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ARAŞTIRMA MAKALESİ **RESEARCH PAPER**

The Effect of Depth of Rice Hulls Litter on Fattening Performance, Foot Pad Dermatitis, Meat Quality Characteristics of Broiler Chicken

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Abstract: This study was carried out to determine the effect of rice hulls used as litter in two different thicknesses (5 and 10 cm) on fattening performance, mortality rate, foot pad lesions, meat quality and meat colour characteristics of Ross 308 chickens. Rice hulls of 5 cm (T_5) and 10 cm (T_{10}) thickness were laid on the coops that were similar in size and design. Fattening performance, FCR (feed conversion ratio), mortality rate, foot pad lesions, meat quality, and meat colour characteristics were determined in three consecutive fattening periods. It was determined that the feed conversion ratios were 1.748 and 1.577 in the T_5 and T_{10} groups, respectively, and the difference was significant ($P<0.05$). There was no statistically significant difference between the two litter thickness groups in mortality rates, foot pad lesions of the chickens, meat quality characteristics and, meat colour characteristics ($P>0.05$). On the other hand, it was determined that the difference between foot pad lesion scores within the litter thickness groups was significant ($P<0.001$). As a result, although it is considered an advantage that rice hulls are cheaper than other litter varieties, it is a disadvantage that the lesion rates at Score 3 and 4 levels are high. Since there is no significant difference between the T_5 and T_{10} groups without FCR. Therefore, it may be economically beneficial to use 5 cm thick as a substrate instead of 10 cm.

Keywords: Broiler, fattening performance, foot pad dermatitis, litter thickness, rice hulls.

Etçi Piliçlerde Pirinç Kabuğu Altlık Derinliğinin Besi Performansı, Ayak Taban Yangısı ve Et Kalite Özellikleri Üzerine Etkisi

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Öz: Bu araştırma altlık olarak iki farklı kalınlıkta (5 ve 10 cm) kullanılan pirinç kabuğunun Ross 308 piliçlerinde besi performansı, mortalite oranı, ayak taban yangısı, et kalite ve et renk özellikleri üzerine etkisini belirlemek amacıyla yapılmıştır. Boyut ve dizayn olarak birbirinin benzeri iki kümesten birisine 5 cm (T_5), diğerine 10 cm (T_{10}) kalınlığında pirinç kabuğu serilmiştir. Ardışık üç besi döneminde besi performansı, FCR (yem dönüşüm oranı), mortalite oranı, ayak taban yangısı lezyonları, et kalite ve et rengi özellikleri belirlenmiştir. Yem dönüşüm oranlarının T_5 ve T_{10} gruplarında sırasıyla 1,748 ve 1,577 olduğu, aradaki farkın önemli olduğu belirlenmiştir ($P<0,05$). İki altlık kalınlığı grubu arasında ölüm oranları, piliçlerin ayak taban yangıları, et kalite özellikleri ve et rengi özellikleri arasında istatistiksel olarak önemli bir farklılık bulunmamıştır ($P>0,05$). Buna karşın altlık kalınlığı grupları içinde ayak taban yangı skorları arasındaki farkın önemli olduğu belirlenmiştir ($P<0,001$). Sonuç olarak pirinç kabuğunun diğer altlık çeşitlerinden daha ucuz olması avantaj olarak değerlendirilse bile Skor 3 ve 4 düzeyde lezyon oranlarının fazla olması dezavantajdır. T_5 ve T_{10} grupları arasında FCR dışında diğer özelliklerde önemli bir farklılık olmaması nedeniyle altlık olarak 10 cm yerine 5 cm kalınlığında kullanılması ekonomik bakımdan kazanç sağlayabilir.

Anahtar kelimeler: Altlık kalınlığı, ayak taban yangısı, besi performansı, etçi piliç, pirinç kabuğu.

INTRODUCTION

Litter is a material consisting of a mixture of feces, feed, feathers, and bedding material that is laid on the floor of the hens to prevent the broilers from coming into direct contact with the ground. The litter has many functions (Toledo et al., 2019). The duties of the litter include enabling natural behaviors such as dust bathing, helping animals to exhibit their scratching behavior, serving as an insulation material, and providing a soft and warm floor (Munir et al., 2019). For the litter to be of good quality, it should be clean, not odorless, and should not contain any toxic chemicals. For the litter to fulfill its insulation function, it must have a high moisture absorption ability, as well as a moisture release ability and a low heat permeability. Apart from all these features, being light, easy to find, and economical litter material are among the desired features (Atasoy, 2000; Shepherd et al., 2017).

If a litter material can be obtained easily and cheaply from an area, the litter is evaluated by an enterprise. For this reason, the selection of the material to be used as a litter varies from region to region (Gençoğlan, 2017; Shao et al., 2015; Shepherd et al., 2017). Wood shavings, rice hulls, straws, corn cobs, pieces of paper, and sand are widely used as litter material throughout the world (Şekeroğlu et al., 2013). Each litter type has advantages and disadvantages (Gençoğlan, 2017; Munir et al., 2019).

The advantage of sawdust is its high water absorption capacity. For this reason, it is preferred more than other substrate materials. However, with the increase in the use of sawdust in the animal industry and its preference in other areas of use, the availability of the material became more difficult and the sales price increased The use of rice hulls has become increasingly common in Turkey because it is cheap, easy to manage, and rice hulls can be mixed with pine sawdust or used alone (Shao et al., 2015; Petek et al., 2014; Toledo et al., 2019).

Another important factor affecting the performance of broilers is the thickness of the litter (Shao et al., 2015). Litter thickness varies according to the structural characteristics of the houses, climatic conditions, quality, and variety of litter material. The litter thickness to be used in broiler production is required to be 5-7 cm (Atasoy, 2000; Moesta et al., 2008; Sarıca & Erensoy, 2020). The type and thickness of the litter material can affect performance, health, and welfare conditions such as broiler nutrition, growth, meat quality, and foot diseases (Sarıca & Erensoy, 2020; Sogunle et al., 2006). Litters containing unsuitable materials such as large and sharp particles, poor quality litter type and high litter moisture are among the most important factors in the formation of pododermatitis (Shepherd et al., 2017; Kaukonen et al., 2017). As a result of pain caused by pododermatitis, walking activity, fattening performance, and meat quality of broilers are affected (Shepherd et al., 2017). There are limited studies on the effects of litter type, and thickness on fattening performance, mortality rate, foot diseases, and especially meat quality characteristics of broiler chickens. This research was carried out to determine the effects of two different litter thicknesses (5 and 10 cm) on fattening performance, mortality rate, foot pad lesions, meat quality, and meat colour characteristics.

MATERIAL AND METHOD

This research was carried out on Ross 308 broiler chickens, which were grown in two broiler chicken coops, which are similar in size and design, belonging to a private company in the Bafra district of Samsun. The research was started in February 2019, and it was applied 3 times with a 10-day break between the fattening periods in both houses. One day before the start of the work, 5 cm (T_5) and 10 cm (T_{10}) rice hulls were laid on the coops' concrete floor whose size was 145 m x 90 m (1260 m^2) and then heated. Before each broiler rearing period, litter thicknesses were checked by walking in the 'Z' shape on coops' floor. In both houses, the feeders and drinkers are in the same design, the length of the feeder and drinker per chicken is fixed, and the round type feeder is adjusted to be at least 2.5 cm, and a nipple drinker for 8-10 chickens. Feed and water were provided ad libitum. A 24-hour light application was made in the coops. Throughout the study, broiler chickens were fed with three different diets: during the initial 11 days, the diet contained 23.5% crude protein (CP) and 2850 kcal/kg metabolizable energy (ME); between days 12 and 22, the diet contained 22% CP and 2950 kcal/kg ME; finally, leading up to slaughter, the diet contained 20% CP and 3010 kcal/kg ME.

Temperature, humidity, and ventilation were automatically controlled in identical coops. The temperature of the henhouses was set to 32 ^{0}C in the first week, reduced to 24 ^{0}C at the end of the 3rd week, and continued to work at this temperature until the chickens were sent to slaughter. Ventilation rate and relative humidity were adjusted as 2 m^3/h/kg body weight and 65%, respectively, in both houses.

The feeders were filled, and the amount of feed consumed was recorded on a weekly basis, along with the daily count of chicken mortalities. According to the litter thickness group, the total weight of the chickens sent from the coops to the slaughterhouse was divided by the area of the coop and calculated as the average live weight per square meter. FCR (feed conversion ratio) was calculated for each fattening period by dividing the total amount of feed consumed by the total weight gain. Some fattening performance characteristics of the litter thickness groups are given in Table 1. On the slaughter day, an 8-hour fasting

period was applied to the chickens in both houses. Water supply was maintained until the animals were captured. The broilers were placed into crates at night, and both their transportation and slaughtering were conducted during night time

Chickens belonging to the same litter thickness group were placed in crates of 80 cm length x 45 cm width x 30 cm height at the density recommended by FAWC (1991) and then placed in transport vehicles according to the litter thickness group. Each transport vehicle travelled 125 km at a constant speed of 50 km/h on average and reached the slaughterhouse in 2 hours and 30 minutes. During the transport, the transport vehicles completed the transport without stopping, without sudden acceleration and deceleration. The broiler chickens in the transport vehicles were slaughtered after resting in the slaughterhouse for 1 hour. After the rest period, the broilers were unloaded from the crates and hung upside down on the slaughter line. Electric current was given to broilers before slaughter after they were cut by hand after blood flow was provided, they were passed through a hot water tank at 60 ^{0}C and their feathers were automatically plucked. After the internal organs were removed automatically, the carcasses were taken to the relevant sections for cooling.

120 chicken meat samples (2 litter thickness x 3 fattening periods x 20 samples) were taken from randomly selected chickens in the transport vehicles separated according to litter thickness. Meat samples were obtained from broilers in the top row and lowest row chicken collection boxes in the center of the transport vehicle, in the parts closest to the side curtain of each transport vehicle.

FPD (Foot Pad Dermatitis) Scoring: On the day of slaughter, 100 broiler chickens were selected for a fattening period of each litter thickness group, 10 broilers from 10 different parts of each coop, and the scoring of foot lesions of a total of 600 chickens was made according to the method of Welfare Quality (2009).

In this evaluation, Score 0 if there is no lesion on the sole or if it is a slight lesion, Score 1 and 2 if there is a minimal lesion on the sole, Score 3 and 4 if the lesions become necrotic and spread to the soles and even the fingers.

Meat quality analysis: *Musculus pectoralis major* was taken from the 20 carcasses for each practice. The pH of the *pectoralis major* muscle was measured 4 hours after slaughter utilizing a pH meter (Testo 205, Testo Instrument Co. Ltd., Germany) and the result was recorded as pH_{4h}. Samples of *Musculus pectoralis major* of nearly 20 g for drip loss measurement were removed. Later, the moisture on the exterior surfaces of the samples removed for this purpose was dried with a paper towel. It was weighed by a precision balance (HT-1000NH+ model, Dikomsan, Istanbul) and recorded as the initial weight ($W_{initial}$). The specimen taken was placed in a transparent bag that it would not touch the bag. It was weighed again after it was kept in the refrigerator at 4^{o}C for 24 hours. The drip loss ratio (DL) is calculated with the following formula (Çolak & Teke, 2022; Honikel, 1998): $DL\ (\%) = [(W_{initial} - W_{last}) / W_{initial}] \times 100$

Meat Colour Measurement: Minolta CR 400 device was used to measure (Konica Minolta Sensing, Inc., Osaka, Japan) the meat colour parameters (L*, a*, b*). The standards described by CIE (1976) were used in the measurements, and D65 was utilized as the light source. The machine was calibrated according to the standard white plate (Y=93.8; x=0.316; y=0.3323). Measurements were recorded from three different places of the sample. First, measurement was registered as soon as the sample was taken. Later, the specimens were kept in a refrigerator at 4^{o}C for 24 hours. Afterward, a second colour measurement was taken. The device is adjusted to take three records per command and calculate their average. The average value was accepted as the colour value of that sample.

Cooking loss analysis: The remaining part of the sample was utilized for cooking loss and texture analysis. The samples were weighed, vacuumed, and cooked in a water bath at 80^{o}C for 20 minutes. Later, the samples were removed from the bath. Their temperature was lowered under water until their internal temperature reached room temperature. Afterward, the samples were kept at 4^{o}C for 24 hours, taken out of their bags, dried with paper towels, and weighed. Cooking loss (%) was calculated as the proportion of the difference between pre-and post-cooking weights to the initial weight (Honikel 1998).

Texture analysis: Instron 3343 machine (Instron, Norwood, USA) was used for texture analysis. The samples utilized in the cooking loss were used in this analysis. Three sub-samples from each cooked sample were cut parallel to the muscle fibres with a cross-section of 1×1 cm and 2.5-3 cm length. The average value was recorded as the texture value of that sample (Honikel 1998).

Statistical Analysis: In this study, two independent samples t-test was used to compare the fattening performance characteristics, mortality rates, meat quality and colour characteristics of two different litter thicknesses. The Mann Whitney U test was used to compare the scores of foot pad lesions between two different litter thickness groups, and the Mann Whitney U test within the litter thickness groups. The chi-square test was used to compare the scores of foot pad lesions. SPSS 21.0 statistical program was used for statistical analysis.

RESULTS

Some fattening performance characteristics, mortality rates, and significance levels of the litter thickness groups are given in Table 1. Accordingly, it was determined that there was not a statistical difference between the T_5 and T_{10} groups in terms of average body weights at the end of

fattening (P>0.05). It was determined that the feed conversion ratios were 1.748 and 1.577 in the T_5 and T_{10} groups, respectively, and the difference was significant (P<0.05). On the other hand, there was no statistically significant difference between the two litter thickness groups in mortality rates (P>0.05).

The comparison of the scores of foot pad lesions between the litter thickness groups and their significance levels is given in Table 2. Accordingly, in the comparison between two different litter thickness groups, it was determined that there was no significant difference between foot pad lesions of chickens (P>0.05). On the other hand, it was determined that the difference between the foot pad lesion scores within the litter thickness groups was significant (P<0.001).

Meat quality characteristics values and significance levels of litter thickness groups were given in Table 3, and meat colour characteristics values and significance levels were given in Table 4. Accordingly, it was determined that there was no significant difference between the litter thickness groups in terms of both meat quality characteristics and meat colour characteristics (P>0.05).

Table 1. Some fattening performance characteristics, mortality rates and significance levels of litter thickness groups.

Characteristics	Thin Litter Group (T_5)	Thick Litter Group (T_{10})	Significance
Pen area (m^2)	1260	1260	
Number of chicks (bird)	20287 (±56.97)	20230 (±43.59)	ns
Average live weight (g)	2639 (±10.73)	2736 (±57.17)	ns
Total feed consumption (kg)	88683 (±187.82)	83490 (±162.58)	**
FCR (Feed conversion rate)	1.748 (±0.007)	1.577 (±0.041)	*
Mortality rate (%)	5.22 (±0.11)	4.35 (±0.16)	ns
Chicken density (bird/m^2)	16.10 (±0.05)	16.05 (±0.03)	ns
Chicken density (kg/m^2)	40.27 (±0.07)	41.02 (±0.28)	ns

*: P<0.05, **: P<0.01, ***: P<0.001

Table 2. Comparison of the scores of foot pad lesions between and within the litter thickness groups and their significance levels.

Litter Thickness Groups	Score 0 n (%)	Score 1 and 2 n (%)	Score 3 and 4 n (%)	Overall	Significance
Thin Litter Group (T_5)	3 8 (2.67)^c (1)^c	75 (25)^b	222 (74)^a	300	***
Thick Litter Group (T10)	8 (2.67)^c	96 (32)^b	196 (65.3)^a	300	***
	ns	ns	ns		

a, b, c: Score values denoted by different letters in the same row are significantly different (P<0.05).
***: P<0.001
ns: P>0.05.

Table 3. Means and standard errors (SE) for pH, drip loss, cooking loss and WarnerBratzler Shear Force (WBSF) values of *pectoralis major* muscles in T_5 ve T_{10} groups.

Characteristics	**Thin Litter** (T_5)		**Thick Litter** (T_{10})		Sig
	Mean	SE	Mean	SE	
pH_{4h}	5.89	0.20	6.00	0.01	ns
pH_{ult}	5.99	0.16	6.03	0.19	ns
Drip loss, %	1.81	0.46	1.72	0.41	ns
Cooking loss, %	17.41	0.38	17.46	0.41	ns
WBSF, kg	1.74	0.39	1.77	0.42	ns

pH_{4h}: pH measured 4 hours after slaughter
pH_{ult}: pH measured 24 hours after slaughter
T_5 : 5 cm litter thickness
T_{10}: 10 cm litter thickness
ns: P>0.05.

Table 4. Means and standard errors (SE) for meat colour characteristics of *pectoralis major* muscle in T_5 ve T_{10} groups.

Characteristics	**Thin Litter** (T_5)		**Thick Litter** (T_{10})		Sig.
	Mean	SE	Mean	SE	
Colour parameters at 0 h					
$(L^*)^{0\ h}$	49.87	0.22	50.45	0.27	ns
$(a^*)^{0\ h}$	2.24	0.09	1.95	0.09	ns
$(b^*)^{0\ h}$	4.29	0.19	4.30	0.19	ns
Colour parameters at 24 h					
$(L^*)^{24\ h}$	49.77	0.26	50.38	0.26	ns
$(a^*)^{24\ h}$	2.48	0.10	2.27	0.10	ns
$(b^*)^{24\ h}$	4.01	0.18	4.07	0.25	ns

T_5 : 5 cm litter thickness
T_{10}: 10 cm litter thickness
ns: P>0.05.

DISCUSSION

In this study, the FCR rates in the T_5 and T_{10} groups were 1,748 and 1,577, respectively. In other words, it was determined that the conversion value of feed to live weight consumed by the chickens in the T_{10} group was better than the T_5 group, and this difference was statistically significant (P<0.05). On the other hand, there was no significant difference between the T_5 and T_{10} groups in terms of mortality rate (5.22% and 4.35%) and mean body weights after fattening (2639 and 2736 g) of broilers (P>0.05).

In this study, in the comparison between T_5 and T_{10} groups, it was determined that there was no significant

difference between foot pad lesions of chickens (P>0.05), whereas the difference between foot pad lesion scores in T_5 and T_{10} litter thickness groups was significant (P<0.001). In this study, it was determined that the ratio of Score 0 was the lowest in both litter thickness groups, while the ratio of Score 3 and Score 4 was the highest. It was determined that the use of rice hulls as a litter caused an increase in foot pad lesions of chickens at Score 3 and 4 levels in general. In addition, the use of rice hulls with a thickness of 5 or 10 cm did not cause a difference between foot pad lesions.

In the study of Benabdeljelil & Ayachi (1996) in Morocco, in which 5 cm thick rice hulls were used as the litter, the mortality rate was reported as 5.3%.

Garces et al., (2017) reported that the average live weight was 1772 g, feed consumption per chicken was 3206 g, FCR ratio was 1.86, and liveability ratio was 93.2% in Cobb chickens in Mozambique, where 5 cm thick rice hulls were used as litter. In addition, in terms of footpad dermatitis, it was reported that while the rate of chickens without lesions was 78.0%, the rate of chickens with moderate lesions was 22%, and the rate of chickens with severe lesions was not.

In a study in Bangladesh (Anisuzzaman & Chowdhury, 1996), de Starbro 15 chickens, 7.5 cm thick rice hulls were used as litter, weight gain per chicken was 1634 g, feed consumption per chicken was 3353 g, FCR ratio was 2.05, livability ratio was 94.44%. Veltmann et al., (1984) reported that rice hulls had no significant negative effect on body weight, FCR rate, mortality rate, and foot pad dermatitis lesions in turkeys.

Haque & Chowdhury, (1994) reported live weight gain (1628, 1712, 1683, and 1670 g, respectively), feed consumption (4867, 4904, 5056, and 4887 g, respectively), FCR when used as litter at a depth of 2, 3, 4 or 5 cm of rice hulls. It was reported that there were no significant differences between the rate of mortality (2.98; 2.86; 3.00 and 2.92, respectively) and the liveability rates (94.44%, 94.44, 91.66 and 97.2, respectively). Brown et al., (1977) reported that body weight gain and FCR ratio were not affected by litter thickness.

In a study conducted by Huang et al., (2009) on Ross chickens in South Korea, it was reported that 5 cm thick rice hulls were used as litter, the weight gain was 1432 g, feed consumption was 2524 g, and the FCR ratio was 1.76.

Onu et al., (2011) conducted a study in Nigeria where 5 cm of rice hulls was used as a substrate and it was reported that the liveability rate was 97.5%.

Petek et al., (2014) reported that the body weight per chicken was 2589 g, the FCR rate was 1.65, the mortality rate was 2.31%, and the length of the foot pad lesions on the feet of chickens was 2.99 mm, in the study of which rice hulls was used as a litter material at a depth of 5 cm.

In the study of Ramadan & Khloya, (2017) using 5 cm rice hulls as litter in Cobb chickens in Egypt, the weight gain per chicken was 1903 g, the FCR ratio was 2.21; the mortality rate was 1.96. The mean foot pad lesion score (between 0 and 2) has been reported to be 1.50.

In the study of Sarıca & Cam, (2000) in which 10 cm deep rice hulls were used in Ross broilers, the average broiler weight at the end of fattening was 2454 g, and the FCR ratio was 2.14. The mortality rate has been reported to be 5.65%.

In a study by Angelo et al., (1997) using 5 cm thick rice hulls litter in Ross chickens in Brazil, the end-feeding weight of the broilers was 2736 g, the FCR rate was 1.91, and the mortality rate was 4.85%. The foot pad lesion score was assessed in 42-day-old chickens, and the mean score is reported as 0.82, ranging from 0 to 2.

In the study of Teke et al., (2019) in which 7 cm thick rough sawdust litter was used in Ross 308 chickens and the housing density of the chickens was 39 kg / m^2, the average live weight was 2315 g, the average feed consumption per chicken was 4073 g, the FCR ratio was 1.75 and the mortality rate has been reported to be 5.85%. In addition, it has been reported that there is a significant difference between foot pad scores in the same housing density.

In the research conducted by Kabir & Uddin, (2010) in Bangladesh, rice hulls in 3 different thicknesses 2 inches (5.08 cm), 4 inches (10.16 cm), and 6 inches (15.24 cm) were used as the substrate. Average daily live weight gain per chicken was 67, 61, and 59 g according to rice hull thickness; average daily feed consumption was 103, 88, and 93 g; average FCR was 1.54; 1.56, and 1.68. The dressing percentage was 88.82%, 88.29 and 85.05, respectively. As a result of the research, it has been reported that the production performance of broiler chickens at 6 inches (15 cm) thickness is better than other thicknesses.

In this study, it was determined that there was no significant difference (P>0.05) between the T_5 and T_{10} groups in terms of meat quality characteristics and meat colour characteristics between the litter thickness groups.

The mortality rate obtained in this study is similar to the values reported in some studies (Anisuzzaman & Chowdhury, 1996; Benabdeljelil & Ayachi, 1996; Haque & Chowdhury, 1994; Sarıca & Cam, 2000; Teke et al., 2019), differs from the values reported by some researchers (Garces et al., 2017; Onu et al., 2011; Petek et al., 2014; Ramadan & Khloya, 2017). The value found for the FCR value in this study is similar to the values reported in some studies (Garces et al., 2017; Huang et al., 2009; Petek et al., 2014; Teke et al., 2019), but different from the value

reported by others investigators. In this study, the findings for foot pad lesions are similar to the value reported by some researchers (Ramadan & Khloya, 2017; Teke et al., 2019), but different from the value reported by Kabir & Uddin, (2010) and Garces et al., (2017). The difference in mortality rate, FCR value and foot pad lesion obtained in this study may be because the number of samples used in this study was higher than in other studies, and the differences in genetic materials, housing densities, indoor humidity, temperature and ventilation values between studies.

CONCLUSION

As a result of this study, the FCR value of the T_{10} group was superior to that of the T_5 group. The utilization of rice hulls as litter led to an increase in the incidence of Score 3 and 4 lesions, namely, moderate and severe lesions, in both the T_5 and T_{10} groups. Moreover, there was no significant difference in lesion rates between the T_5 and T_{10} groups.

Although it is considered an advantage that rice hulls are cheaper than other litter varieties, it is a disadvantage that the lesion rates at Score 3 and 4 levels are high. Since there is no significant difference between the T_5 and T_{10} groups without FCR. Therefore, it may be economically beneficial to use 5 cm thick as a substrate instead of 10 cm.

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