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STUDIES ON SOME WELFARE ASPECTS OF BROILERS REARED UNDER DIFFERENT STOCKING DENSITIES

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ABSTRACT

Nowadays, there is much concern expressed about stocking density as it is related to the well-being and welfare of broilers, and to define some welfare aspects of broilers in an environmentally uncontrolled conventional house under two different densities, this experiment was conducted using a total number of 120 one day old Cobb broiler chicks that were randomly divided into two groups with three replicates of each in 6 floor pens (1m × 1.6 m). The first group (control) were housed at a density of 1000 cm^2/ bird (16 birds/replicate/pen) while the second group (high density HD) were housed at a density of 666.66 cm^2/ bird (24 birds/ replicate/pen). Results showed that litter quality was deteriorated ($P<0.05$) at HD group especially at the 4^{th}, 5^{th} and 6^{th} week of the growing cycle where the all quality parameter together were the worst. Additionally the incidence of the breast irritation and ammonia burns were greater at higher density group, moreover the severity was increased with limiting floor space due to worsening of the litter condition which adversely ($P<0.05$) affect both leg strength as indicated by latency to lie test (LTL) and feather condition as indicated by plumage cleanliness score.

Keywords: broiler, welfare, stocking density, leg health.

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INTRODUCTION

Global demand to poultry meat has been growing nowadays and chicken has become most famous meat consumed in the world. In Egypt the poultry industry is one of the main agricultural industries that considered as a major animal protein source supply **(Abouelenien *et al.*, 2016)** which differ from other animal production activities in high growth rate and feed efficiency utilization shown by the broilers **(Duclos *et al.*, 2007)**.

Welfare of broiler is regulated by various intrinsic and extrinsic factors such as management, stress, nutrition, stocking density, poor ventilation, light intensity, immunosuppression and exposure to disease **(Yakubu *et al.*, 2009)**. Maintaining high welfare standards results in high quality of animal products **(Sundrum, 2001)** which will reflect on the profitability, unlike it was generally assumed that any improvement in the area of animal welfare will have a negative impact on farm profitability **(Estevez, 2007).**

Litter quality with particular regard to its moisture content is identified as an important welfare issue **(Dawkins *et al.*, 2004)** having a great negative influence on feather conditions **(Shanwany, 1988)** leg health, incidence of contact dermatitis **(Haslam *et al.*, 2006 and Meluzzi *et al.*, 2008)**. Contact dermatitis is a skin condition of broilers which results in the downgrading of up to 15-30% of broiler carcasses/week **(Greene *et al.*, 1985 and Castañeda *et al.*, 2005)** and described as a brown-black coloured erosions and ulcers occur on the breast (breast blisters, "BB"), hock (hock burns, "HB") and foot skin (foot pad dermatitis, "FPD") **(Martland, 1985; Haslam *et al.*, 2007)**. Leg weakness and contact dermatitis are important broiler welfare problems indicators **(Berg, 1998; Bradshaw *et al.*, 2002 and Meluzzi *et al.*, 2008)** which can both be painful themselves, leading to other welfare problems and also having adverse effects on production because damaged feet cannot be sold and affected broilers may take longer to gain weight **(Martland, 1985)**.

In order to reduce the fixed costs of production, produce more kilograms of chickens per unit area and achieve a satisfactory economic return; producers were forced to rear broilers under high stocking densities **(Abudabos *et al.*, 2013 and Pongchan Na-Lampang, 2014)**, however, the economic profit may come at the cost of reduced bird performance and compromised health, carcass quality and welfare **(Heckert *et al.*, 2002; Feddes *et al.*, 2002; Dozier *et al.*, 2005, 2006 and Estevez, 2007)**. High stocking density (HSD) has been accused of compromising bird's welfare in several aspects including, deteriorated litter quality **(Malone, 2005 and Škrbić *et al.*, 2009[a])**, increased leg disorders and contact dermatitis **(Meluzzi *et al.*, 2008**) making the bird suffer and consequently retrogradation of welfare, so the objective of this study was to define the welfare of broiler under different stocking densities by evaluation of litter quality, feather condition, incidence and degree of HB, FPD, and BB and leg strength.

MATERIALS AND METHODS

The experiment was conducted in the poultry house of Animal and Poultry Management and Wealth Development Department at the Faculty of Veterinary Medicine Beni-Suef University, Egypt.

1.Birds' accommodation and experimental design

A total number of 120 unsexed one day old (Cobb type breed) chicks, purchased from a commercial hatchery at Beni-Suef. The chicks were randomly distributed into two groups with three replicates of each in 6 floor pens each measured 1m × 1.6 m. The first group (control) were housed at a density of 1000 cm^2/ bird (16 birds/replicate/pen) while the second group (High density HD) were housed at a density of 666.66 cm^2/ bird (27 birds/ replicate/pen).

Each group was brooded at 33ºC using electric heaters for the first week of age, then they were divided into three replicates and transferred to their pens with new wood shaving litter material to overcome the possible deteriorated air and litter quality occur during the brooding period. All birds were reared under the same environmental conditions; the ventilation was maintained using windows, fans and suction fans. Heating was performed by the electric heaters, with a decrease in the temperature 2º C each week. Lightening program was set as continuous lightening for the first week and 23 hour light and 1hour dark till the end of the experiment by regularly distributed bulbs.

Feed and water were provided adlibtum using manual plastic feeders and drinkers. A ration containing 23%protein was used through the starter period then a grower diet with 21% protein was used for the rest of the growing cycle.During the experimental period, a vaccination program was followed according to the manufacturer recommendation.

2.Data collection, sampling and measurements

2.1.Data collection and sampling

Data about litter and contact dermatitis scoring was recorded at the 6th wk of age by visual examination of litter, breast and legs of each live bird in each group.

Litter samples were collected weekly starting from the end of the 2nd wk. of the growing cycle, from five different points of each pen including whole litter depth, then were mixed together to form one representative sample that was transferred to the lab for measurement of PH and moisture content.

2.2.Parameters measured

2.2.1.Litter quality measures

2.2.1.1.Litter temperature

Litter temperature was recorded weekly using a thermometer including whole litter depth.

2.2.1.2. The litter PH measurement

10 grams of litter were agitated and suspended in 100 ml deionized water and left to rest for one hour; the reading was done in a pH-meter **Farhadi *et al.*, (2016).**

2.2.1.3. Litter moisture measurement

Ten grams of well mixed sample was transferred to reweighed empty clean Petri dish and the sample with Petri dish weighed and introduced to the hot air oven maintained at a temperature of 105 ºC for 24 hours. On cooling in a desiccator they were reweighed and the percentage of moisture of the samples were worked out with excluding the petri dish weight.

$$\textbf{Moisture \% of the litter} = \frac{\text{weight before heating in the oven} \times 100}{\text{Weight after heating}}$$

2.2.1.4.Litter score

Litter was scored visually at the end of the cycle on a scale of 1 to 5 **(Guardia *et al.*, 2011)** as following:

1 = friable, no capping or compaction whatsoever
2 = light capping, under a friable crumb surface
3 = surface capped and compacted
4 = surface wet and sticky
5 = litter depth wet and dough like.

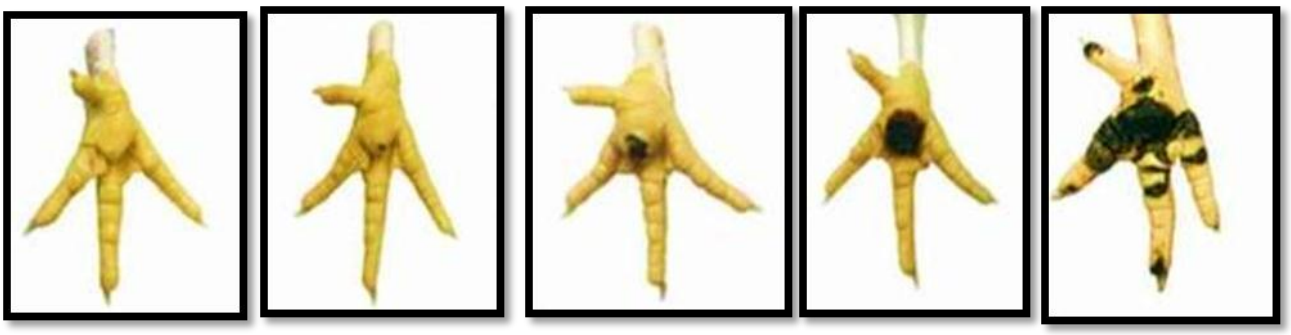
2.2.2.Plumage cleanliness

Feather condition is considered as a reflection of housing condition particularly that concerning the litter. Feather condition is evaluated using scoring scale from 0 (clean feather) to 3 (very dirty feather) according to the broiler assessment protocol **(Welfare quality ®, 2009).**

2.2.3. Measuring leg health

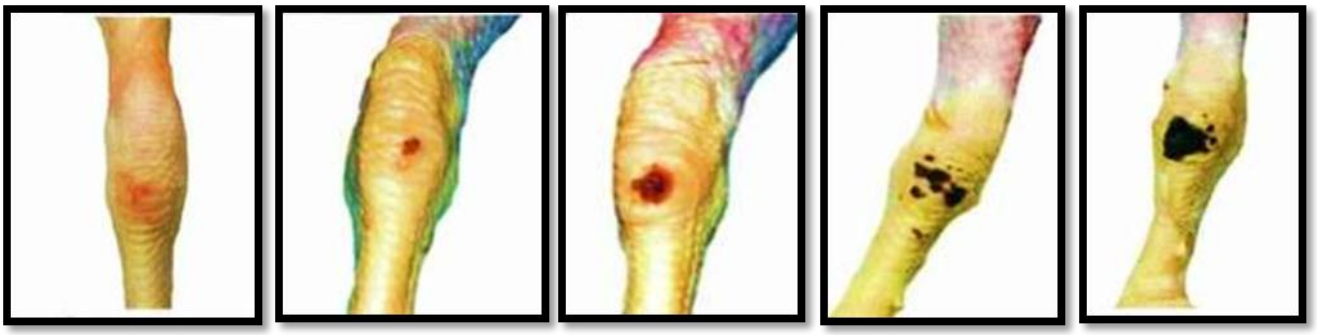
2.2.3.1.Foot pad dermatitis (FPD) and Hock burns (HB): All birds in each group were visually scored for the presence of FPD or HB lesions with regard to their severity according to **(Welfare quality ®, 2009)** as illustrated in **fig. 2. and fig 3.**

Figure 2: Illustrate FPD scoring system.



Score 0 Score 1 Score 2 Score 3 Score 4

Figure 3: Illustrate HB scoring system.



Score 0 Score 1 Score 2 Score 3 Score 4

Figure 4. illustrate BB and BI scoring system

BI BB

2.2.3.2) Leg strength

Leg strength is measured using LTL test that measures the amount of time a chicken can remain standing to avoid sitting down in shallow, lukewarm water and is correlated to the walking ability **(Berg and sanotra, 2003)**, in which 6 birds/treatment (2birds / replicate) were placed individually, without visual or physical contact with other birds, in water-filled tubs for 10 minutes (600s) test period, the amount of time a chicken can remain standing to avoid sitting down in the shallow lukewarm water was measured, additionally, the amount of time till the first attempt by the chicken to lie and number of attempts were also recorded.

2.2.4. Breast blisters (BB) and breast irritation (BI)

All birds of each group were scored as described by **(dejong et al., 2011)** and illustrated in figure 3., in which the affected birds either with BB or BI independent of the size of the lesion will be scored (1) while birds free from both affections scored (0). Then the incidence of contact dermatitis (FPD, HB oreBB) will be assessed as according to **(Gresham and Barwick, 1961):**

= No of affected birds / total number * 100

Statistical analysis

Data were presented as mean ± standard error of mean and analysed by independent T test using SPSS (Statistical Package for Social Science).probability values less than 0.05 ($P<0.05$) are considered significant.

RESULTS

Table 1: The effect of stocking density on the broiler's litter temperature, PH and moisture content throughout the growing cycle

Stocking den	Weeks of growing	Temperature (ºC)	PH (1:10)	Moisture (%)	litter score (1:5)
Control group (1000 cm^2/ bird)	Wk.2	32.03±0.15	6.18±0.09	15.44±1.01	1.00±0.00
	Wk.3	29.93±0.30	6.20±0.06	21.77±3.04	1.33±0.33
	Wk.4	29.83±0.17	6.42±0.08	24.42±1.91	2.00±0.00
	Wk.5	28.17±0.17	6.44±0.06	28.14±1.88	2.67±0.33
	Wk.6	28.47±0.26	6.47±0.01	30.50±1.09	3.33±0.33
HD group (666.66 cm^2/ bird)	Wk.2	32.43±0.23	6.40±0.06	20.17±0.48 *	1.67±0.33
	Wk.3	30.5±0.29	6.20±0.05	29.83±0.47 *	2.67±0.33*
	Wk.4	31.8±0.15*	6.95±0.03 *	35.29±1.03 *	3.67±0.33*
	Wk.5	32.13±0.19 *	7.43±0.27 *	40.40±2.18*	4.67±0.33 *
	Wk.6	33±0.29 *	7.93±0.12*	50.33±1.48 *	5.00±0.00 *

* superscripts within rows indicate significant difference at $P<0.05$. HD= high density Wk. = Week

Table 2: The contact dermatitis incidence and plumage cleanliness score of broilers reared at two different densities:

Stocking density	HB Incidence (%)	FPD Incidence (%)	BB Incidence (%)	BI Incidence (%)	Plumage cleanliness Score (0:3)
Control group	54.167 ± 4.1	58.33 ± 4.17	ND	4.17 ± 4.16	1.94 ± 0.56
HD group	97.22 ± 2.78*	88.89 ± 5.56*	ND	63.89 ± 18.22*	3.00 ± 0.00*

Control group = (1000 cm^2/ bird) HD group =(666.66 cm^2/ bird) Wk. = Week
Results are expressed as Means ± Standard Error (S.E.).
* superscripts within rows indicate significant difference at P<0.05. HD= high density
HD= High density. HB= Hock burns. FPD= Foot bad dermatitis. BB= Breast Blisters. BI=Breast irritation. ND= Non detectable.

Table 3: The severity of hock burns and Foot pad dermatitis in legs of broilers reared at two different densities:

Stocking density	HB					FPD					
	Hock burn scores (%)					Foot pad dermatitis scores (%)					
	0	1	2	3	4	0	1	2	3	4	5
Control group	0.63 ± 0.07	45.83 ± 4.17	45.83 ± 4.17	8.33 ± 4.16	0.00 ± 0.00	0.79 ± 0.15	41.67 ± 4.17	41.66 ± 4.17	12.50 ± 7.22	4.17 ± 4.17	0.00 ± 0.00
HD group	2.72 ± 0.19*	2.78 ± 2.78*	13.89 ± 2.78*	16.67 ± 4.81	41.67 ± 4.81*	1.94 ± 0.15*	11.11 ± 5.56*	25.00 ± 4.81	30.56 ± 2.78	22.22 ± 2.78*	11.11 ± 2.78*

Control group = (1000 cm^2/ bird) HD group =(666.66 cm^2/ bird)
Results are expressed as Means ± Standard Error (S.E.).
* superscripts within rows indicate significant difference at P<0.05.
HD= High density. HB= Hock burns. FPD= Foot bad dermatitis.
Fig.5.a.): The severity of incidence of HB 5.b.): The severity of incidence of HB

in control group:

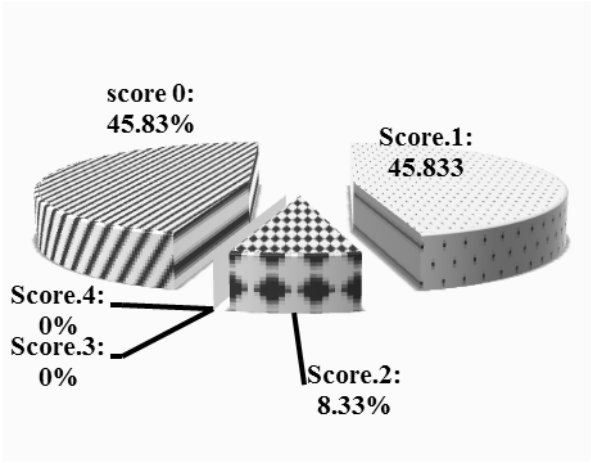


Fig.5. c.: The severity of HB in both groups:

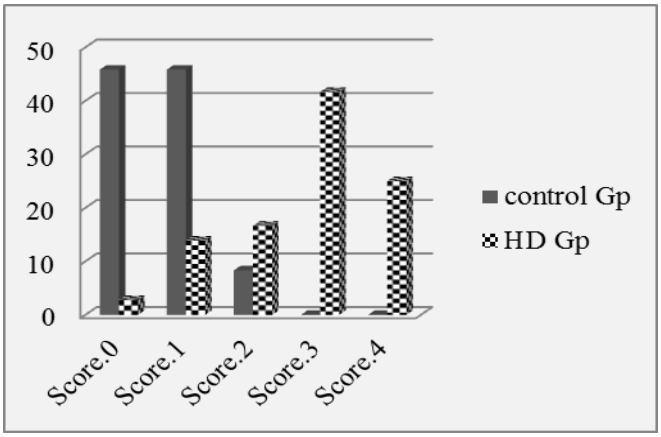
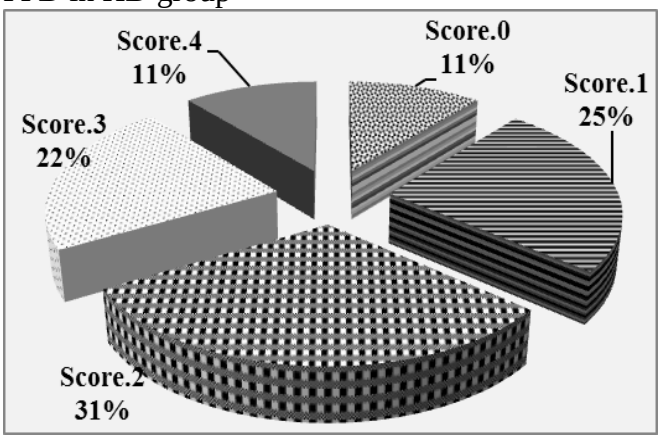


Fig 6.b: The severity of incidence of FPD in HD group



in control group:

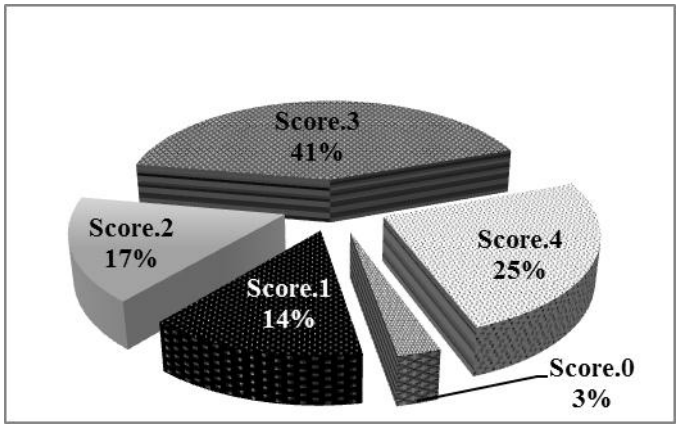


Fig 6.a: The severity of incidence of FPD in HD group

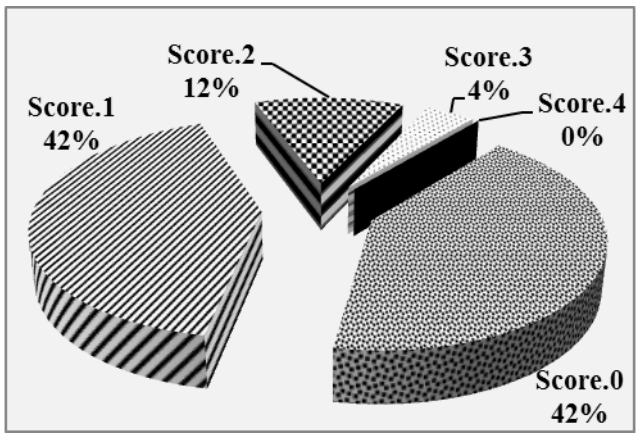


Fig 6.c: The severity of FPD in both groups

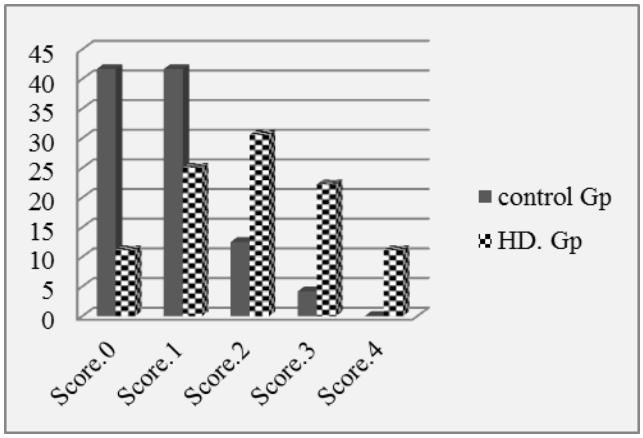


Table 4: The leg health as measured by latency to lie test, of broilers reared at two different densities:

	first attempt to lie (Sec)	number of attempts	latency to lie (Sec)
Control group (1000 cm^2/ bird)	304.38 ± 76.54	2.13 ± 0.61	502.00 ± 64.44
HD group (666.66 cm^2/ bird)	120.29 ± 33.21	5.00 ± 0.62*	259.57 ± 90.13*

Results are expressed as Means ± Standard Error (S.E.).
* superscripts within rows indicate significant difference at P<0.05.
HD=High density

DISCUSSION

Litter quality having a great importance as it is determinal to quality of the in-house environment **(Yardimci and Kenar, 2008)**, in this study it was deteriorated by increasing stocking density as illustrated in table 2. The litter temperature was significantly (P< 0.05) increased in HD group starting from the 4th week of the growing cycle till the end of the experiment, while the litter temperature was still within the recommended limit (73: 82º F) in the control group as reported by **Malone (2005)** even at the 6th wk. of the experiment. These findings were similar to those reported by **Elwinger (1995); Dozier *et al.*, (2005); Dozier *et al.*, (2006) Mendes *et al.*, (2004); Škrbić *et al.*, (2009[b]) and Lolli *et al.*, (2010).** The reason of the rise in litter temperature with increasing stocking density was due to the accumulation of droppings that increase the bacterial fermentation in the litter and increase temperature **(Reiter and Bessei, 2001; Yadgari *et al.*, 2006)**.

litter PH is also determinal for litter quality as increasing litter PH lead to more bacterial population, fermentation and ammonia volatilization **(Malone 2005)** which will have an adverse effect on broiler welfare and leg health by increasing FPD incidence which is linked to ammonia content of litter **(Algers and Svedberg, 1989; Meluzzi *et al.*, 2008 and Haslam *et al.*, 2006)**. Results of the current study revealed a significant (P<0.05) increase in litter PH with decreasing floor space starting at the 4th and continued for the 5th and 6th wk. of the growing cycle. This disagree with findings of **Meluzzi *et al.*, (2008), Zhang *et al.*, (2011) and Farhadi *et al.*, (2016)** who found no significant effect of stocking density on litter PH.

The litter moisture content is considered as an important welfare issue that having greatest negative impact on birds health and production **(Dawkins *et al.*, 2004),** it was significantly (P<0.05) higher from the beginning of experiment in HD group. but started to exceed the threshold percent, 35% as recommended by **The National Chicken Council Welfare Guidelines (2003)**, at the 5th wk. (40.40 ± 2.18 %) and 6th wk. (50.33 ±1.48%) while the moisture content of the litter in the other (control) group was still within the recommendations. this is in accordance with other studies done by **Mendes *et al.*, (2004); Shivakumar et al., (2004); Thomas *et al.*, (2004); Dozier *et al.*, (2005); Malone (2005); Dozier et al., (2006); Jayalakshmi et.al., (2009) and Škrbić *et al.*, (2009)[b]** and disagree with **Farhadi *et al.*, (2016)** who found that stocking density had no significant effect on litter moisture content even at a (22 bird/ m^2).

Finally, The litter score is corresponding to the wetness and compactness of the litter which in turn a result of high moisture content, in this study litter score was generally higher in HD group and significantly (P< 0.05) differed starting from the 3rd wk. while the 5th and 6th weeks had the worst scores, this is more or less similar to the

findings of **Guardia *et al.*, (2011)** who found higher litter score ($P < 0.01$) at high density group.

Contact dermatitis was reported to be increased at HSD (**Proudfoot *et al.*, 1979; Greene *et al.*, 1985; McIlroy *et al.*, 1987 and Bessei, 2006)** due to moist litter **(Weaver and Meijerhof, 1991; Ekstrand, 1993; Ekstrand *et al.*, 1997; kstrand and Carpenter, 1998; Dawkins *et al.*, 2004; Jones *et al.*, 2005; Haslam et al., 2006; Yardimci and Kenar, 2008 Meluzzi *et al.*, 2008)** or due to ammonia in the litter **(Cravener *et al.*, 1992)**. This agrees with the findings that were described in table 2 which showed a significant ($p< 0.05$) increase in the incidence of FPD, HB and BI in HD group. Regarding the FPD, about 88.89±5.56% of the birds were affected with increasing stocking density, while the percent of affected birds in the control group was significantly ($p< 0.05$) lower (8.33±4.7%), this is similar to previous results reported by **Lewis and Hurnik (1990); Bessie and Reiter (1992); Cravener *et al.*, (1992) Sørensen *et al.*, (2000) and Meluzzi *et al.*, (2004).**

Also similar results announced by **Ventura *et al.*, (2010)** who found that pens with lower densities contained a higher proportion of birds with healthier feet and added that birds housed at a density of 8 birds /m^2 were less affected with footpad dermatitis than those kept at 13birds/m^2. Moreover, they found that the detrimental effect of high density was especially pronounced at 18 birds/ m^2.

The data in the present study disagree with **Martrenchar et al. (2002), Sirri *et al.*, (2007) and Farhadi *et al.*, (2016)** who did not find any influence of stocking density on the prevalence of foot pad dermatitis. Similarly**, Haslam *et al.*, (2006)** failed to detect the effect of stocking density on FPD at least not up to 14 birds /m^2. Additionally **Algers and Svedberg (1989)** and **Meluzzi *et al.*, (2008)** found that the incidence of dermatitis varies with humidity of the litter and ammonia concentration but not with stocking density as such. The results seem to support the view that stocking density per se is less important to bird welfare than litter characteristics.

As well, increasing stocking result in a significant ($P< 0.05$) increase in HB incidence in HD group as compared by control group, this could be due to low activity levels of the bird **(Haslam *et al.*, 2006)** or poor litter condition, regarding to friability and moisture **(Tucker and Walker, 1992; Dawkins *et al.*, 2004, Malone 2005)** which both were achieved as stocking density increased, this was optimized by the nature of broiler chickens who spend most of the time lying down on the litter due to their increased live weight as they age **(Kjaer *et al.*, 2006)**. Similar results are documented by **Martland (1985), Malone and Martin (1997), Berg (1998) and Dozier et al. (2006)**. Similarly **Ventura *et al.*, (2010)** reported a 50% incidence among birds reared under HSD as compared with 30% incidence of HB in lower density group. On the other hand, studies done by **Melluzi *et al.*, (2008) and Farhadi *et al.*, (2016)** failed to found a relation between the stocking density and incidence of HB.

BB is another type of contact dermatitis that was investigated in this study; table 2 showed that it wasn't detected in both groups, these findings disagree with **proudfoot *et al.*, (1979) and Sørensen and Kestin (2000)** who announced that increasing stocking density lead to increasing the incidence of BB. While, agree with **Mayes, (1980)** who reported that stocking density did not affect the incidence of BB, even when it exceeded 19 birds/ m^2. On the contrary, a study by **Zhao *et al.*, 2009** reported a significant increase in the incidence of BB when the stocking density was 17 birds/ m^2 but not when the density increased from 11 to 14 birds/ m^2. Additionally, **Cravener *et al.*, 1992** found a higher percentage of breast blisters in birds housed at density of 0.05 m^2 /bird than at other densities, while no significant differences between other densities (0.07, 0.09 and 0.11 m2/ bird).

In this study BI was observed and its incidence showed a significant ($P<0.05$) increase in HD group as compared with control group, this run with the concept of **Dejong *et al.*, (2011)** who declared that it was hard to detect BB**.**

Birds use their feathers to keep warm and to protect them from moisture, dirt and skin infection. Clean and healthy birds spend a lot of time keeping their feathers preened and if their

feathers become wet or soiled with litter (bedding), feces and dirt, the feathers con lose their protective properties and so severe feather soiling have significant effects on bird welfare **(Welfare quality ®, 2009),** in this study birds at HSD show significantly (P<0.05) poorer plumage cleanliness score as compared with control group as illustrated in table 2. Similar results obtained by **Shanwany (1988)** who announced that birds at high densities they exhibited a rough and soiled plumage due to damp and packed litter.

Regarding the severity of HB and FPD lesions, results revealed that there was a tendency for increased severity of hock and foot lesions with increasing density as in table 3 and figure 5&6. The average score of HB and FPD were significantly (P<0.05) increased with density. Additionally, the tendency of hocks to be affected with higher scores (score 3 and score 4) was significantly (P<0.05) increased at HD group as compared with other group in which the affection was 0%. The affected foots showed a similar significant (P<0.05) increase in the lesion severity in HD group where the incidence of score 3 was only 4.17±4.17 and score 4 was 0%. Similar results obtained by **Škrbić *et al.*, (2009[a])** who declared an increase of the frequency of poor scores hock burns and foot pad lesions with the increase of stocking density from 10 to 16 birds/m^2.

Also **Ventura *et al.*, (2010)** found that the severity of HB and FP lesions were increased with increasing density from 8 to 13 bird / m^2 and added that this effect of high density was especially pronounced at 18 birds /m^2. Moreover, **Dozier *et al.*, (2005)** found that increasing stocking density also altered foot pad scores . While **Buijs *et al.*, (2009)** found the significant worsening effect of increasing density on HB and FPD scores only with density of 56 kg/ m2 (22 birds/m2), this was probably due to frequent litter exchange in this study. Similarly. The increased severity of the HB and FP lesions may be a reflection of the poor litter quality associated with high stocking density **(Dozier *et al.*, 2005).**

Latency to lie test (LTL) is used in the current study to evaluate the leg strength as a welfare indicator, results in table 4 demonstrated that leg strength was significantly decreased (P<0.05) by increasing stocking density in term of shorter time till first attempt is done by the bird to lie, increased numbers of lying attempts and finally shorter latency to lie duration in HD and control . These findings support the findings of **Buijs *et al.*, (2009)** who found a decrease in leg strength with increasing density causing a decrease in LTL duration. Similarly, other studies done by **(Sørensen *et al.*, 2000 and Sanotra *et al.*, 2001)** mentioned that High rearing densities in broilers are associated with an increased incidence of leg problems which may be related to the reduced level of activity observed with increasing housing densities **(Estevez, *et al.*, 1997).**

CONCLUSION

Limiting floor space from 1000cm^2/bird to 666.66cm^2/bird can lead to deterioration of litter quality in the term of increased litter temperature, PH & moisture content and also poor scores of the litter. This has a direct impact on leg health by increasing the incidence and severity of contact dermatitis and shorter LTL duration that reflect decreased leg strength. Additionally the decreased litter quality with regard to its moisture, compactness can lead to poor feather condition. All these consequences will have an adverse effect on the welfare of broilers housed under higher stocking density in an environmentally uncontrolled house.

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