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EFFECT OF DIFFERENT LITTER MATERIALS ON THE PRODUCTIVE AND PHYSIOLOGICAL PERFORMANCE OF BROILER CHICKENS

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SUMMARY

A total of 198 one-day-old Ross 308 broiler chicks were used in a five-week study to investigate the effect of different litter materials on their productive and physiological performance. At the beginning of the experiment, chicks were randomly divided into three experimental groups, with six replicates each. The three groups were assigned the following litter materials: 1) wood shavings, 2) agricultural waste (tree pruning waste), and 3) a 50/50 mixture of wood shavings and agricultural waste. Results indicate that litter types didn't significantly affect the final body weight, weight gain, total feed intake, feed conversion ratio, and mortality rate. However, litter types significantly impacted the weight of the bursa of Fabricius, RBCs, WBCs, PCV, and Hb content in the blood. The highest values were observed in group 1 followed by groups 3 and 2 respectively. On the other hand, raising birds on agricultural waste litter resulted in the lowest production cost and the highest profit or economic efficiency, followed by birds raised on mixture litter, compared to those reared on wood shavings alone. In conclusion, the performance of birds raised on wood shavings was the best numerically in most production and physiological measurements, followed by birds raised on the mixed litter, and finally, the group raised on agricultural waste litter alone. Based on these results, agricultural waste and the mixture of wood shavings + agricultural waste can be considered viable alternatives as cost-effective bird bedding compared to wood shavings alone. Therefore, this study recommends their use in broiler farms.

Keywords: *Litter material, broiler, performance, carcass, blood, thermoregulation.*

INTRODUCTION

Litter refers to the bedding material used to cover the floor when rearing birds. Broiler chickens are typically raised on the floor using various types of litter material (Sharma *et al.*, 2015). At the end of the production cycle poultry litter consists of a mixture of poultry excreta, spilt feed, water, feathers, and the bedding material used in poultry operations (Koli *et al.*, 2017). The choice of litter material plays a crucial role in poultry farming, contributing to better production and lower mortality rates (Sapcota *et al.*, 2014).

The purpose of using litter on the floor is to absorb moisture from the bird's droppings, keeping the floor dry and ensuring a comfortable environment for the birds. It helps reduce the contact between birds with the floor and their droppings, enhances their welfare, and allows them to engage in normal behaviors such as soil scratching, dust bathing, and searching for food (Karamanlis *et al.*, 2008).

Poor environmental conditions prevent broilers from expressing their full genetic potential. Litter quality has a significant impact on the quality of the in-house environment (Ritz *et al.*, 2009). The importance of litter includes moisture absorption, thermal insulation, dust control, moisture and ammonia management, preventing direct contact with the floor, cushioning impacts, and incorporating excreta and feathers (Ekstrand *et al*., 1997; Youssef *et al*., 2010; Zikic *et al*., 2017). These factors enhance animal comfort and allow birds to exhibit natural behaviors such as scratching and dust bathing on bedding materials, which are crucial for their welfare.

Wood shavings are commonly used as litter in intensive broiler chicken production, especially in Egypt. However, due to high demand, this substrate often becomes difficult to obtain, leading to increased costs and reduced usage. This situation justifies the ongoing search for and evaluation of alternative materials for poultry litter. Several alternatives have already been tested, including agricultural waste and mixtures of agricultural waste and wood shavings (Huang *et al*., 2009; Davis *et al*., 2010; Garcia *et al*., 2012).

Litter quality is a significant concern in broiler production because it is closely linked to performance, health, carcass quality, and the welfare of broilers (Taherparvar *et al*., 2016). In broiler production, factors such as chick quality, feed, and water traditionally received more attention than the quality of litter materials used. However, litter quality is increasingly recognized as a key factor contributing to environmental and management problems in the commercial poultry industry (Garcês *et al*., 2013).

As an environmental factor, litter quality is crucial for maintaining the proper conditions inside poultry facilities to achieve efficient productive and reproductive performance. Therefore, litter material should possess desirable properties such as low moisture content and pH, the ability to dry quickly, being dust-free, soft and compressible, free of contaminants, absorbent, buoyant, and having thermal conductivity to act as insulation, and it should not cake (Grimes *et al*., 2002). The type of litter can affect performance of broiler birds (Billgilli *et al*., 1999). Litter type influences litter bacteria and litter consumption, which may impact the immunity and performance of broilers (Lien *et al*., 1992).

Common litter materials include rice husk, paddy straw, wood shavings, sawdust, peanut hulls, shredded sugar cane, straw, and other dry, absorbent, low-cost organic materials, and sand is also occasionally used as litter. The efficiency of a litter type can be influence by various factors such as the physical properties of the material, particle size, moisture content buildup, and rate of caking. In many areas, sawdust and wood shavings are most commonly used bedding materials for commercial poultry production. However, the higher cost, limited supply, and unavailability of these litter materials have driven the search for suitable substitutes. Good bedding materials should absorb the moisture from body wastes, limit the production of harmful pathogenic microorganisms and ammonia, and provide a dry, comfortable medium for broilers to dust themselves in and rest upon. Therefore, it should be soft, compressible, absorbent and capable of drying quickly.

Globally, the deep litter system is the most popular method for housing broiler chickens (Kryeziu *et al.,* 2018 and McGahan *et al.,* 2021). In many countries, including Egypt, wood shaving and wheat straw are the most commonly used litter materials in poultry farms. However, the availability of these materials is expected to decline due to the rapid growth in broiler production, limited natural resources, competition with other industries, the expansion of lignocellulosic-based biofuel production, the gradual banning of cage systems, and their use in animal feed (Ramadan *et al.,* 2013; Kuleile *et al.,* 2019; Monckton *et al.,* 2020 and Farghly *et al.,* 2021). Consequently, in Egypt and many other countries, there is an increasing need to explore and adopt unconventional litter materials as alternatives to wheat straw and wood shaving. Various factors are compelling broiler producers and researchers to seek alternative bedding materials for commercial poultry (Farghly *et al.,* 2015; Kuleile *et al.,* 2019; and Monckton *et al.,* 2020).

Since the type of litter can significantly affect the efficiency and performance of broiler production, this study was designed to evaluate the productive performance of broiler chickens reared on different types of litter under prevailing conditions.

The specific objective of this study is to assess the impact of various litter materials on the productive and physiological performance of broiler chickens.

The expected results of this study will be valuable for several reasons:

1. Contributing to the reduction of production costs.
2. Enhancing the value and efficiency of litter for use as fertilizer in various crops.
3. Helping to clean the environment by preventing the burning of polluting agricultural waste.
4. Providing a cost-effective option for small farm owners in the Egyptian countryside by utilizing agricultural waste as bedding for raising poultry.

MATERIALS AND METHODS

Location, experimental birds and management of the flock:

The study was conducted at the Livestock and Agricultural Development Association Station, Agricultural Administration, Shanshur, Ashmoun, Menoufia, Egypt, using 198 unsexed day-old Ross308 chicks. The chicks were purchased from a reputable commercial hatchery. The experiment lasted for 5 weeks, during which the birds were housed on the floor and provided with free access to feed and water (*ad-libitum*). All experimental diets were isocaloric and isonitrogenous, formulated to meet the strain's nutritional requirements. Diet specifications and composition analysis are given in Table (1). All birds were reared under similar managerial and hygienic conditions. Temperature and humidity were recorded daily through the experiment, ranged from 24.4 °C to 29.9 °C and 51% to 55 % as average respectively.

Experimental design and procedures:

At the start of the experiment, the birds were randomly divided into three experimental groups, with six replicates per group. The groups were based on the following three different litter materials:

T1: Wood shavings.

T2: Agricultural waste.

T3: A mixture of wood shavings and agricultural waste (50/50 ratio).

Table (1): Ingredient and nutrient composition of ration on dry basis.

Ingredient, %	Starter (1-21 days of age)	Grower (22-35 days of age)
Yellow corn	48.45	52.30
Soybean meal	37.00	31.70
Corn gluten meal	7.00	8.30
Sunflower oil	3.20	3.70
Monocalcium phosphate	1.60	1.40
Sodium chloride	0.30	0.30
Limestone	1.70	1.60
DL-methionine	0.20	0.18
Lysine	0.25	0.22
Vitamin and mineral premix[1]	0.30	0.30
Total (Kg)	100	100
Analyzed chemical composition[2]		
Crude protein %	23.00	21.50
Metabolizable energy (Kcal/kg feed)	3000	3100
Calcium %	0.96	0.87
Available phosphorus %	0.48	0.44
DL-methionine	0.56	0.51
Lysine	1.29	1.29
Methionine+ Cystine %	1.08	0.99

[1]*Provided per kilogram of diet: vitamin A, 12,500 IU; vitamin D3, 4000 IU; vitamin E, 30 IU; vitamin K, 2.3 mg; thiamine, 2.2 mg; riboflavin, 8 mg; pantothenic acid, 24.3 mg; niacin, 65 mg; pyridoxine, 4 mg; folic acid, 1.2 mg; biotin, 0.25 mg; vitamin B12, 3 mg; choline, 600 mg; iron from ferrous sulfate, 60 mg; copper from copper sulfate, 7.5 mg; manganese from manganese oxide, 125.1 mg; zinc from zinc oxide, 110 mg; iodine from ethylene diamine dihydroidide, 1.8 mg; selenium from sodium selenite, 0.35.*

[2]*Calculated chemical composition values according (N.R.C., 1994).*

Growth performance traits:

All chicks in each replicate were individually weighed weekly from 1 to 5 weeks of age. Additionally, feed intake (FI) per replicate was recorded weekly. The estimated growth performance parameters, including average body weight (BW), body weight gain (BWG), feed intake (FI), feed conversion ratio (FCR) and mortality rate were calculated for each replicate.

Slaughter test and meat chemical composition:

At the end of the experimental period (5 weeks), four birds (2 males and 2 females) were randomly selected from each replicate to assess the effect of treatments on slaughter performance. The selected birds were fasted for approximately 16 hours before being individually weighed. They were then slaughtered and fully bled, followed by feather plucking. After the removal of the head, shanks, spleen, gizzard, liver and heart, the body was weighed to determine the dressed carcass weight (including wings and neck). The weights of edible organs (heart, empty gizzard and liver), lymphoid organs (bursa of Fabricius, thymus, and spleen), and abdominal fat were recorded. The dressing percentage was calculated based on live body weight. Additionally, the moisture, crude protein, ether extract, and ash content of the breast and thigh meat were determined according to the standard methods of the Association of Official Analytical Chemists (AOAC, 1990).

Physiological traits:

a- Blood sampling and plasma chemical analysis:

Blood was sampled from 6 birds from each treatment at the end of the experiment. Blood was drawn from the jugular vein in Heparin tubes. Blood was centrifuged at 3000 rpm for 15 minutes to separate the plasma. Plasma was then collected and kept frozen at (-20°C) till analysis. Packed Cell Volume (PCV) was determined by centrifuging the capillary tubes and Hemoglobin (Hb) was determined by Cyanomethemoglobin method (Beutler, 1984). White blood cells and red blood cells were determined according to the procedure outlined by Schalm *et al.*, (1975).

Plasma total protein was determined according to Weichselbaum (1946), while albumin was measured according to Doumas (1971). Globulin values were calculated by subtracting albumin values from the corresponding total protein values. Albumin/ globulin (A/G) ratio was obtained by dividing the albumin values by globulin values. Triglycerides and total cholesterol in plasma were determined colorimetrically according to Zollner and Kirsch (1962). High density lipoprotein (HDL) was measured following the method of Siedel (1983). The plasma very low-density lipoprotein (VLDL) cholesterol was estimated using the Friedewald formula (plasma triglycerides/5) as described by Friedewald *et al.* (1972). Low-density lipoprotein (LDL) cholesterol was calculated using the Friedewald equation (LDL cholesterol = total cholesterol - HDL cholesterol - triglycerides/5) as per Friedewald *et al.* (1972). Plasma alanine and aspartate aminotransaminase (ALT and AST) activities were determined colorimetrically using the method of Retiman and Francle (1957).

b- Thermoregulation measurements:

Cloacal temperature (Tc), skin temperature (Ts) and respiration rate (RR) were measured at the end of experiment.

Statistical analysis:

Data were subjected to analysis of variance using the General Linear Models procedure of SPSS software program package **(SPSS, 2001, version 11.0).** All percentages were first transformed to arcsine being analyzed to approximate normal distribution before ANOVA. Also, significant differences among means were determined by Duncan's multiple range test **(Duncan, 1955)** at 5% level of significant. Data were analyzed by one way method using the following model:

$$Yij = u + Ni + eij$$

Where *Yij* = the observed value, *u* = population means, *Ni* = the effect of treatment, *eij* = the standard error.

RESULTS

Productive performance:

The effect of litter type material on the productive performance of broilers is summarized in Table (2). The results indicate that the main effects of litter type were insignificant on initial body weight, final body weight, weight gain, total feed intake, feed conversion ratio, and mortality rate percentage.

Carcass characteristics, immune organs weights and meat chemical composition:

The effect of litter type on the carcass characteristics of broilers is summarized in Table (3). The main effects of litter type were not significant for any carcass components. Table (4) shows that the main effects of litter type were not significant for spleen weight and thymus weight. However, litter type had a significant effect on bursa gland weight. The highest values were recorded in birds reared on wood shaving and mixture of wood shaving + agricultural waste litter, while the agricultural waste litter group recorded the lowest values.

The effect of litter type on the meat chemical composition of broiler chickens at the end of the experimental period are given in Table (5). There were no significant differences in moisture percentage

(P≤0.05), crud protein percentage (P≤0.05), ether extract percentage (P≤0.05) or ash percentage (P≤0.05) among all experimental groups.

Table (2): Shows productive performance of broiler chickens affected by the litter types at 5th weeks of age (Means ± SE).

Treatments (litter type)	Initial body weight (g)	Final body weight (g)	Body weight gain (g)	Total feed intake (g)	Feed conv. ratio (g feed/g gain)	Mortality rate %
Wood shaving	41.08[1] ±0.12	2466.48 ±9.89	2425.41 ±9.92	3870.60 ±44.77	1.60 ±0.01	Nil
Agricultural waste	41.05 ±0.11	2443.82 ±10.56	2402.77 ±10.56	3841.07 ±46.49	1.60 ±0.02	Nil
Wood shaving + agricultural waste	41.17 ±0.11	2470.91 ±11.48	2429.74 ±11.48	3886.45 ±45.05	1.60 ±0.01	Nil
ANOVA						
Litter type	n.s.	n.s.	n.s.	n.s.	n.s.	-

a-c: *within rows, values with different superscript letters differ significantly (P≤0.05),*
n.s.; no significant; [1]Mean ± SE

Table (3): Effect of litter type on carcass characteristics of broiler chickens at 5th weeks of age.

Treatments (litter type)	Live body weight (g)	Eviscerated weight (g)	Dressing (%)	Giblets (%)	Gizzard (%)	Liver (%)	Heart (%)	Abdominal fat (%)
Wood shaving	2471.25[1] ±26.67	1748.72 ±19.34	70.76 ±0.24	4.58 ±0.13	1.42 ±0.04	2.71 ±0.14	0.46 ±0.01	1.06 ±0.03
Wood shaving + agricultural waste	2474.18 ±28.71	1737.10 ±24.35	70.20 ±0.20	4.67 ±0.10	1.48 ±0.03	2.76 ±0.05	0.44 ±0.01	1.05 ±0.02
WA	2445.85 ±28.29	1715.32 ±25.97	70.12 ±0.26	4.92 ±0.10	1.42 ±0.02	3.02 ±0.05	0.47 ±0.01	1.08 ±0.02
ANOVA								
Litter type	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

a-c: *within rows, values with different superscript letters differ significantly (P≤0.05). n.s.; no significant; [1]Mean ± SE.*

Table (4): Effect of litter type on absolute immune organ weights (g) of broiler chickens at 5th weeks of age.

Treatments (litter type)	Spleen weight (g)	Bursa weight (g)	Thymus weight (g)
Wood shaving	1.92[1] ±0.07	1.82^{a} ±0.03	6.55 ±0.33
Agricultural waste	1.95 ±0.11	1.45^{b} ±0.06	6.83 ±0.15
Wood shaving + agricultural waste	2.20 ±0.07	1.85^{a} ±0.08	6.78 ±0.13
ANOVA			
Litter type	n.s.	0.004	n.s.

a-c: *within rows, values with different superscript letters differ significantly (P≤0.05). n.s.; no significant; [1]Mean ± SE*

Physiological traits:

The results of hematological parameters affected by litter type are presented in Table (6). The effect of litter type on red blood cells (RBCs), white blood cells (WBCs), packed cell volume (PCV), and hemoglobin (Hb) content in blood was significant ($P \leq 0.05$; Table 6). The highest values for RBCs, WBCs, PCV, and Hb were recorded in birds reared on wood shavings and the wood shavings + agricultural waste mixture, while the agricultural waste litter group recorded the lowest values Table (6).

Table (7) exhibits that the main effects of litter type were not significant for total cholesterol, triglycerides, high-density lipoproteins (HDL), low-density lipoproteins (LDL) and very low-density lipoproteins (VLDL).

Table (5): Effect of litter type on meat chemical composition of broiler chickens at 5th weeks of age.

Treatments (litter type)	Moisture (%)	Crud protein (%)	Ether extract (%)	Ash (%)
Wood shaving	68.05^{1} ±0.26	20.75 ±0.36	9.38 ±0.44	1.80 ±0.01
Agricultural waste	67.64 ±0.26	20.76 ±0.37	9.79 ±0.53	1.80 ±0.01
Wood shaving + agricultural waste	67.25 ±0.28	20.24 ±0.41	10.69 ±0.37	1.80 ±0.01
ANOVA				
Litter type	n.s.	n.s.	n.s.	n.s.

a-c: *within rows, values with different superscript letters differ significantly (P≤0.05).*
n.s.; no significant; ^{1}Mean ± SE

Table (6): Effect of litter type on haematological parameters of broiler chickens at 5th weeks of age.

Treatments (litter type)	RBCs ($\times 10^6$/mm^3)	WBCs ($\times 10^3$/mm^3)	PCV (%)	Hb (g/dl)
Wood shaving	2.71^{a1} ±0.05	14.35^{a} ±0.18	42.85^{a} ±0.34	14.57^{a} ±0.18
Agricultural waste	2.28^{b} ±0.11	13.77^{b} ±0.19	38.55^{b} ±1.53	12.38^{b} ±0.51
Wood shaving + agricultural waste	2.84^{a} ±0.08	14.78^{a} ±0.06	45.17^{a} ±0.81	13.72^{a} ±0.17
ANOVA				
Litter type	n.s.	0.001	n.s.	0.017

a-c: within rows, values with different superscript letters differ significantly (P≤0.05).
n.s.; no significant; ^{1}Mean ± SE

Table (7): Effect of litter type on plasma concentrations of ALT, AST, total cholesterol, triglycerides, HDL, LDL and VLDL of broiler chickens at 5th weeks of age.

Treatments (litter type)	ALT (U/L)	AST (U/L)	Total cholesterol (mg/dl)	Triglycerides (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Wood shaving	29.50^{c1} ±2.84	219.50^{b} ±4.00	134.83 ±2.91	70.50 ±6.70	67.17 ±2.86	55.40 ±3.91	12.00 ±1.38
Agricultural waste	63.00^{a} ±2.22	295.67^{a} ±19.51	135.83 ±3.87	60.00 ±6.91	64.33 ±5.14	59.50 ±7.51	14.10 ±1.34
Wood shaving + agricultural waste	51.83^{b} ±3.30	250.00^{b} ±11.26	139.50 ±3.49	66.33 ±4.21	67.00 ±3.47	59.23 ±2.72	13.27 ±0.84
ANOVA							
Litter type	0.001	0.004	n.s.	n.s.	n.s.	n.s.	n.s.

a-c: within rows, values with different superscript letters differ significantly (P≤0.05), n.s.;no significant; ^{1}Mean ± SE

However, the effect of litter type on alanine aminotransferase (ALT) and aspartate aminotransferase (AST) was significant (P≤0.05). The highest ALT and AST values were recorded in birds reared on agricultural waste litter, while the lowest values were found in the wood shavings litter group. The results presented in Table (8) indicated that the main effects of litter type were not significant for total protein, albumin, globulin and the albumin/globulin ratio.

The results presented in Table (9) show that the main effects of litter type were not significant for skin temperature (Ts). However, Table (9) indicates that the main effects of litter types on cloacal temperature (Tc) and respiration rate (RR) were significant (P≤0.05). The highest values for Tc and RR were recorded in birds reared on wood shaving litter, while the wood shaving + agriculture waste litter group recorded the lowest values.

Table (8): Effect of litter type on plasma concentrations of total protein, albumin, globulin and albumin/globulin ratio of broiler chickens at 5th weeks of age.

Treatments (litter type)	Total Protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Albumin/Globulin ratio
Wood shaving	3.53[1] ±0.10	1.75 ±0.07	1.78 ±0.05	0.98 ±0.03
Agricultural waste	3.27 ±0.13	1.86 ±0.07	1.41 ±0.16	1.41 ±0.18
Wood shaving + agricultural waste	3.45 ±0.10	1.91 ±0.05	1.54 ±0.10	1.26 ±0.09
ANOVA				
Litter type	n.s.	n.s.	n.s.	n.s.

a-c: within rows, values with different superscript letters differ significantly (P≤0.05).
n.s.; no significant; [1]Mean ± SE

Table (9): Effect of litter type on cloacal temperature (Tc), skin temperature (Ts) and respiration rate (RR) of broiler chickens at 5th weeks of age

Treatments (litter type)	Tc (ºC)	Ts (ºC)	RR (r.p.m)
Wood shaving	42.10[a] ±0.19	40.46 ±0.42	77.17[a] ±0.60
Agricultural waste	40.67[b1] ±0.27	41.00 ±0.47	73.17[b] ±0.40
Wood shaving + agricultural waste	40.22[b] ±0.32	40.70 ±0.35	70.00[c] ±0.52
ANOVA			
Litter type	0.004	n.s.	0.001

a-c: within rows, values with different superscript letters differ significantly (P≤0.05).
n.s.; no significant; [1]Mean ± SE

Economic efficiency:

Data presented in Table (10) show that all economic metrics (input and output items) for the broiler groups were influenced by the type of litter used. As expected, using agricultural waste as litter in broiler production requires a larger quantity of material (kg/m²). However, the agricultural waste type was cheaper per bird compared to other bedding materials used in this study, which positively impacted the reduction of variable costs (litter cost per bird) and the overall cost of broiler production. Notably, broiler chicks reared on agricultural waste litter and the combination of wood shavings and agricultural waste litter achieved higher economic efficiency or relative economic efficiency throughout the entire growth period.

Table (10): Economic efficiency of broiler chickens reared on different litter types.

Traits	Treatments (litter type) Wood shaving	Agricultural waste	Wood shaving + agricultural waste
Total feed intake (kg) /bird	3.87	3.84	3.89
Price of kg diet (LE)[1]	7.85	7.85	7.85
Cost of feed intake/bird (LE)	30.38	30.14	30.54
Body weight /bird (kg)	2.43	2.40	2.43
Price/ kg meat (LE)[2]	35.00	35.00	35.00
Price of market meat (LE)	85.05	84.00	85.05
Cost of litter/bird (LE)[3]	1.10	0.20	0.65
Cost of chick + management (LE)	20.00	20.00	20.00
Total production cost/bird (LE)	51.48	50.34	51.19
Net revenue (LE)	33.57	33.66	33.86
Economic efficiency	0.65	0.67	0.66
Relative economic efficiency	100.00	103.10	101.54

[1]*Based on average price of the diets during the experimental diet.*
[2]*According to the local market price at the experimental time.*
[3]*Litter cost/bird = (Price of Kg litter × Litter quantity/square meter) / Stocking density.*

DISCUSSION

Productive performance:

Statistically, no significant difference in body weight were observed among the different litter material groups. These results are consistent with the findings of Navneet *et al.* (2011), Farghly (2012) and Karousa *et al.* (2012), who reported that different litter types had no significant effect on body weight. This lack of effect may be due to factors such as species/strain differences, litter quality, and agro-climatic variations.

Similarly, no significant difference in body weight and weight gain were observed among the different litter materials. This finding aligns with reports by Atencio *et al.* (2010) and Navneet *et al.* (2012), who found no significant differences in body weight gain due to different types of litter. In contrast, Adebayo *et al.* (2009) and Chakma *et al.* (2012) reported significant differences in body weight gain among broilers using different types of litter. These variations could be attributed to species/strain differences, types of litter used, agro-climatic factors, seasons, and other variables. Additionally, litter material treatments had no significant influence on final body weight and body weight gain (Kuleile *et al.*, 2019) or on feed intake and feed conversion ratio (Ramadan and Khloya, 2017). Such results may be due to differences in the broiler strains, stoking rates, housing conditions, seasonal variations, and/or ration types.

Carcass characteristics, immune organs weights and meat chemical composition:

In the present study, the litter types did not affect relative carcass traits or immune organs except for the bursa gland. This finding is consistent with several studies indicating that relative carcass traits were not influenced by the type of litter used for broilers (Toghyani *et al.*, 2010; Farghly *et al.*, 2015). For instance, El-Deek *et al.* (2011) found that the percentages of lymphoid glands were not significantly affected by litter types. Similarly, Ramadan and El-Khloya (2017) reported no significant differences in the percentage of live body weight, heart, gizzard, spleen and bursa among birds reared on different types of litter. In contrast, Toghyani *et al.*, (2010) observed that only the gizzard percentage was significantly affected by litter type. This inconsistency in carcass traits may be attributed to variations in the physical quality of litter, such as particle size, moisture content, caking score, and other factors affecting the litter materials (Farghly, 2012).

Physiological traits:

The lower surface temperature of the wood shaving + agricultural waste litter may may contribute to an improved house environment (ambient temperature and relative humidity), which in turn significantly reduced the bird’s cloacal temperature (Tc), and respiration rate (RR), although skin temperature (Ts) was not significantly affected. These findings align with those of Gernat (2009), who reported that sand, having the lowest temperatures, positively impacted bird's body temperatures, particularly during the summer season. Additionally, Kuleile *et al.* (2019) found that birds raised on wood shavings litter experienced a gradual increase in body temperature, while those reared on sand had lower body temperatures compared to those raised on all other studied litter materials.

Regarding the effect of litter types on the blood constituents of broiler chickens, there is unfortunately no available literature on the relationship between litter type and certain blood constituents, such as ALT, AST, Hb, and WBC. In the current study, non-significant impacts of biochemical markers, including total protein, albumin, globulin, and the albumin-to-globulin ratio, were observed across the different litter types. It is believed that the increased levels of ALT, AST, and WBC may be attributed to factors such as varying stocking densities and competition among birds for feed and water. Broilers raised at higher stocking densities experience greater competition for these resources, increasing the probability of muscular injuries. This may explain the elevated levels of these two liver enzymes in the blood serum (Nobakht and Fard, 2016).

Economic efficiency:

In the present study, litter type significantly affected broiler profitability (Table 10). Notably, birds reared on agricultural waste litter and a combination of wood shavings and agricultural waste litter exhibited the highest economic efficiency values compared to those reared on wood shaving litter alone. Similarly, Farghly (2017) reported that litter type significantly influences economic efficiency. These findings are consistent with El-Sagheer *et al.* (2004), who observed that broilers raised on sand litter had the best economic efficiency values compared to those raised on wood shavings or wheat straw. Furthermore, Abdel-Hafeez *et al.* (2009) concluded that sand litter is superior to sawdust in terms of availability and cost-effectiveness.

CONCLUSION

Based on these results, the performance of birds raised on wood shavings was the best numerically in most production and physiological measurements, followed by birds raised on the mixed litter, and finally, the group raised on agricultural waste litter alone. Based on these results, agricultural waste and the mixture of wood shavings + agricultural waste can be considered viable alternatives as cost-effective bird bedding compared to wood shavings alone. Therefore, this study recommends their use in broiler farms.

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تأثير مواد الفرشة المختلفة على الأداء الإنتاجي والفسيولوجي لدجاج التسمين

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استخدم في هذه الدراسة عدد 198 كتكوت تسمين من سلالة Ross 308 عمر يوم في تجربة حقلية استمرت لمدة خمسة أسابيع؛ وذلك لدراسة تأثير أنواع من مواد الفرشة المختلفة على الأداء الإنتاجي والفسيولوجي لكتاكيت التسمين. في بداية التجربة، تم تقسيم الطيور عشوائياً إلى ثلاث مجموعات تجريبية، بواقع ست مكررات لكل مجموعة. حيث تم استخدام مواد الفرشة التالية للمجموعات الثلاث: **1)** نشارة الخشب **2)** المخلفات الزراعية و**3)** خليط بنسبة 50/50 من نشارة الخشب والمخلفات الزراعية.

أظهرت النتائج أن تأثير نوع الفرشة كان غير معنوي على وزن الجسم، ومعدل وزن الجسم المكتسب، وإجمالي كمية العلف المأكول، ومعدل التحويل الغذائي، ومعدل النفوق، ولكن لوحظ فروق رقمية بين المعاملات. ومع ذلك، كان لنوع الفرشة تأثير معنوي على وزن غدة البرسا. ولوحظت أعلى القيم في الطيور التي تمت تربيتها على نشارة الخشب ونشارة الخشب + خليط المخلفات الزراعية، بينما سجلت مجموعة المخلفات الزراعية أدنى القيم.

بالإضافة إلى ذلك، كان لنوع الفرشة تأثير معنوي على محتوى الدم من كرات الدم الحمراء وخلايا الدم البيضاء والنسبة المئوية للمواد الخلوية والهيموجلوبين؛ حيث سجلت الطيور التي تمت تربيتها على نشارة الخشب ونشارة الخشب + خليط المخلفات الزراعية أعلى القيم في قياسات الدم السابقة، وكانت أقل القيم في الطيور التي تم تربيتها على فرشة المخلفات الزراعية.

مما سبق نستنتج أن أداء الطيور التي تمت تربيتها على نشارة الخشب هو الأفضل رقمياً في معظم القياسات الإنتاجية والفسيولوجية، تليها الطيور التي تمت تربيتها على نشارة الخشب + خليط المخلفات الزراعية، وأخيراً المجموعة التي تمت تربيتها على فرشة المخلفات الزراعية وحدها؛ على الرغم من أن تربية الطيور على فرشة المخلفات الزراعية كانت الأقل في تكلفة الإنتاج والأعلى في الربح أو في الكفاءة الاقتصادية تلتها الطيور المرباه على فرشة خليط من نشارة الخشب + المخلفات الزراعية بنسبة 50 /50.

وبناءً على هذه النتائج، يمكن اعتبار المخلفات الزراعية والخليط من نشارة الخشب + المخلفات الزراعية مادة بديلة كفرشة للطيور رخيصة الثمن بالمقارنة بنشارة الخشب وحدها، ولذلك توصي هذه الدراسة باستخدامها حقلياً بشكل مثالي في مزارع دجاج التسمين.