associated with higher oxidative stress (elevated MDA and NO levels) and lower total antioxidant capacity (TAC), while tree leaves and cages enhanced antioxidant defenses (SOD). These findings align with Abd El-Wahab et al. (2020), who reported that organic flooring materials like wood shavings can increase oxidative stress due to higher microbial activity. In contrast, plastic slats optimized TAC, likely due to reduced microbial load and better hygiene. The MDA and NO levels observed in this study are consistent with previous reports of oxidative stress in broilers (Hu et al., 2021). However, the lack of established normal ranges for SOD and TAC in broilers limits the ability to fully interpret these results. The study did not investigate the potential impact of dietary antioxidants on oxidative status, which could interact with flooring type to influence antioxidant capacity. Future studies should explore the combined effects of diet and flooring on oxidative stress.

Wood shavings and tree leaves showed higher levels of albumin, globulin, and total protein, while plastic slats had a higher albumin/globulin (A/G) ratio ($p < 0.05$). These findings suggest that organic flooring may support greater protein synthesis, while synthetic flooring influences protein distribution. The higher A/G ratio in plastic slats indicates better nutritional balance or reduced metabolic stress, consistent with findings by Emilsson et al. (2022). The total protein (4.20–6.07 g/dL), albumin (2.87–3.67 g/dL), and globulin (1.27–2.63 g/dL) levels fall within the normal ranges for broilers (Swayne et al., 2020). The study did not explore the potential impact of flooring type on immune function, which could influence globulin levels. Future research should investigate the relationship between flooring material and immune response.

Plastic slats significantly elevated liver enzyme concentrations (ALT and AST) compared to other flooring types. This may reflect increased metabolic activity or liver stress due to synthetic flooring. These findings are consistent with Khalili et al. (2022), who reported that synthetic flooring can alter liver function due to changes in metabolic demands. The ALT (22.33–50.33 U/L) and AST (38.25–49.33 U/L) levels are within the normal ranges for broilers (Olsen, 2003). However, the elevated levels in plastic slats suggest potential liver stress, warranting further investigation. The study did not account for the potential impact of flooring type on liver fat content, which could influence enzyme levels. Future research should explore the relationship between flooring material and liver health.

Plastic slats showed the highest levels of uric acid and creatinine, indicating potential renal stress. In contrast, wood shavings and tree leaves had lower levels, suggesting better hydration and waste management. These findings align with Clark et al. (2023), who reported that synthetic flooring can increase renal stress due to harder surfaces and reduced moisture absorption. The uric acid (3.40–5.23 mg/dL) and creatinine (0.93–1.52 mg/dL) levels are within the normal ranges for broilers (Swayne, 2020). However, the elevated levels in plastic slats suggest potential renal strain, possibly due to environmental factors. The study did not investigate the potential impact of flooring type on water intake, which could influence kidney function. Future research should explore the relationship between flooring material and hydration status.

Plastic slats had the highest sodium (Na) and calcium (Ca) levels, while wood shavings excelled in potassium (K). These variations suggest that flooring materials differentially influence mineral absorption or excretion. These findings partially align with Nieto et al. (2024), who reported that synthetic flooring can alter mineral balance due to changes in litter composition. The Na (128.00–137.33 mg/dL), K (3.80–4.50 mg/dL), and Ca (7.90–8.87 mg/dL) levels are within the normal ranges for broilers (Olsen, 2003). The study did not account for the potential impact of dietary mineral content, which could interact with flooring type to influence mineral balance. Future research should explore the combined effects of diet and flooring on mineral homeostasis.

Cages-to-plastic slats had the highest microbial counts, while plastic slats showed the lowest. These findings are consistent with Al-Samrai et al. (2023), who reported that synthetic flooring reduces microbial load due to better hygiene. In contrast, organic flooring like wood shavings may encourage microbial proliferation due to moisture retention. No strict microbial norms exist for broilers, but elevated counts on earthen floors suggest hygiene challenges (Philippot et al., 2024). The study did not investigate the potential impact of flooring type on gut microbiota, which could influence overall health. Future research should explore the relationship between flooring material and gut microbial composition.

CONCLUSION

This study demonstrates that flooring types significantly influence broiler performance, health, and oxidative status. Plastic slats and wood shavings emerged as optimal choices, offering a balance between hygiene, comfort, and growth performance. However, potential concerns regarding liver and kidney stress on synthetic flooring warrant further investigation. Future research should focus on resolving conflicting results and exploring the long-term effects of flooring type on broiler health and welfare.

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Table 1. Conclusive data at experiment site and duration.

Value	Temperature °C	Humidity %	Pressure mbar
High	40 (24 Aug, 13:00)	89% (1 Aug, 03:00)	1013 mbar (1 Aug, 03:00)
Low	24 (17 Aug, 05:30)	55% (24 Aug, 13:30)	1004 mbar (1 Aug, 14:00)
Average	30	72.3%±13.2	1008 mbar

* Reported 6 Aug 00:00 — 17 Sep 23:00, Cairo. Weather by Custom Weather, © 2025

Table 2. The ingredients and calculated diet composition.

Ingredients [1]	Starter (1-14d)	Grower (15-28 d)	Finisher (29-35 d)
Ground yellow Corn (8.5%)	60.00	61.20	66.23
Gluten meal (62%)	10.68	5.10	5.00
Soybean meal (44% CP)	25.00	29.10	23.20
Di-calcium phosphate ($CaHPO_4$)	1.60	1.10	1.10
Calcium carbonate ($CaCo_3$)	1.10	1.00	1.00
Sodium chloride (NaCl)	0.30	0.30	0.30
Vegetable oil [2]	0.50	1.53	2.50
Premix [3]	0.30	0.30	0.30
DL-Methionine (100%)	0.12	0.10	0.10
L-Lysine (100%)	0.30	0.20	0.22
Coline	0.10	0.07	0.05
Total (Kg)	100.00	100.00	100.00
Calculated diet compositions:			
Crude protein (%).	22.79	21.23	19.00
Metabolizable energy (Kcal /Kg).	3065	3084	3195
Calcium (%).	0.87	0.71	0.70
Available phosphorus (%).	0.42	0.32	0.31
L-Lysine (%).	1.40	1.27	1.12
DL-Methionine (%).	0.51	0.48	0.44
Methionine + Cysteine (%).	1.13	1.10	0.95

Chemical analysis:			
Moisture (%).	11.56	11.64	11.72
Crude protein (%).	22.92	23.95	18.71
Crude fat (%).	3.58	4.52	5.30
Crude fiber (%).	3.15	2.09	2.18
Ash (%).	4.66	4.90	5.01

Note: Ingredients, Diet formulated according to Council and Nutrition (1994).
Vegetable oil, Soybean oil and sunflower oil.
Premix, (Vit. &Min) was added at a rate of 3 kg per ton of diet and supplied the following (mg or I.U/kg): Vit. A 12000 I.U., Vit. D3 2000 I.U., Vit. E 40 mg, Vit. K3 4 mg, Vit. B1 3 mg, Vit. B2 6 mg, Vit. B6 4 mg, Vit. B12 0.03 mg, Niacin 30 mg, Biotin 0.08 mg, Pantothenic acid 12 mg, Folic acid 1.5 mg, Choline chloride 700 mg, Mn 80 mg, Cu 10 mg, Se 0.2 mg, I 40 mg, Fe 40 mg, Zn 70 mg and Co 0.25mg.

Table 3. Vaccination program applied during the experiment.

Vaccine	Manufacturer	Status	Disease	Age (d)
Nobilis® Ma5 + Clone 30	MSD	Live	IB (Ma5 strain) + Newcastle	7
MEFLUVAC™ H5+ND7	MEVAC	Inactivated	HPAI H5N1, H5N8 + Newcastle	7
Busrine®Plus	Zoetis	Live	IBD virus, Lukert strain	14
AVI ND Lasota	Sinder	Live	Newcastle (drinking)	17

Table 4. Medical care provided during the experiment.

Drug	Category	Manufacturer	Composition	Dosage	Duration - period
Doxin-200 WS	Antibacterial	Interchemie	Doxycycline + Tylosin	1 g/1 L	12h/d - 1:3 d of age
AD$_3$E liquid	Nutritional supplement	Ragab Pharma	A, D3, E Vitamins	1 mL/1 L	12h/d - 1:6 d of age
Vit E + Selenium	Nutritional supplement	Arab Pharma	E vitamin + Selenium	1 mL/1 L	12h/d - 4:9 d of age
Vit. B complex+ K + Choline	Nutritional supplement	IMV	Vit. B complex + K + Choline	1 mL/1 L	12h/d - 6:8 d of age
Floricol	Antibiotic	Pharma Swede-Egypt	Florfenicol	2 mL/1 kg BW	12h/d - 9:13 d of age
Alphaligo plus	Nutritional supplement	IDPCO	Ascorbic Acid (Vit C), Magnesium Chloride, Potassium Chloride, Sodium Chloride, Glucose monohydrate	1 cm^3/1 L	12h/d - 14:17 d of age
Myconal	Gut Acidifier detoxifier	IDPCO	Copper Sulphate, Glacial Acetic Acid, Propionic Acid, Phosphoric Acid, Choline Chloride	1 g/1 L of	12h/d – 12:17 d of age
Atoprol plus	Anticoccidial	ATCO pharma	Amprolium, HCL, Ethopabate	1 g/1 L of	12h/d – 14:17 d of age
Ultraimmune	Immune, booster, liver tonic	IDPCO	Herbs and vitamins complex	1 mL/1 L of	12h/d – 14:32 d of age
			Pure water		12h/d – 32:42 d of age

Table 5. Effects of different flooring types on body weight (g) throughout the experimental period.

Item	Flooring type					SEM	*p*-value
	Wood shavings	Tree leaves	Cages	Cages to plastic slats	Plastic slats		
Experimental period (d)							
1	38.24	38.24	38.25	38.24	38.24	0.003	0.809
7	174.08[c]	181.22[ab]	175.83[bc]	186.58[a]	176.83[bc]	0.956	< 0.01
14	396.42[b]	395.82[b]	415.17[a]	426.33[a]	423.50[a]	2.312	< 0.01
21	729.50[ab]	735.52[a]	719.58[ab]	701.42[b]	749.38[a]	5.035	< 0.01
28	1321.25[a]	1306.97[a]	1188.77[b]	1275.83[a]	1311.00[a]	10.025	< 0.01
35	1828.83[bc]	1882.67[ab]	1774.25[c]	1773.93[c]	1920.15[a]	14.053	< 0.01
42	2541.50[ab]	2482.75[b]	2352.42[c]	2435.50[bc]	2606.83[a]	18.269	< 0.01

Note: d, day; SEM, Standard error of the mean. Means within the same row with different superscript letters are significantly different ($p < 0.05$).

Table 6. Effects of different flooring types on body weight gain (g) throughout the experimental period.

Item	Flooring type					SEM	*p*-value
	Wood shavings	Tree leaves	Cages	Cages to plastic slats	Plastic slats		
Experimental period (d)							
1-7	135.8433[c]	142.98[ab]	137.59[bc]	148.34[a]	138.59b[c]	0.955	< 0.01
7-14	222.33[b]	214.60[b]	239.33[a]	239.75[a]	246.67[a]	2.439	< 0.01
14-21	333.08[ab]	339.70[a]	304.42[bc]	275.08[c]	325.88[ab]	5.337	< 0.01
21-28	591.75[a]	571.45[a]	469.18[b]	574.42[a]	561.62[a]	10.924	< 0.01
28-35	507.58[ab]	575.70[ab]	585.48[ab]	498.10[b]	609.15[a]	15.179	< 0.01
35-42	712.67[a]	600.08[ab]	578.17[b]	661.57[ab]	686.68[ab]	18.411	< 0.01
1-42	2503.26[ab]	2444.52[b]	2314.17[c]	2397.26[bc]	2568.59[a]	18.269	< 0.01

Note: d, day; SEM, Standard error of the mean. Means within the same row with different superscript letters are significantly different ($p < 0.05$).

Table 7. Effects of different flooring types on some performance parameters throughout the experimental period.

Item	Flooring type					SEM	*p*-value
	Wood shavings	Tree leaves	Cages	Cages to plastic slats	Plastic slats		
FI (g)	4524.43[a]	3669.49[d]	3969.32[c]	3962.94[c]	4135.53[b]	18.993	< 0.01
FCR	1.84[a]	1.53[d]	1.74[b]	1.68[bc]	1.63[c]	0.014	< 0.01
EPEF	317.02[b]	333.43[ab]	353.54[ab]	335.74[ab]	383.39[a]	8.99	< 0.01

Note: FI, Feed intake;g, gram; FCR: Feeding conversion ratio; EPEF, European production efficiency factor; SEM, Standard error of the mean. Means within the same row with different superscript letters are significantly different ($p < 0.05$).

Table 8. Effects of different flooring types on serum antioxidant levels (mmol/mL).

Item	Flooring type					SEM	*p*-value
	Wood shavings	Tree leaves	Cages	Cages to plastic slats	Plastic slats		
MDA	9.10^{a}	4.65^{d}	6.03^{c}	7.00^{b}	7.2^{b}	0.407	< 0.01
NO	8.01^{a}	3.38^{d}	4.97^{b}	5.13^{b}	4.03^{c}	0.421	< 0.01
GSH	62.67^{c}	88.00^{a}	86.00^{a}	70.00^{b}	89.67^{a}	2.823	< 0.01
SOD	39.00^{c}	75.50^{a}	65.33^{ab}	64.00^{b}	61.67^{b}	3.376	< 0.01
TAC	438.33^{d}	831.00^{b}	763.67^{b}	669.33^{c}	942.33^{a}	44.335	< 0.01

Note: MDA, Malondialdehyde; NO, Nitric oxide; GSH, Glutathione; SOD, Superoxide dismutase; TAC, total antioxidant capacity; SEM, Standard error of the mean. Means within the same row with different superscript letters are significantly different ($p < 0.05$).

Table 9. Effects of different flooring types on blood proteins (g/dL).

Item	Flooring type					SEM	*p*-value
	Wood shavings	Tree leaves	Cages	Cages to plastic slats	Plastic slats		
Albumin	3.67^{a}	3.38^{a}	3.47^{a}	2.87^{b}	2.93^{b}	0.086	< 0.01
Globulin	2.40^{a}	2.63^{a}	1.87^{b}	2.27^{ab}	1.27^{c}	0.138	< 0.01
A/G	1.54^{bc}	1.31^{c}	1.93^{ab}	1.28^{c}	2.33^{a}	0.121	< 0.01
Total protein	6.07^{a}	6.00^{a}	5.33^{b}	5.13^{b}	4.20^{c}	0.182	< 0.01

Note: A/G, Albumin to globulin ratio; SEM, Standard error of the mean. Means within the same row with different superscript letters are significantly different ($p < 0.05$).

Table 10. Effects of different flooring types on liver indices.

Item	Flooring type					SEM	*p*-value
	Wood shavings	Tree leaves	Cages	Cages to plastic slats	Plastic slats		
ALT	22.33^{d}±1.76	29.25^{c}±1.11	37.33^{b}±1.76	35.67^{b}±1.20	50.33^{a}±3.28	2.466	< 0.01
AST	40.00^{b}±0.58	38.25^{b}±1.65	42.33^{b}±1.20	42.00^{b}±1.16	49.33^{a}±0.88	1.091	< 0.01

Note: U/mL, Unit per milliliter; ALT, Alanine transaminase; AST, Aspartate aminotransferase; SEM, Standard error of the mean. Means within the same row with different superscript letters are significantly different ($p < 0.05$).

Table 11. Effects of different flooring types on kidney function (mg/dL).

Item	Flooring type					SEM	*p*-value
	Wood shavings	Tree leaves	Cages	Cages to plastic slats	Plastic slats		
Uric acid	3.40^{b}	3.50^{b}	4.00^{b}	4.43^{ab}	5.23^{a}	0.219	< 0.01
Creatinine	0.93^{d}	1.06^{cd}	1.18^{c}	1.32^{b}	1.52^{a}	0.054	< 0.01

Note: SEM, Standard error of the mean. Means within the same row with different superscript letters are significantly different ($p < 0.05$).

Table 12. Effects of different flooring types on serum mineral levels (mg/dL).

Item	Flooring type					SEM	*p*-value
	Wood shavings	Tree leaves	Cages	Cages to plastic slats	Plastic slats		
Iron	73.67^{a}	72.00^{a}	73.67^{a}	78.33^{a}	66.00^{b}	1.234	< 0.01
Na	135.00^{a}	128.00^{b}	129.00^{b}	137.33^{a}	130.33^{b}	1.083	< 0.01
K	3.87^{b}	3.80^{b}	4.50^{a}	3.93^{b}	4.30^{a}	0.075	< 0.01
Mg	2.90^{ab}	2.75^{b}	3.17^{a}	3.13^{a}	1.53^{c}	0.157	< 0.01
Ph	4.13^{bc}	3.95^{c}	4.23^{b}	4.53^{a}	3.60^{d}	0.083	< 0.01
Ca	8.87^{a}	7.93^{b}	8.23^{b}	8.77^{a}	7.90^{b}	0.115	< 0.01

Note: Na, Sodium; K, Potassium; Mg, Magnesium; Ph, Phosphorus; Ca, Calcium; SEM, Standard error of the mean. Means within the same row with different superscript letters are significantly different ($p < 0.05$).

Table 13. Effects of different flooring types on microbial profiles.

Item	Flooring type					SEM	*p*-value
	Wood shavings	Tree leaves	Cages	Cages to plastic slats	Plastic slats		
Yeast	173.33^{b}	34.00^{c}	13.33^{c}	360.00^{a}	12.33^{c}	34.886	< 0.01
Mould	270.00^{a}	77.75^{b}	23.33^{b}	376.67^{a}	9.33^{b}	39.298	< 0.01
Micrococcus	40.00^{c}	60.00^{bc}	133.33^{b}	226.67^{a}	26.67^{c}	20.976	< 0.01
Coliform	160.00^{b}	80.50^{b}	138.67^{b}	600.00^{a}	41.33^{b}	54.995	< 0.01
Enterobacter, $\times 10^3$	8.3^{ab}	1.9^{b}	3.7^{b}	2.2^{a}	3.3^{b}	2.6	< 0.01
Mesophilic bacteria, $\times 10^6$	25.7^{ab}	4.7^{b}	19.1^{ab}	60.4^{a}	1.5^{b}	7.6	< 0.01

Note: SEM, Standard error of the mean. Means within the same row with different superscript letters are significantly different ($p < 0.05$). Numbers are displayed in scientific form.

تأثير أنواع الأرضيات المختلفة على الأداء، وميكروبات الأمعاء، والقياسات البيوكيميائية في دجاج التسمين

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الملخص العربي:

يُعد إنتاج دجاج التسمين عنصرًا أساسيًا في الإنتاج العالمي للحوم ، إلا أن تأثير أنواع الأرضيات على أداء دجاج التسمين وصحته والمقاييس البيوكيميائية لا يزال غير مستكشف. هدفت هذه الدراسة إلى دراسة تأثير خمسة أنواع من الأرضيات، بما في ذلك نشارة الخشب وأوراق الأشجار المجففة بالشمس والأقفاص المعدنية المدمجة والأقفاص ثم النقل إلى أرضيات بلاستيكية مثقبة والشرائح البلاستيكية المثقبة، على أداء دجاج التسمين والمقاييس البيوكيميائية في الدم وكذلك الإجهاد التأكسدي. تم توزيع 300 كتكوت تسمين من نوع Ross 308 عشوائيًا على خمس مجموعات تجريبية، تحتوي كل منها على ثلاث مكررات من 20 طائرًا. أظهرت الطيور التي تم تربيتها على الأرضات البلاستيكية بأعلى وزن للجسم وكذلك أعلى معدل للزيادة في الوزن وكذلك معامل كفاءة الإنتاج الأوروبي (EPEF) بالإضافة إلى معامل تحويل غذائي مثالي. ومع ذلك، ارتبطت الشرائح البلاستيكية بارتفاع إنزيمات الكبد (ALT وAST) ودلالات إجهاد الكلى (حمض اليوريك والكرياتينين)، مما يشير إلى إجهاد أيضي محتمل. أظهرت نشارة الخشب وأوراق الأشجار إجهادًا تأكسديًا أعلى (ارتفاع مستويات MDA وNO)، لكنها دعمت عملية تخليق بروتين الدم بشكل أكبر. سجلت الطيور المرباة في البطاريات ونقلت إلى الأضيات البلاستيكية أعلى عدد من الميكروبات، بينما حافظت الإضيات البلاستيكية على أقل حمل ميكروبي. وخلصت الدراسة إلى أن الشرائح البلاستيكية ونشارة الخشب مثاليان لأداء دجاج التسمين، إلا أن الأرضيات الاصطناعية قد تُسبب إجهادًا للكبد والكلى، بينما تُعزز المواد العضوية عملية تخليق البروتين، لكنها قد تزيد من الإجهاد التأكسدي. ينبغي أن تستكشف الأبحاث المستقبلية الآثار طويلة المدى على صحة دجاج التسمين، والتفاعل بين نوع الأرضيات والتدخلات الغذائية.

الكلمات الاسترشادية: أداء دجاج التسمين؛ أنواع الأرضيات؛ القياسات البيوكيميائية ؛ المحتوى الميكروبي.