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Use of fibre palm as a local alternative litter material for broiler production: Effect on broilers' welfare and performance

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ABSTRACT

This study evaluated the quality of three types of bedding materials and investigated their effects on growth performance and the welfare state of broilers. The experiment was carried out on 48,540 broilers equitably distributed in three poultry houses with three distinct types of litter material: chopped wheat straw, wood shavings, and palm fibre. The quality of the litter was assessed by scoring each type of litter, determining their absorbency, humidity and counting darkling beetle population. Growth performance was measured and welfare parameters were evaluated. Litter evaluation results revealed that wheat straw retained less water (76%), was the most humid at the end of the trial (69.82%), and was in very bad condition since the third week of the experiment, while palm fibre has the highest water-holding capacity (175.6%). Compared to wood shavings, palm fibre had the same litter quality assessment until the fourth week of the trial, and moisture rates were comparable. Regarding growth performance, there were no significant differences among litter types. However, significant effects on the health state of broilers were noted. The highest incidence of footpad lesions, pododermatitis and hock burns were recorded in broilers raised on wheat straw litter, while wood shavings and fibre palm showed comparable results. Therefore, palm fibre could be a local alternative litter material and can replace wood-shaving litter in broiler farms.

Keywords: Broiler chickens, Health, Litter management, Litter type, Performance

The production of broiler chickens is an essential part of the worldwide poultry business, for meeting the growing need for sources of high-quality protein (Tripathi *et al.* 2019). Providing high production while respecting broiler welfare is a major issue. Broiler welfare includes good feeding, good housing, good health, and appropriate behaviour (Ben Larbi *et al.* 2024). Litter quality is one of the most important elements impacting broiler welfare, health, and performance (Patel *et al.* 2023), and as the business develops, there is an increasing focus on improving these characteristics and various types of litter may cause different reactions in different birds (Van Limbergen *et al.* 2020). A study by Kheravii *et al.* (2017) showed that the kind of litter has a direct impact on footpad dermatitis prevalence and overall bird production. Studies revealed that various bedding materials have an impact on the productivity and psychological well-being of birds, in addition to their physical health (Boussaada *et al.* 2022, Durmus *et al.* 2023, Thennakoon *et al.* 2024). Hence, in poultry farming, choosing the right bedding material is essential to preserve health, welfare, and productivity of broilers. Indeed, wood shaving is one of the most used litter materials due to its high quality, which positively impacts chicken health, and consequently the profits of broiler farms (Awojobi *et al.* 2017, Boussaada *et al.* 2022) but the increasing demand for wood shaving and its scarcity amplified research interest in alternative litter material (Siaka *et al.* 2021, Thennakoon *et al.* 2024).

In Tunisia, there are more than 4 million date palms which occupy nearly 41 thousand hectares. After the date fruit harvesting, important quantities of date palm wastes accumulate every year in Tunisian agricultural lands (Hamza *et al.* 2013). Thus, the purpose of this study was to investigate the potential of litter palm fibre as an alternative local bedding material in broiler chicken farming.

MATERIALS AND METHODS

Ethical approval: The protocols and animal manipulation in this project were approved by the Official Animal Care and Use Committee of the National Institute of Agronomy of Tunisia (Protocol No. 05/15).

Birds, housing, and experimental design: A total of 48,540 one-day-old chicks of the Arbor *T. Majus* breed were randomly and equally (n=16,180) allocated into three

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buildings of a center belonging to Poulina Company located in the Mornag region of Tunisia (sub-humid bioclimatic zone), each provided with either palm fibre, chopped straw, or wood shavings as litter materials at a depth of 5 cm. Each building was divided into 4 batches. The buildings had the same dimensions: 100 m length and 10 m width, providing a surface area of 1000 m^2, equipped with 38 breeders, five extractors, 1200 drinkers, four feeding chains, and 384 feeders. Lighting was provided by 30 lamps and natural light, as each building had 22 windows. The light/dark applied cycle was 23L/1D. Birds were reared under the same environmental conditions and received the same quality and quantity of drinking water and feed according to breeder recommendations (Aviagen 2018).

Litter quality assessment: The quality of each litter type, including litter rating, water holding capacity (WHC), moisture content, and beetle count, was evaluated. Litter scoring was performed on days 1, 14, 21, 28, and 33, according to a previously developed point scale as described by Welfare Quality protocol (2009) (Table 1). WHC was calculated according to the formula:
where, W, weight of the container and the wet litter material; w, weight of the container and the dry litter material.

$$\text{WHC (\%)} = \frac{\text{W(g)–w(g)}}{\text{500 g}} \times 100$$

Moisture content was measured after drying the samples collected from four different locations in each building for 24 h at 105°C. It was evaluated on days 9, 20, and 30. The darkling beetle population was counted using traps made with 23 × 4 cm PVC tubes filled with corrugated rolled paper and placed under drinkers, feeders, and ventilators (Abreu *et al.* 2011). Traps were removed weekly to count the number of larvae, nymphs, and adults of beetles.

Measurement of zootechnical parameters: Over the 33 days of the trial, average weight (AW) and feed conversion ratio (FCR) were recorded weekly on a sample of 100 broilers per building (25 birds/batch). Animals were weighed weekly at the same hour from their arrival until slaughter. Mortalities were recorded daily throughout the rearing period.

Welfare indicators: The on-farm animal welfare status was assessed using the Welfare Quality protocol for poultry (Welfare Quality 2009). Footpad lesions, pododermatitis, hock burns, feather dirtiness, and visible scratches on the thighs and breast were visually assessed. Footpad lesions are classified using the five-point scale that quantifies the severity of lesions (Welfare Quality 2009). Pododermatitis is quantified visually by attributing the following scores: 0 for absence, 1 for minimal presence, and 3 for obvious presence of pododermatitis. Hock burns, plumage dirtiness, and visible scratches on the thighs and breast were also evaluated by observing the birds and assessing scores from 0 to 4 for hock burns, 0 to 3 for plumage dirtiness, and 0 or 1 for scratches (Welfare Quality 2009).

Table 1. Litter scoring

Score	Description for scoring
0	completely dry and flaky litter
1	Dry litter, but not easy to move with foot
2	Litter leaves an imprint of foot and will form a ball if compacted, but the ball does not stay well together.
3	Litter sticks to boots and sticks readily in a ball if compacted
4	Litter sticks to boots once the cap or compacted crust is broken

Source: Welfare Quality Protocol (2009).

Data analysis: Data was analyzed using the SAS software (SAS version 9.4, SAS Inst., Cary, NC, USA) and data was subjected to a one-way analysis of variance (one-way ANOVA) to determine the differences among different litter materials. Differences between LS Means were assessed by Tukey-Kramer's test and $P < 0.05$ was considered a significant value. The statistical model used was:

$$Yij = \mu + Li + eij$$

where, Yij, an observation; μ, overall mean; Li, litter type effect and eij, the experimental error.

RESULTS AND DISCUSSION

Litter quality: Results showed significant differences ($p<0.05$) between rates of WHC, particularly between wheat straw and palm fibre (76% vs 175.6%) (Table 2). In moisture content, wood-shaving litter was the most dry at D30, while chopped straw litter was the most humid at D30. Litter scoring revealed that chopped straw litter was in very bad condition (score 4) at the end of the trial and in a bad condition (score 3) from the third week, while palm fibre litter was still acceptable (score 2) until the fourth week, and wood shaving litter was still in acceptable condition (score 2) until the fifth week (Table 1).

Wood-shaving litter had the highest beetle count for adults, larvae, and nymphs around feeders and drinkers and under ventilators over the 5-week trial period. Overall, wood shavings were most suitable bedding material for rearing broilers due to their ability to absorb excess water and to be dried quickly, since litter moisture increases the development of pathogenic microorganisms such as *Salmonella*, *Campylobacter*, *Listeria* spp., and *Eimeria* spp. (Carr *et al.* 1995, Siaka *et al.* 2021). Additionally, litter plays a major role in preventing excessive damage to footpads and improving poultry welfare (Strašifták and Juhás 2023), which is the case of wood shavings followed by fibre palm in the current study.

For the spatial evolution of darkling beetles (*Alphitobius diaperinus*) on different litter materials (Supplementary Fig. 1), wood shavings had the highest number of adults, larvae, and nymph beetles. The highest count was found under the drinkers due to higher humidity, while the lowest count was observed under ventilators, the driest area. In previous research, Asaniyan *et al.* (2007) found that wood shavings harbor more beetles compared to sand litter and Abreu *et al.* (2011) reported that soybean straw litter

Table 2. Properties of different litter material

Parameter	Litter material			P-value
	Chopped straw	Wood shavings	Palm fibre	
WHC (%)	76±4.55[a]	140±913[b]	175.6±5.51[c]	<0.001
Moisture evolution				
D0	13.45±1.08[a]	13.93±0.25[b]	10.79±0.71[a]	<0.001
D9	46.13±0.69[a]	25.34±0.68[b]	30.45±0.49[c]	<0.001
D20	68.52±0.66[a]	31.67±0.39[b]	46.07±0.75[c]	<0.001
D30	69.82±1.20[a]	36.22±0.63[b]	58.26±0.48[c]	<0.001
Litter scoring				
W1	1	1	1	
W2	2	1	1	
W3	3	1	2	
W4	3	2	2	
W5	4	2	3	

D, day; W, week. [a], [b], different letters indicate statistically significant differences (P<0.05).

has a higher beetle count than rice husks. In the present study, a high number of beetles in wood shavings was found, as compared with fibre palm or chopped straw which can be attributed to a previous contamination of the building by darkling beetles that persisted in the building, probably caused by an improperly performed sanitary vacuum. For this reason, this parameter cannot be taken into consideration when comparing the quality of the three types of litter, but a rapid and efficient intervention is required to control darkling beetles by modifying litter *p*H (Watson *et al.* 2003); by applying insecticide in the whole building during downtime (Salin *et al.* 2003); or ideally with entomopathogenic fungi, a potential eco-friendly method for monitoring darkling beetles, that prevents insecticides residues (Japp *et al.* 2010). Darkling beetles constitute a major vector of different bacteria such as *E. coli*, *Salmonella* spp., *Clostridium perfringens*, a virus such as avian leucosis virus, and parasites such as coccidian, avian tapeworms, and helminths which are responsible for the most common avian diseases (Abreu *et al.* 2013).

Hence, compared to wood shavings, fibre palm has a better water-holding capacity, the same litter quality assessment until the fourth week of the rearing period, and moisture rates which are comparable until the fourth week. Other studies also suggested that palm wastes can be used as substitute bedding materials with various degrees of success (El-deen *et al.* 2021a, El-deen *et al.* 2021b).

Growth performance: At the end of the trial, AW and FCR were not influenced by the type of litter material (Table 3). Litter material significantly affects mortality rates, the lowest was recorded in broilers kept on wood-shaving litter (3.4%), followed by those kept on palm fibre (5.07%) and chopped straw (6.4%).

Various studies testing different types of bedding materials showed varying effect on the growth performance of broiler chickens, but few have focussed on the potential of palm residues as an alternative litter material. Al-Homidan *et al*. (2018) reported that chopped palm leaves can be a good alternative bedding material to wood shavings and wheat straw in commercial broiler production. El-deen *et al.* (2021a) showed that broilers reared on palm stem slats, wheat straw litter, and wooden slats floors had significant superiority of body weight (2186.3, 2189.7, and 2200.8 g vs 1900.5, 2162.1 and 1986.4 g) over the broilers reared on wire net, plastic net, and palm fibre mat floors, respectively. In another study, El-Deen *et al.* (2021b), when evaluating plant residues as an alternative litter material, found that broiler reared on palm spine chips, wheat straw, and corn stalks chips litters had significant superior body weight (2139.3, 2143.9 and 2140.2 g vs 2125.6, 1921.3, and 1928.1 g) over the broiler reared on wood sawdust, rice hulls, and chopped palm fibre, respectively.

Some researchers suggest that bedding material does not affect growth performance, such as Martinez and Gernat

Table 3. Effect of litter material on growth performance

Parameter	Litter material			P-value
	Chopped straw	Wood shavings	Palm fibre	
Average body weight (g)				
D1	38.01±6.40	38.08±5.54	38.12 ±6.26	0.96
W1	140.0±5.84[a]	152.0±5.20[b]	151.1±5.50[b]	0.02
W2	464.1±6.13	485.1±5.75	468.4±5.78	0.06
W3	845.6±5.80	893.0±5.82	852.1±5.94	0.07
W4	1339±5.93	1375±5.82	1342±6.29	0.06
W5	1754±6.33	1814±5.77	1760±5.29	0.08
FCR	1.62	1.50	1.58	0.34
Mortality (%)	6.40[a]	3.40[b]	5.07[c]	0.04

D, day; W, week; FCR, feed conversion ratio. [a], [b], different letters indicate statistically significant differences (P<0.05).

Table 4. Percentage distribution of broiler chickens across welfare parameter scores measured in the three types of litter

Parameter	Litter material		
	Chopped straw	Wood shavings	Palm fibre
Footpad lesions (%)			
Score 0	47.8	71.2	68.6
Score 1	19.8	21.4	11.8
Score 2	32.4	7.40	19.6
Pododermatitis (%)			
Score 0	0	12	10
Score 1	0	44	30
Score 2	100	44	60
Hock burns (%)			
Score 0	74.0	87.0	90.6
Score 1	16.4	8.00	6.80
Score 2	9.60	5.00	2.60
Feather dirtiness (%)			
Score 0	81.8	91.2	96.6
Score 1	14.8	7.20	2.00
Score 2	3.40	1.60	1.4
Visible scratches on thighs and breasts (%)	0	0	0

(1995) when they used chopped computer and bond paper mixed with wood shavings as litter material; Sanjayaranj *et al.* (2019) when they tested four types of litter material, namely paddy husk, chopped newspaper, coir dust, and sand; and Kuleile *et al.* (2019) when they utilized wood shavings, dried pine leaves, decomposed kraal manure, and sand litters. Contrarily, others highlighted the importance of considering litter material in broiler rearing, such as Sigroha *et al.* (2017) who showed that sawdust, wheat straw, rice husk, river bed sand, and sandy soil litters significantly affected the FCR during the third and fourth weeks of the experiment; Durmuş *et al.* (2023) who observed that FCR were significantly affected by the type of litter material (thick sawdust, fine sawdust, and rice hull) and Eser *et al.* (2022) who recorded that among the six bedding material groups (wood shavings, paper waste sludge, sepiolite, mix of 25% paper waste sludge and 75% sepiolite, mix of 50% paper waste sludge and 50% sepiolite, and mix of 75% paper waste sludge and 25% sepiolite), the body weight at slaughter age and body weight gain of broilers reared on the wood shavings and mix of 50% paper waste sludge and 50% sepiolite were higher than those of the sepiolite and paper waste sludge groups.

Welfare parameters indicators: The impact of litter material on footpad lesions, pododermatitis, hock burns, feather dirtiness, and visible scratches on the thighs and breasts are shown in Table 4. The highest incidence of footpad dermatitis was found in wheat straw bedding with a rate of 32.4%, followed by palm fibre (19.6%), and wood shavings (7.4%) with a score of 2. Regarding pododermatitis, the majority of broilers reared on the three types of litter had a score of 2, but the highest rate was recorded in broilers raised on chopped straw, followed by those raised in palm fibre, and in wood shaving. Hock burns were more prevalent in flock reared on chopped straw litter. The cleanest feather was noted in birds reared in palm fibre litter; 96.6% of sampled birds had a score of 0. No visible scratches were recorded on the thighs and breasts of broilers sampled and reared on the three types of litter. Related studies suggest that litter material can have a significant impact on various welfare parameters. Regarding foot health, the findings of the current study are in agreement with other findings, where they found that wood-shaving litter had the lowest footpad incidence compared to other types of litter such as decomposed kraal manure, sand, and dry pine tree leaves (Kuleile *et al.* 2019) or standard quality straw, low-quality straw, sawdust, and crop residues (Boussaada *et al.* 2022). This may be due to its ability to quickly release moisture. Indeed, in the present study, wood shavings were the less humid litter material. In a similar context, El-deen *et al.* (2021a) observed the lowest score for broilers raised on wheat straw litter, wooden slats, and palm slat floors in comparison with those raised on wire net, palm fibre net floors, and plastic net floors. Thereby, the type of litter has an effect on animal health, which may impact growth performances because of reduced movement of chicks with leg problems such as foot sores and hock burns, which impacts feed intake and consequently weight gain (El-deen *et al*. 2021a, Ben Larbi *et al*. 2024).

It is well established that wood shavings are among the most satisfactory bedding materials in terms of quality and effects on broiler performance and health. Throughout the trial, when comparing palm fibre to wood shavings, palm fibre demonstrated a better water-holding capacity, a similar litter quality assessment until the fourth week of the trial and comparable moisture rates. In terms of growth performances, no significant differences were observed. Regarding welfare parameters, palm fibre generated lower hock burns and less feather dirtiness compared to wood shavings. Based on these findings, palm fibre can be recommended to farmers as a local, natural, renewable, environment friendly alternative and promising litter material for poultry.

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