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Research Article

Effect of Reusing Litter on Broiler Performance, Foot-Pad Dermatitis and Litter Quality in Chickens with Different Growth Rates

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Abstract

This study examined the effect of reusing litter on performance, viability and foot pad dermatitis (FPD) rates of three meat-type chicken genotypes with different growth rates and slaughter weights. Caking and manure accumulation of reused litter were also measured. A total of 780 chicks of 3 genotypes were raised in compartments (26 chickens per compartment, 11.55 chickens/m^2). Wood shavings were used as litter, with 5 compartments containing new litter and 5 containing re-used litter for each genotype. Differences in live weight, feed consumption, feed conversion ratio, viability and carcass parameters were significant among genotypes (P<0.05), but insignificant between new and used litter groups. FPD, caking and manure scores were higher on used litter. Overall findings suggest that with sufficient ventilation, litter can be reused, thereby decreasing costs of poultry production.

Keywords: *Reused litter, Wood shavings, Foot pad dermatitis, Caking score, Manure score*

Farklı Gelişme Düzeyindeki Etlik Piliçlerde Altlığın Yeniden Kullanılmasının Broiler Performansı, Foot-Pad Dermatitis ve Altlık Kalitesine Etkileri

Özet

Bu çalışma farklı gelişme hızına ve kesim ağırlığına sahip üç etlik piliç genotipinde altlığın ikinci defa kullanımının performans, yaşama gücü ve foot pad dermatitis (FPD) gibi özelliklere etkisini ortaya koymak amacıyla yürütülmüştür. Kullanılmış altlıktaki kekleşme ve gübre seviyeleri de belirlenmiştir. Her genotip grubunda 5 yeni ve 5 ikinci defa kullanılan kaba rende talaşı altlık ve 8 nipel suluk bulunan bölmelerde, 3 genotipten toplam 780 civciv olacak şekilde (26 piliç; m^2'de 11.55 piliç) deneme yürütülmüştür. Genotipler arasında canlı ağırlık, yem tüketimi, yemden yararlanma oranı ve yaşama gücü ile karkas özelliklerinde farklılıklar önemli bulunmuştur (P<0.05), buna karşılık yeni ve kullanılmış altlıkta yetiştirme bu özellikler üzerinde farklılık yaratmamıştır. FPD skorları, kekleşme skoru ve gübreleşme skorları ile altlık nem düzeyi kullanılmış altlıkta daha yüksek bulunmuştur. Elde edilen sonuçlar, yeterli havalandırma ile altlığın ikinci defa kullanmanın uygun olacağını ve altlık giderlerini azaltmada etkili olabileceğini önermiştir.

Anahtar sözcükler: *Altlığın ikinci kullanımı, Kaba rende talaşı, Foot pad dermatitis, Kekleşme skoru, Gübreleşme skoru*

INTRODUCTION

Short production periods, negative effects of the cage system on carcass characteristics and concerns over animal welfare have contributed to the increased use of litter in broiler production. Litter materials consist mainly of post-harvest plant waste, wood industry residuals and various locally available products [1]. Common litter materials that have shown good results include wood shavings [2,3]; rice hulls and ash [4-7]; soft sawdust; corncob particles, fodder and stems of legumes and poaceae, sugarcane stems and peanut shells [8,9]; exsiccated tree leaves [10]; hazelnut husks [11,12]; composted municipal garbage [13]; recycled paper chips, shredded paper and pelleted newspaper [14-16]; and inorganic soil products, pumice, clay, zeolite and sand [3,17-20]. Other alternatives developed in recent years include pelleted industrial litter composed of various disinfected materials.

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All suitable litter material must possess adequate moisture-holding capacity and no toxic or other negative effects on animal health and physical characteristics. Other important litter properties include sustainability of ventilation and resistance to 'caking', the term used to describe the sealing of the litter surface that can occur if the moisture content of the litter reaches the maximum level. Moisture content and caking are related in that high moisture levels produce caking, and caking traps water, thereby increasing moisture levels. When the water that is saturating litter is unable to escape, the poultry are raised on a continually damp, slippery and sticky surface. Caking as well as slippery surfaces can lead to foot and carcass defects [17-19,21].

Based on these requirements, wood shavings have become the most common litter material throughout the world. However, due to increases in the use of wood shavings in industry and difficulties in finding alternative litter material, litter costs have come to represent a significant part of production costs. Furthermore, litter materials now account for a significant proportion of environmental pollution in regions with intensive broiler production [18]. For these reasons, the reuse of litter, particularly in healthy flocks, is worth examining. Several studies have indicated that reusing litter could increase the quality of litter manure and help to reduce some of the environmental problems associated with litter [18,22,23].

Bird performance is affected by litter conditions, which are in turn affected by stocking density, slaughter age and weight, house climate conditions and litter enrichments. Studies have shown that ammonia production starts earlier when litter is re-used, thus increasing ventilation and heating costs; however, costs of litter as well as costs related to cleaning and changing litter are minimized in good weather conditions [23,24]. This study investigated the effects of reusing litter on broiler performance, mortality, slaughter and carcass characteristics, incidence of foot pad dermatitis and litter moisture content, manure levels and caking. A new subjective scoring method developed by the authors was used to determine caking and manure levels.

MATERIAL and METHODS

This study was conducted at the Ondokuz Mayis University, Agricultural Faculty experimental farm between February-July 2013. All procedures were approved by the Ondokuz Mayis University Animal Care and Use Ethics Committee (2009/15). Animal material consisted of 3 different genotypes, as follows: SG1: slow-growing meat production ROSSx(ROSSxRIR); SG2: slow-growing meat production ROSSx(ROSSxBAR); FG: fast-growing ROSS-308 hybrids.

Chicken were reared using a floor system with 8-cm-thick wood shavings as litter in a 20×12×2.5 m windowed, artificially lighted, ventilated house containing 8 infrared heaters. For each genotype, a total of 260 mixed male/female chicks were randomly allocated among 10 1.5×1.5 m×2 m wire-mesh compartments (n=26; 11.55 chicks per m^2) containing 1 round feeder and 8 nipple drinkers. In order to prevent litter material from escaping, the wire mesh was covered with plastic sheeting to a height of 15 cm from the compartment floor. Water and feed were provided ad libidum. Diet was formulated according to NRC [25] and purchased from a commercial mill and varied with age *(Table 1)*. Chicks were vaccinated against Newcastle disease, Gumboro disease and Infectious Bronchitis, and no health problems were observed. All chickens were slaughtered at 7 weeks of age.

Following slaughter, litter was removed from the compartments in which new litter was to be placed (5 compartments per genotype), and all compartments were cleaned, fumigated and ventilated for two days. For each genotype, 5 compartments were refilled with new litter (wood shavings to a height of 8 cm), whereas the used litter and manure in the remaining 5 compartments were dredged and redistributed. After these preparations, the house was heated, and the study was initiated under the conditions described above, with 5 new-litter compartments and 5 reused-litter compartments for each genotype.

Broiler performance traits measured included live weights, feed consumption, feed conversion ratios,

Table 1. *Nutritional content of feeds used in the study**
Tablo 1. *Çalışmada kullanılan yemlerin besin madde düzeyleri*

Nutrients	Broiler Chick Starter (1-7.days)	Broiler Chick (8-28.days)	Broiler Chicken (29-35.days)	Broiler Finisher (36 days- slaughter)
Crude Protein (%)	23.00	22.00	21.00	18.00
ME (Kcal/kg)	3000	3100	3100	3100
Crude cellulose (%)	4.00	4.00	4.00	6.00
Crude ash (%)	5.00	5.00	5.00	8.00
Ca (%)	1.00	0.95	0.80	0.80
Phosphorus (%)	0.50	0.50	0.45	0.60
Methionine (%)	1.00	0.45	0.40	0.40
Lysine (%)	1.35	1.20	1.10	1.00

*** Calculated values***

mortality rates and slaughter-carcass characteristics. Feed conversion ratios were calculated weekly based on feed consumption (measured by compartment) and chicken weight. Chickens were counted daily, and overall mortality rates were determined for each genotype. At 49 days, after reaching slaughtering weights of 2-2.5 kg, 40 SG1 and 40 SG2 chickens were slaughtered (2 male and 2 female chickens from each compartment). In addition, 40 FG chickens were slaughtered at both 42 days, the common age for this commercial genotype, and at 49 days, to facilitate comparisons among genotypes. (FG birds slaughtered at 42 days were designated as 'FG6' and 'FG7', respectively). Slaughtering weight was determined before slaughter, and cold-carcass weight was determined after storage at +4°C for 24 h. Carcasses were cut into parts according to standard methods [26], and thigh and breast weights and ratios to carcass weights were recorded.

Foot pad dermatitis (FPD) scores were measured according to Mayne [27]; as follows: 0 = No external signs of FPD; 1 = raised central pad, reticulate scales are separated, with or without small, black necrotic areas; 2 = marked swelling of the foot pad, black reticulate scales forming scale-shaped necrotic areas, with necrosis evident on less than one-quarter of the total foot pad area; 3 = marked swelling and enlargement of the entire foot pad, necrosis extending up to one-half of the total foot pad area; 4 = marked swelling and enlargement of the entire foot pad, necrotic cells covering more than one-half of the total foot pad area.

Litter moisture content was determined following slaughter of chickens at 42 and 49 days. Litter samples were collected from 3 different places in each compartment and mixed together; 100 g of this mixture was dried at 60°C for 48 h, after which moisture contents were measured [28]. Litter caking was determined visually for each compartment at the end of the study and scored as follows: 0: No caking of litter; 1: caking in less than 1/4 of litter; 2: caking in 1/4-1/3 of litter; 3: caking in 1/3-1/2 of litter; 4: caking in more than 1/2 of litter. Litter manure level was similarly determined visually for each compartment as follows: 0: No manure on the litter; 1: manure observed on less than 1/4 of litter; 2: manure on 1/ 4-1/3 of litter; 3: manure on 1/3-1/2 of litter; 4: manure on more than ½ of litter.

Factorial analysis was conducted using a completely randomized design (3 x 2 x 5), with genotype and litter type as factors on the data of performance, carcass traits and litter moisture. Data recorded as percentages were subjected to arcsine square root transformation, and real mean values were calculated and are presented in the tables. Differences among genotypes were identified using Duncan's multiple comparison test. A difference of $P<0.05$ was considered statistically significant. Kruskal-Wallis test was used to determine correlations between food pad dermatitis and litter manure and caking scores. Kruskal-Wallis results showed the effects of genotype and litter on FPD, litter manure and litter caking scores as well as litter moisture content (%) to be significant, but the interaction between genotype and litter to be insignificant; therefore, the Mann-Whitney test was used for 2-way comparisons between genotype and litter type, with results given as means, medians and standard errors of means. Kendal's Tau test was used to determine correlations between caking and manure scores and live weights.

RESULTS

Significant differences were found in live weight, feed consumption, feed conversion ratio and mortality rates among genotypes at the end of the production period ($P<0.05$; *Table 2, 3, 4*). Mortality rates were significantly lower among SG1 (1.43%) and SG2 (1.76%) than FG (3.43%) chickens ($P<0.05$).

Table 2. *Live weight of chickens, by age, genotype and litter type*
Tablo 2. *Piliçlerin yaşa, genotipe ve altlık tipine göre canlı ağırlıkları*

Traits		Age (weeks)							
		Hatch	1	2	3	4	5	6	7
Genotype	SG1	42.85b	222.96b	462.89b	668.78b	1075.79b	1531.96b	2034.27b	2429.25b
	SG2	41.11b	216.11c	450.18b	646.17b	1041.21b	1499.05b	1985.79b	2411.43b
	FG	45.23a	233.93a	518.73a	829.41a	1407.80a	2028.66a	2759.26a	3452.72a
Litter Type	New	42.88	224.57	474.22	710.02	1175.95	1687.98	2272.90	2780.17
	Used	43.24	224.09	480.31	719.55	1173.92	1685.13	2247.64	2748.78
SEM		0.358	0.903	3.277	5.757	9.032	12.802	15.752	18.937
Effects									
Genotype		**	**	**	**	**	**	**	**
Litter		NS	NS	NS	NS	NS	NS	NS	NS
Genotype x Litter		NS	NS	NS	NS	NS	NS	NS	NS

SEM: *Standard Error of Means; ** P<0.01;* ***NS:*** *Insignificant, P>0.05;* ***a. b. c:*** *According to Duncan Test, different letters in the same column indicate significant differences*

Live weight, feed consumption and feed conversion ratios did not vary significantly between chickens reared on new and used litter. Mortality rates were higher with used litter (3.77%) than new litter (2.85%), but the difference was insignificant.

The present study found some slaughter and carcass characteristics varied significantly between genotypes of different growth rates (P<0.05; *Table 5*), but not among chickens raised on new or used litter. FG chickens slaughtered at 6 weeks had higher abdominal fat contents than SG chickens slaughtered at 7 weeks. Breast ratios of FG at 6 and 7 weeks were also higher than those of SG1 and SG2 genotypes at 7 weeks. Thigh ratios of SG1, SG2 and FG at 6 weeks were similar and higher than those of FG at 7 weeks (P<0.05).

Table 6 shows the findings of this study for FPD. Significant differences in FPD scores were found between chickens of all genotypes.

Caking scores of litter in our study were found to correlate with litter moisture content, with significant differences found between caking scores of chickens related to differences in live weights among genotypes (P<0.05; *Table 7*). Caking scores also varied between new (2.77) and used (3.17) litter, but this difference was insignificant. Manure levels on litter varied significantly by genotype, with manure levels of fast-growing chickens higher (3.40 at 6 weeks and 3.80 at 7 weeks) than those of slow-growing chickens (2.05 for SG1 and 2.55 for SG2 at 7 weeks).

Table 3. *Feed consumption of chickens, by age, genotype and litter type*
Tablo 3. *Piliçlerin yaşa, genotipe ve altlık tipine göre yen tüketimleri*

Traits		Age (weeks)						
		1	2	3	4	5	6	7
Genotype	SG1	201.1a	504.9a	984.7b	1726.9b	2607.9b	3673.6b	4703.6b
	SG2	191.2b	477.6b	952.8b	1670.6b	2556.1b	3584.4b	4643.3b
	FG	207.9a	526.7a	1092.1a	2032.6a	3140.4a	4579.7a	6041.9a
Litter Type	New	199.2	495.5	992.1	1790.1	2747.4	3937.0	5148.9
	Used	200.9	511.6	1027.8	1829.9	2788.8	3954.8	5110.4
SEM		1.408	4.588	8.599	15.260	19.891	25.902	35.048
Effects								
Genotype		**	**	**	**	**	**	**
Litter		NS	NS	*	NS	NS	NS	NS
Genotype x Litter		NS	*	NS	NS	NS	NS	NS

SEM: *Standard Error of Means; * P<0.05; ** P<0.01;* ***NS:*** *Insignificant, P>0.05;* ***a.b:*** *According to Duncan Test, different letters in the same column indicate significant differences*

Table 4. *Feed conversion ratio and mortality rates, by age, genotype and litter type*
Tablo 4. *Piliçlerin yaşa, genotipe ve altlık tipine göre yemden yararlanma oranı ve ölüm oranları*

Traits		Feed Conversion Ratio (age, weeks)							Mortality (%)
		1	2	3	4	5	6	7	
Genotype	SG1	0.902a	1.089a	1.472a	1.607a	1.702a	1.807a	1.937a	1.43b
	SG2	0.885a	1.061a	1.477a	1.606a	1.705a	1.804a	1.926a	1.76b
	FG	0.888a	1.016b	1.319b	1.446b	1.548b	1.660b	1.755b	3.43a
Litter Type	New	0.887	1.045	1.407	1.536	1.637	1.745	1.870	2.85
	Used	0.897	1.065	1.439	1.570	1.666	1.769	1.875	3.77
SEM			0.008	0.011	0.010	0.010	0.009	0.010	0.012
Effects									
Genotype		NS	**	**	**	**	**	**	**
Litter		NS	NS	NS	NS	NS	NS	NS	NS
Genotype x Litter		NS	NS	NS	NS	*	NS	NS	NS

SEM: *Standard Error of Means; * P<0.05; ** P<0.01;* ***NS:*** *Insignificant, P>0.05;* ***a.b:*** *According to Duncan Test, different letters in the same column indicate significant differences*

***Table 5.** Slaughter and carcass traits of chickens*
***Tablo 5.** Piliçlerin kesim ve karkas özellikleri*

Traits		**Carcass Traits**						
		Live Weight (g)	**Carcass (g)**	**Carcass Yield (%)**	**Gizzard (g)**	**Abdominal Fat (%)**	**Thigh (%)**	**Breast (%)**
Genotype	SG1	2481.8d	1822.2d	73.38	30.24b	2.70b	27.12a	36.02b
	SG2	2637.4c	1916.6c	72.69	28.86b	3.16a	27.19a	35.27c
	FG6	2842.5b	2126.6b	73.91	32.12a	1.93d	26.63a	40.27a
	FG7	3532.7a	2644.5a	74.84	32.60a	2.41c	25.77b	40.35a
Litter Type	New	2863.9	2123.9	74.06	31.03	2.46	26.70	37.93
	Used	2883.8	2131.0	73.35	30.88	2.64	26.66	38.02
Gender	M	3185.6	2359.1	73.95	33.37	2.07	27.19	37.47
	F	2561.9	1895.8	73.46	28.54	3.04	26.18	38.48
SEM		14.810	11.820	0.318	0.329	0.050	0.105	0.134
Effects								
Genotype		**	**	NS	**	**	**	**
Litter		NS	NS	NS	NS	NS	NS	NS
Gender		**	**	NS	**	**	**	**
Genotype x Litter		NS	NS	NS	NS	NS	NS	NS
Genotype x Gender		NS	NS	NS	NS	NS	NS	NS
Litter x Gender		NS	NS	NS	NS	NS	NS	NS
Genotype x Litter x Gender		NS	NS	NS	NS	NS	NS	NS

***SEM:** Standard Error of Means; ** P<0.01; **NS:** Insignificant, P>0.05; **a.b.c.d:** According to Duncan Test, different letters in the same column indicate significant differences*

***Table 6.** FPD scores of chickens, by genotype and litter type*
***Tablo 6**. Piliçlerin , genotipe ve altlık tipine göre FPD skorları*

Genotype and Traits	**Left Foot FPD Score**		
	X±Sx	**Median**	**Min-Max**
Genotype			
SG1	2.45±0.16 b	3	0-4
SG2	1.75±0.22 c	2	0-4
FG6	2.60±0.17ab	3	0-4
FG7	2.83±0.11 a	3	0-4
Litter Type			
New	2.39±0.10a	3	0-4
Used	2.64±0.14 b	3	0-4

***a. b. c:** According to Kendal's Tau comparison test, different letters in the same column indicate significant differences*

DISCUSSION

SG1 and SG2 chickens were hatched from the eggs of slow-growing parents, so that a one-week difference in growing rates between these chickens and FG chickens was expected [25,29]. The mean final body weight of the FG group (2759.26 g) at 6 weeks was higher than that of the SG1 (2429.25 g) and SG2 (2411.43 g) groups at 7 weeks. Sarica and Cam [23] also reported no differences in live weight, feed consumption, or feed conversion ratios among chickens reared on new and second-use litter of different materials, but found mortality to be significantly lower with re-used litter. But, Cressman [30] found that live weight of chickens reared on re-used litter was 5.5% higher than the ones reared on new litter and there were not significant differences between the mortalities of chickens reared on new and used litter.

Overall carcass yields did not vary significantly among genotypes. In line with our findings, previous studies [3,12,31] reported re-use of litter did not significantly affect carcass characteristics.

FG chickens had significantly higher FPD scores than SG1 and SG2 genotypes at both 6 and 7 weeks (P<0.05). SG1 chickens also had significantly higher FPD scores than SG2 chickens, despite the similarity in live weights between these genotypes (P<0.05). FPD scores could have been affected by specific factors related to genotype, particularly live weight and growth rate. In line with our findings, a previous study examining FPD scores of chickens with different growth rates in a free-range production system found growth rate and FPD scores to be highly correlated, with scores of 0.44 and 2.35, respectively, for slow-growing and fast-growing chickens [32].

FPD scores in our study were also affected by litter reuse, with FPD scores for new litter significantly lower than those for reused litter (P<0.05). In contrast to our findings, Ruiz et al.[31] found no significant differences in FPD scores between new and used litter. Cressman [30] used FPD scores as a criterion of animal welfare and reported

Table 7. *Litter caking and manure scores and moisture ratios*
Tablo 7. *Altlık kekleşme ve gübreleşme skoru ile nem yüzdeleri*

Genotype and Traits	Caking Score			Manure Score			Moisture of Litter (%)	Effects
	X±Sx	Median	Min-Max	X±Sx	Median	Min-Max		
Genotype								
SG1	2.95±0.17bc	3.0	2.0-3.5	2.55±0.19b	2.5	2.0-3.5	22.99 A	
SG2	2.35±0.27c	2.0	1.5-4.0	2.05±0.05c	2.0	2.0-2.5	21.63 AB	
FG6	3.40±0.12c	4.0	3.0-4	3.40±0.19a	3.5	3.0-4.0	27.15 BC	
FG7	3.80±0.24ab	3.0	3.5-4.0	3.80±0.20a	3.0	3.0-4.0	31.17 C	
Litter Type								
New	2.77±0.23	3.0	1.5-4.0	2.50±0.19	2.0	2.0-4.0	24.38	Genotype **
Used	3.17±0.18	3.0	1.5-4.0	2.97±0.21	3.0	2.0-4.0	27.02	Litter **
							SEM 0.734	Gen x litter NS

a.b.c: *According to Kendal's Tau comparison test, different letters in the same column indicate significant differences;* ***SEM:*** *Standard Error of Means; ** P<0.01;* ***NS:*** *Insignificant, P>0.05;* ***A,B,C:*** *According to Duncan Test, different letters in the same column indicate significant differences*

that bird welfare was not affected by litter treatment. Litter moisture and ventilation have been found to be the most important factors affecting FPD [27,33,34]. Other factors include production system, water management and feed composition [32,35]. Yıldız et al.[19] showed that adding vermiculite to litter lowered FPD scores. Also, Garcia et al.[36] showed that FPD lesions were affected by litter material.

The differences in FPD scores found in our study could be related to differences in litter moisture content and caking levels *(Table 7)*. Litter moisture content was significantly higher for the FG chickens at 7 weeks (31.7%) than for the FG chickens at 6 weeks (27.15%) and for the SG1 and SG2 chickens at 7 weeks (22.99% and 21.63%, respectively). The high moisture levels of litter in the compartments of fast-growing chickens could be due to higher levels of feed and water consumption or because the high live weights of these chickens induce them to spend most of their time lying on the litter [32,34]. Litter moisture levels also varied significantly between new (24.38%) and used (27.02%) litter; however, in both cases, levels were within acceptable limits and were not considered to adversely affect performance [1,3,11,18,20,23].

This finding was expected, given that chickens with higher live weights produce more feces and urine. Differences in manure levels of SG1 and SG2 genotypes were also significant (P<0.05) and may be attributed to the higher live weights of the SG2 genotype. Differences in manure scores did not vary significantly between new and re-used litter.

In conclusion, the results of this study indicate that use of litter for a second time has no adverse effect on performance, viability, carcass traits, litter caking scores, litter manure scores, or litter moisture levels. However, FPD incidence increases with re-use of litter. These results suggest that the re-use of litter could be an advantage in terms of shortening the length of time between production periods and reducing litter costs, particularly in seasons when ventilation can be easily provided.

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