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RESEARCH ARTICLE

Effects of Stocking Density and Litter Type on Litter Quality and Growth Performance of Broiler Chicken

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Summary

This study was conducted to investigate the effects of stocking density and litter type on growth performance of broiler chickens as well as dressing percentage and some litter quality indicators. 684 male broiler (Ross PM_3) was used for a 6 weeks period in the experiment. The day-old chicks were randomly assigned in two litter groups: Rice hulls and wood shavings. Each litter group was further divided in three stocking density (15, 19 and 23 chicks/m^2). Chicks in the each group were randomized into three replicates at hatch and they were housed in a deep litter pens (1x2 m, each) in an environmentally controlled house. The litter type and stocking density had significant effect on the final body weight of broiler ($P<0.05$, $P<0.001$), lenght of foot pad lesions of the birds ($P<0.001$, $P<0.001$), litter moisture ($P<0.01$, $P<0.05$) and litter pH contents ($P<0.05$, $P<0.05$). The results of this study suggest that greater stocking density more than 15 chicks per square meter and rice hull adversely affects live body weight of broilers and main litter quality indicators. But up to a critical point, profitability increases with increased stocking density because of the reduction of fixed cost and more kilograms production of broiler per area. Depends on the price and availability rice hull can be used as litter material instead of wood shaving.

Keywords: *Broiler, Stocking density, Litter type, Litter quality, Growth performance*

Etlik Piliçlerde Yerleşim Sıklığı ve Altlık Türünün Altlık Kalitesi ve Büyüme Performansı Üzerine Etkileri

Özet

Bu çalışma etlik piliçlerde yerleşim sıklığı ve altlık tipinin büyüme performansı, karkas randımanı ve altlık kalite parametreleri üzerine etkisini araştırmak amacı ile yapılmıştır. Çalışmada Ross PM_3 genotipi 684 adet erkek etlik civciv kullanılmış ve çalışma 6 hafta sürmüştür. Çevre kontrollü bir kümeste yer alan deneme ünitesinde; pirinç kavuzu ve odun talaşının kullanıldığı gruplar ile herbir altlık grubu üzerinde; metrekare alanda 15, 19 ve 23 adet civcivin yer aldığı (2x3=6) altı ana grup oluşturulmuş ve her ana grupta 3 tekrarlı grup yer almıştır. Altlık türü ve barındırma yoğunluğunun canlı ağırlık ($P<0.05$, $P<0.001$), ayak tabanı lezyonu ($P<0.001$, $P<0.001$), altlık rutubet ($P<0.01$, $P<0.05$) ve pH ($P<0.05$, $P<0.05$) üzerine etkisi önemli bulunmuştur. Çalışmada birim metrekare alanda onbeşten fazla hayvan sayısı ve pirinç kavuzunun canlı ağırlık ve altlık kalitesini olumsuz etkilediği sonucuna ulaşılmıştır. Ancak birim alandaki sabit masrafların azalması ve üretim miktarının artmasından dolayı kritik bir noktaya kadar yerleşim sıklığı artırılabilir. Fiyat ve elde edilme imkanlarına bağlı olarak odun talaşı yerine pirinç kabuğu da altlık olarak kullanılabilir.

Anahtar sözcükler: *Etlik piliç, Yerleşim sıklığı, Altlık tipi, Altlık kalitesi, Büyüme performansı*

INTRODUCTION

Great number of research paper about broiler stocking density and litter are focused on growth and economic performance, carcass quality and in recent period, poultry welfare. One of the major welfare concerns in broiler production is detrimental effects of high stocking density, especially in the final weeks of growing period [1,2]. Bokkers et al.[3] showed that a stocking density in large flocks exceeding 16 birds/m^2 leads to compression of birds. But the correlation between broiler welfare and stocking density are not so clear [4]. A large-scale study in Europe on broiler welfare has shown that stocking density did not affect bird behavior [5].

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One of main factor influencing litter quality in broiler production is litter or bedding material and providing high litter quality. An ideal litter material should be dry with high water absorption capacity, but should also be able to release the absorbed moisture quickly [6]. Litter material and therefore the quality of litter directly affects the performance, health, carcass quality, and welfare of poultry [7-9].

There is an important relationship between stocking density and litter quality in broiler production. Especially in high stocking density conditions litter material had been disturbed faster than low density and higher levels of litter moisture may result with some leg problems such as angle-out legs and unblemished hocks [10]. Litter quality also has a direct influence on skin condition of birds and carcass quality. In that reason controlling the environment of the birds, particularly in house humidity and ammonia along with litter moisture is crucial to provide good welfare. Litter materials with high water-holding capacity, such as wood shavings, are believed to result in better litter quality than litter materials with poorer absorption capacity such as straw [11]. Torok et al.[12] showed that litter choice may have an important role in poultry gut health particularly in the absence of in-feed antibiotics. Much attention should be given to create good growing conditions to reducing adverse effect of high stocking density [13]. This could be performed by using the most ideal litter material and more bedding material per unit area in high stocking density conditions. Additionally, the bedding or litter material must be readily available in sufficient quantities and most importantly, it must be economical [14].

Within the last several years, economic and practical conditions in Turkey have led to a shortage of wood shavings conventionally used as poultry litter. Limited supplies, higher cost, and unavailability of suitable material have encouraged the search for alternative litter materials. As a result of this effords the use of rice hull is being becoming very popular as litter material in broiler production in Turkey. But its quality and effects on performance and bird welfare is very questionable. Therefore, the objective of this study was to evaluate effects of rice hull compared to wood shavings on main litter quality indicators and growth performance in broiler production in three different stocking density conditions.

MATERIAL and METHODS

The experimental procedures conducted in this study were in accordance with the principles and guidelines set out by the Committee of the Faculty of Veterinary Medicine. 684 day-old male chicks (Ross PM_3) obtained from a commercial hatchery were reared in a deep litter pens (in total 18 pens, 1x2 m each) in an environmentally controlled house (Faculty farm) in spring season until they were six weeks old. The day-old chicks were randomly assigned in two litter type groups as rice hulls and wood shavings. Each litter groups were further divided into three stocking density (15, 19 and 23 chicks/m^2). Chicks in the each litter type x stocking density treatment groups were randomized into three replicates *(Table 1)*.

Management

All chicks were brooded and reared at 32-33 °C from hatch to 7 d of age, 28-30°C from 8 to 14 d of age, 24-26°C from 15 to 21 d of age, and 21-24°C from 22 day of age to the end of the experiment. Standard commercial broiler feed (220 g protein/kg diet and 3.000 kcal metabolisable energy/kg diet from 1 to 14 d of age, 200 g protein/kg diet and 3.050 kcal metabolisable energy/kg diet from 15 to 35 d of age, 180 g protein/kg diet and 3.100 kcal metabolisable energy /kg diet from 36 to 42 d of age) were used used for each group [15]. Starter feed was provided as crumples, and subsequent feeds were pellets. All birds had ad libitum access to feed and water. Chicks received vaccinations for Newcastle, Infectious Bronchitis and Gumboro diseases ones for each. Each pen was equipped with fresh litter material as 8 kg/m^2 (thickness of litter was 15 cm, approximately), two tube feeders and two bell drinkers. Intermittent lighting program with 2 h Light:2 h Dark was given to both treatment groups during the whole experiment, except first seven days of age. Continuous light was provided for first seven days of the 42-days of study. Feed was withdrawn eight hour before slaughter. All birds were evaluated for carcass weight by neckcutting.

Data

Individual body weight of birds in all groups are measured at the beginning and the end of the experiment. Feed consumption and mortalities were recorded as it required or occurred throughout the experiment and total consumption was measured at the end of experiment. Feed convertion ratio in replicates was calculated by total feed consumed by the birds/total weight gain. Carcass weight (dressing percentage) was determined after chilling and calculated as a percentage of live body weight of all bird in all replicate groups.

Welfare was assessed with the length of foot pad lesions (None:no lesion present; Mild:lesion<7.5 mm;

Table 1. *The bird number in each replicate in the treatment groups*
Tablo 1. *Deneme gruplarında her tekerrürde yer alan hayvan sayıları*

Treatment Groups (Litter type x stocking density, bird number/m^2)	Number of Replicate	Bird Number in Each Replicate
Rice hull x 15	3	30
Rice hull x 19	3	38
Rice hull x 23	3	46
Wood shavings x 15	3	30
Wood shavings x 19	3	38
Wood shavings x 23	3	46

Severe: lesion>7.5 mm), litter moisture and pH which are the main indicator of litter quality at the end of growth period [16,17]. All birds were scored for foot pad lesion.

Litter samples were collected from four locations within each pen (four peripheral, equidistant from each pen corner) and thoroughly mixed to obtain material representative of the entire pen. At least 200 g of litter were placed in a plastic container and a subsample was taken for further analysis at the laboratory. The litter moisture samples were collected by compositing litter from four locations in each pen, mixing, and obtaining a 100 g litter subsample was placed in 15 x 30 cm tray and oven-dried for 48 h at 60°C. The percentage of moisture was calculated by using the weight loss between initial and dried litter [18]. The upper 10 cm of the litter was collected at each sample position and transported back to the laboratory for determination of pH. The pH of each litter type was measured after litter samples of nearly 5 g were suspended for 30 min in 25 mL of distilled water and stirred for 5 min using a pH meter (Mettler Toledo, GmbH, Switzerland) [19].

Statistical Analysis

The live body weight, dressing percentage and food pad lesions were analyzed by ANOVA with three levels of stocking density and two levels litter material [20]. Multiple comparison of means was performed using the Duncan test. Arc sine transformation was performed on dressing percentage data prior to analysis and then analysed. Non-parametric Kruskall-Wallis and Mann-Whitney U tests were used for the rest of the data. All statistical tests were analyzed in SPSS® computer software 13.00 [21].

RESULTS

The effect of litter type and stocking density on the final performance of broilers are summarized in *Table 2*. The litter type and stocking density had significant effect on the final body weight of broiler (P<0.05, P<0.001). The final live weight of broiler in the wood shaving and the lowest stocking density group were found to be 2757 and 2.946 g., respectively. There were no significant differences for the feed conversion ratio (P>0.05), mortality (P>0.05) and dressing percentage (P>0.05) neither in stocking density nor litter type. It was observed no significant stocking density x litter type interactions for the traits related with the growth performance (P>0.05).

The moisture content and pH of the litter at the end of the experiment are given in *Table 3*, along with the foot pad lesions of birds in the main and interactive groups. Both of the main factors investigated in the experiment were significantly affected the foot pad lesions of the birds (P<0.001, P<0.001). Greater stocking density had a negative effect on the foot health of the broiler. Also birds raised in the rice hull litter group had a greater foot pad lesions than birds raised in the wood shaving. Litter moisture

Table 2. *Performance traits in the experimental groups*
Tablo 2. *Denemede yer alan hayvanların performans özellikleri*

Treatments	Body Weight[1] g	Feed Conversion Ratio, g/g	Mortality %	Dressing Percentage[1]*
Litter type				
Wood shaving	2757±42	1.76	2.10	77.3±0.1
Rice hull	2589±43	1.65	2.31	78.8±0.1
Stocking density (chicks/m²)				
15	2946±56[a]	1.59	1.94	77.1±0.2
19	2638±49[b]	1.71	2.01	79.2±0.1
23	2436±45[c]	1.82	2.71	77.9±0.2
Litter type x Stocking density				
W x 15	3000±79	1.59	1.66	77.1±0.3
W x 19	2748±70	1.76	1.75	77.1±0.2
W x 23	2524±64	1.92	2.89	79.4±0.3
R x 15	2891±80	1.58	2.22	79.0±0.3
R x 19	2528±68	1.65	2.19	75.5±0.2
R x 23	2347±62	1.71	2.53	80.3±0.3
ANOVA				
Litter type	0.05	n.s.	n.s.	n.s.
Stocking density	0.001	n.s.	n.s.	n.s.
Litter type x Stocking density	n.s.	n.s.	n.s.	n.s.

a-c: *within rows, values with different superscript letters differ significantly (P<0.05, P<0.001), n.s.;no significant; * As a percentage of live weight; [1] Mean ± SE*

Table 3. *Some litter quality traits and foot-pad lesions in the groups*
Tablo 3. *Gruplarda bazı altlık kalite özellikleri ve ayak tabanı lezyonları*

Treatments	Length of Foot Pad Lesion (mm)	Litter pH	Litter Moisture %
Litter type			
Wood shaving	2.19	8.52	58.16
Rice hull	2.99	8.86	57.46
Stocking density (chicks/m²)			
15	0.89[a]	8.58[a]	57.42[a]
19	2.80[b]	8.70[b]	57.89[b]
23	4.08[c]	8.76[b]	58.13[b]
Litter type x Stocking density			
W x 15	0.77	8.35	54.04
W x 19	2.18	8.55	59.75
W x 23	3.65	8.58	60.70
R x 15	1.03	8.81	55.10
R x 19	3.43	8.84	55.55
R x 23	4.52	8.93	61.75
ANOVA			
Litter type	0.001	0.01	0.05
Stocking density	0.001	0.05	0.05
Litter type x stocking density	n.s.	n.s.	n.s.

None: *no lesion present;* ***Mild:*** *lesion<7.5 mm; Severe:lesion>7.5 mm;* ***a-c:*** *within rows, values with different superscript letters differ significantly (P<0.05, P<0.01, P<0.001);* ***n.s.:*** *no significant*

content of the groups were significanly affected by litter type and stocking density (P<0.05, P<0.05). It was 58.16 and 57.42% in litter type group, 57.42, 57.89 and 58.43% in three different stocking density groups, respectively. There were significant differences for the pH value of the litter in both main groups (P<0.01, P<0.05). The pH value of wood shaving and rice hull were 8.52 and 8.86, while it were 8.58, 8.70 and 8.76 in stocking density group of 15, 19 and 23 chicks per square meter, respectively. No significant stocking density x litter type interactions were calculated for the litter quality indicators investigated in this study (P>0.05).

DISCUSSION

In comparison to rice hull group, broiler raised in wood shaving group had significantly better live body weight at the end of this experiment (P<0.05). There were no significant differences for the feed conversion ratio, mortality and dressing percentage between the main groups. In terms of performance data, our findings agreed with those of earlier studies, except the live body weight [22,23]. Numerous studies in which alternative materials have reported that the type of litter material used does not affect the broiler performance [8,24,25]. The observed differences in body weight in our study may be attributed to depression of feed intake associated with litter consumption in birds reared on the rice hull. As birds can eat some litter particle, the base material must be free of any harmful contaminants. Litter materials should also be free of other substances-including chemicals, disease organisms and moulds-that may damage the birds' health. A good litter material should be dust free not cake or compact into layers. Take into account of the growing conditions of rice hull, these adverse effects may be observed more in rice hulls than in wood shavings.

As reported by Petek et al.[13], Uzum and Oral [23], Skomorucha et al.[26] the final body weight of broiler raised in this experiment significantly worsened with increasing stocking density (P<0.001). But the total live weight in per square meter area was found to be highest in greater stocking density group. Similar with some findings [27] there were no significant differences for the feed conversion ratio and survival rates in stocking density groups at the slaughter age. As previously showed by Skrbic et al.[28] rearing of broilers in lower stocking density provides better body development, more intensive growth and higher absolute yield of processed carcass parts which contain more meat, especially in breast.

We found that foot pad lesions in broilers were increased when stocking density increased from 15 to 19 and 23 birds/m². Similar with the findings of Ferrante et al.[29] and Petek et al.[13] stocking density could have negatively affected foot pad lesions and wood shaving resulted to be the better solution for foot condition compared to

rice hull. The incidence of foot pad lesions was positively correlated with increasing humidity and pH as previously identified as main factor for foot pad dermatitis by Ekstrand et al.[30]. Moisture content of litter was significantly greater in high stocking density ($P<0.05$). As a result of this high moisture content resulted in poor litter quality. The decrease of litter quality with increasing stocking density can be explained by different effects. Petek et al.[13] and Ravindran et al.[31] reported that litter quality was poorer at high population densities, but there were no welfare implications as indicated by the lack of effect of density on gait scores and the incidence of hock and foot pad burns. The more birds in the same area mean more manure production. Also, the quality of the in-house environment is highly dependent upon the litter quality. One of the management factors affecting broiler welfare is those relating to good ventilation and air quality such as the type of ventilation, type of drinker and litter type. The type of the watering system we used (bell drinker) may be showed a negative effect on the poor litter quality and greater foot pad lesions. The wetter the litter, the more likely it will promote the proliferation of pathogenic bacteria and moulds. The litter is ideal for bacterial proliferation and wet litter is also the primary cause of high level of ammonia, one of the most serious performance and environmental factors affecting broiler production today. Controlling litter moisture is the most important step in avoiding ammonia problems [32]. To limit ammonia production, the litter pH should be below 7.0; litter moisture below 30%; and temperature at the level of the broiler's comfort demands. In this study, both of these parameters were greater than this ideal condition. In a well-managed broiler house, litter moisture averages between 25 to 35 percent [14]. Interestingly, as reported by Asaniyan et al.[33] thickness of the litter layer might be increased the foot pad lesions score in the groups as thin layers of litter resulted in lower levels of foot pad dermatitis than thicker layers probably because the chickens are less prone to peck, scratch and turn the litter particles over, and thereby help to ventilate the litter, if the layer of litter is thick and compact. Litter that is too dry and dusty can also lead to problems such as dehydration of new chicks and respiratory disease.

The water absorption capacity of wood sawing better than the rice hulls and it is required more effort to stable the litter moisture content of litter rice hull. Similar with our findings Sreehari and Sharma [34] reported that the most suitable litter type and stocking density according to net profit per kilogram body weight was wheat straw litter and 0.18 sq m./bird. Stocking density is important for better welfare quality, but it is not sufficient. The real improvements in broiler welfare will come from establish production standards that combine stocking density and good environment. As reported by Feddes et al.[35] and Jones et al.[8] the control of environment particularly good ventilation, to control temperature and humidity is a key factor in improving broiler welfare. A significant improvement in performance can be obtained by significantly lower litter moisture [36]. Because chickens spend all their life in contact with litter, therefore if litter conditions are not optimal there is a considerable risk that the birds will develop contact dermatitis on their feet and breast. In several experiments the prevalence of contact dermatitis in broilers is related to litter quality [30,37] when the litter is wet, sticky and compact, dermatitis are commonly present.

In this study, greater stocking density and litter material of rice hull were adversely affected live body weight of broilers and main litter quality indicators. But high stocking densities contribute to reduce the fixed costs of production and produce more kilograms of broiler per area. Therefore, up to a critical point, profitability increases with increased stocking density. Depends on the price and availability rice hull can be used as litter material instead of wood shaving. Also, better litter management is very crucial to provide good litter quality and broiler welfare in high stocking densities and rice hull litter condition.

REFERENCES

1. Debut M, Berri C, Arneould C, Guemene D, Sante´-Lhoutellier V, Sellier N, Baeza E, Jehl N, Jego Y, Beaumont C, LeBihan-Duval E: Behavioral and physiological responses of three chicken breeds to pre-slaughter shackling and acute heat stress. *Br Poult Sci*, 46, 527-535, 2005.

2. Jonge J, Trijp HCM: The impact of broiler production system practices on consumer perceptions of animal welfare. *Poult Sci*, 92, 3080-3095, 2013.

3. Bokkers EAM, Boer IJM, Koene P: Space needs of broilers. *Anim Welf,* 20, 623-632, 2011.

4. Kaynak I, Güneş H, Koçak Ö: Yerleşim sıklığının broiler performansına etkileri. *İstanbul Üniv Vet Fak Derg*, 36, 623-632, 2010.

5. Dawkins MS, Donnelly CA, Jones TA: Chicken welfare is influenced more by housing conditions than by stocking density. *Nature*, 427, 342-344, 2004.

6. Ritz CW, Fairchild BD, Lacy MP: Litter quality and broiler performance. Cooperative Extension Service, The University of Georgia College of Agricultural and Environmental Sciences. Publication Bulletin, 1267, 2005.

7. Thomas DG, Ravindran V, Thomas DV, Camden BJ, Cottam YH, Morel PC, Cook CJ: Influence of stocking density on the performance, carcass characteristics and selected welfare indicators of broiler chickens. *N Z Vet J*, 52, 76-81, 2004.

8. Jones TA, Donnel JA, Stamp Dawkins M: Environmental and management factors affecting of the welfare of chickens on commercial farms in the United Kingdom and Denmark stocked at five densities. *Poult Sc*i, 84, 1155-1165, 2005.

9. Şekeroğlu A, Eleroğlu H, Sarıca M, Camcı Ö: Yerde üretimde kullanılan altlık materyalleri ve altlık yönetimi. *İç Anadolu Bölgesi I. Tarım ve Gıda Kongresi Bildiri Kitapçığı*, s.29-38, Ekim 2013, Niğde, Turkey, 2013.

10. Campo JL, Prieto MT: Effects of moist litter, perches, and droppings pit on fluctuating asymmetry, tonic immobility duration, and heterophil-tolymphocyte ratio of laying hens. *Poult Sci*, 88, 708-713, 2009.

11. North MO, Bell DD: Commercial Chicken Production Manual. Fourth ed., 192-193, Chapman & Hall, New York, 1990.

12. Torok TA, Hughes RJ, Ophel-Keller K, Ali M, MacAlpine R: Influence of different litter materials on cecal microbiata colonization in broiler chickens. *Poult Sci*, 88, 2474-2481, 1999.

13. Petek M, Cibik R, Yildiz H, Sonat FA, Gezen SS, Orman A, Aydin C:

The influence of different lighting programs, stocking densities and litter amounts on the welfare and productivity traits of a commercial broiler line. *Vet Ir Zoo (Vet Med Zoot)*, 51, 36-43, 2010.

14. Butcher GD, Miles RD: Causes and prevention of wet litter in broiler houses. Publication VM99, Veterinary Medicine-Large Animal Clinical Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. (http://edis.ifas.ufl.edu), Original publication date September, 1995. Reviewed March 2011.

15. A.O.A.C.: Official methods of analysis. Arlington, VA: Kenneth Hilrich, 1996.

16. Bilgili SF, Alley MA, Hess JB, Nagaraj M: Influence of age and sex on footpad quality and yield in broiler chickens reared on low and high density diets. *J Appl Poult Res*, 15, 433-441, 2006.

17. Grandin T: Animal welfare audits for cattle, pigs, and chickens that use the HACCP principle of critical control points with animal based outcome measures. http://www.grandin.com/welfare.audit.using.haccp, updated September, 2011. http://www.grandin.com/welfare.audit.using.haccp.html, *Accessed:* 23 March 2012.

18. Willis WL, Murray C, Talbott C: Evaluation of leaves as a litter material. *Poult Sci*, 76, 1138-1140, 1997.

19. Miles DM, Owens PR, Rowe DE: Spatial variability of litter gaseous flux within a commercial broiler house: Ammonia, nitrous oxide, carbon dioxide, and methane. *Poult Sci*, 85, 167-172, 2006.

20. Snedecor GW, Cochran WG: Statistical Methods. 8th ed., The Iowa State University Press, Ames, IA, 1989.

21. Spss®: Statistical Software for Windows version 13, SPSS Inc, Headquarters, 233 s., Wacker Drive, Chicago, Illinois 60606, USA, 2004.

22. İpek A, Karabulut A, Canbolat Ö, Kalkan H: Değişik altlık materyalinin etlik piliçlerin verim özellikleri ve altlık nemi üzerine etkileri. *Uludag Üniv Zir Fak Derg,* 16, 137-147, 2002.

23. Uzum MH, Oral Toplu HD: Effects of stocking density and feed restriction on performance, carcass, meat quality characteristics and some stress parameters in broilers under heat stress. *Revue Med Vet*, 164, 546-554, 2013.

24. Brake JD, Fuller MJ, Boyle CR, Peebles ED, Latour MA: Evaluations of whole chopped kenaf and kenaf core used as a broiler litter matenal. *Poult Sci*, 72, 2079-2083, 1993.

25. Benabdeljelil K, Ayachi A: Evaluation of alternative litter materials for poultry. *J Appl Poult Res*, 5, 203-209, 1996.

26. Skomorucha I, Muchacka R, Sosnówka-Czajka E, Herbut E: Response of broiler chickens from three genetic groups to different stocking densities. *Ann Anim Sci,* 9, 175-184, 2009.

27. Abudabos AM, Samara EM, Hussein EOS, Al-Ghadi MQ, Al-Atiyat RM: Impacts of stocking density on the performance and welfare of broiler chickens. *Italian J Anim Sci*, 2, DOI: http://dx.doi.org/10.4081/ijas.2013.e11

28. Skrbic Z, Pavlovski Z, Lukic M: Stocking density-factor of production performance, quality and broiler welfare. *Biot in Anim Husb*, 25, 359-372, 2009.

29. Ferrante V, Lolli S, Marelli S, Vezzoli G, Sırrı F, Cavalchini LG: Effect of light programmes, bird densities and litter types on broilers welfare. *XII European Poultry Conference,* Verone, Italy, 10-14 September, 2006.

30. Ekstrand C, Algers B, Svedberg J: Rearing conditions and foot-pad dermatitis in Swedish broiler chickens. *Prevent Vet Med*, 31, 167-174, 1997.

31. Ravindran V, Thomas DV, Thomas DG, Morel PCH: Performance and welfare of broilers as affected by stocking density and zinc bacitracin supplementation. *Anim Sci J,* 77, 110-116, 2006.

32. Atılgan A, Coşkan A, Öz H, İşler E: Etlik piliç kümesinde kış döneminde amonyak gaz düzeyinin vakum sistemi ile azaltılması. *Kafkas Univ Vet Fak Derg,* 16, 257-262, 2010.

33. Asaniyan EK, Agbede JO, Laseinde EAO: Impact assessment of different litter depths on the performance of broiler chickens raised on sand and wood shaving litters. *World J Zoology*, 2, 67-72, 2007.

34. Sreehari S, Sharma RK: Effect of litter type and stocking density on the performance of broilers. *Indian J Poult Sci*, 45, 105-107, 2010.

35. Feddes JJ, Emmanuel EJ, Zuidhof MJ: Broiler performance, body weight variance, feed and water intake, and carcass quality at different stocking densities. *Poult Sci*, 81, 774-779, 2002.

36. Jayalakshmi T, Kumararaj R, Sivakumar T, Vanan TT, Thiagarajan D: Influence of stocking densities on litter moisture, microbial load, air ammonia concentration and broiler performance. *Tamilnadu J Vet & Anim Sci*, 5, 80-86, 2009.

37. Haslam SM, Brown SN, Wilkins LJ, Kestin PD, Warris PD, Nicol CJ: Preliminary study to examine the utility of using foot burn or hock burn to assess aspects of housing conditions for broiler chicken. *Br Poult Sci*, 47, 13-18, 2006.