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EFFECT OF STOCKING DENSITY IN BROILER HOUSING ON AIR QUALITY AND FEED INTAKE

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ABSTRACT

The ultimate target of poultry producers is to maximize the kilograms produced per m^2 of space; thus they may increase the number of birds per m^2 irrespective to air quality that may affect the broilers feed intake. The experiment was conducted to evaluate the effect of two different stocking densities on food consumption and air quality including air temperature, Relative Humidity, Co_2 and ammonia emission levels. A total 120 one day old Cobb broiler chicks were housed at two different densities 10 bird /m^2 as normal stocking density (control group) and 15 bird/m^2as high stocking density (HSD group) from 1 to 42 days. The pen measured 4.8m×1m, and divided by two partitions to accommodate three replicates in each treatment. The feed intake was measured daily and calculated as weekly feed intake, additionally air quality parameters were measured daily at 8:00 to 9:00am and 3:00 to 4:00 pm. Results showed 3.89% increase in feed consumption ($p<0.001$) at wk2 in high density group and this increase continued to the Wk3 (0.92%) of age but without any significance, on the contrary, the feed intake was significantly decreased ($P<0.05$) with increasing density in the 4^{th}, 5^{th} and 6^{th} Wk. of the growing cycle. However, the cumulative feed intake wasn't significantly affected inspite of 1.31% decrease in high density group. The air quality was deteriorated with increasing density and increased Co_2 and Ammonia levels in the microclimate surrounding the birds.

Keywords: stocking density, air quality, feed consumption.

INTRODUCTION

Broiler farming industry has been recognized as a profitable enterprise due to rapid growth rate, high carcass yield **(Meluzzi and Sirri, 2009)**. Moreover, it has a relative advantage of easy management, quick returns to capital investment, higher turnover, and more acceptable product for human consumption when compared to beef industry **(Haruna and Hamidu, 2004 and Beg et al., 2011)**. In Egypt the poultry industry is one of the main agricultural industries. It supplies a great part of the country's animal protein **(Ibrahim, 2017).**The rearing factors including stocking density, light regimen, litter characteristic and air quality (ammonia, carbon dioxide, temperature, humidity and dust) affect the welfare and health condition of birds **(Meluzzi And Sirri, 2009).** Among these factor, stocking density and air quality are the most affecting the bird performance **(Feddes et al., 2002)**.

Broilers release a lot of harmful substances in their metabolisms and activities such as CO2, NH3, CH4, H2S and dust **(Tegethoff and Hartung, 1996 and Osorio et al., 2009)**. These gases in combination with other environmental conditions including temperature and relative humidity, which cannot be controlled, may cause different levels of stress in broilers affecting bird health, performance and welfare **(Turkyilmaz, 2008 and Wang et al., 2014).**

Stocking density (SD) is a term that indicates the number of birds per unit area or body mass per unit area (**Fairchild, 2005 and Thaxton et al., 2006).** Getting the stocking density right is important to the farmer to ensure proper return on his investment, to the integrator to meet its production targets and, to the chickens themselves, to ensure their comfort and physical well-being **(Richard, 2005).** There is a wide range of variables that must be considered in order to determine the 'ideal' highest density which will maximize productivity while maintaining adequate welfare, such variables are: housing conditions, available equipment, litter management, season of the year, location, etc **(Estevez, 2005).**

High stocking density (HSD) seems to be a critical problem linked to decreased performance **(Feddes et al., 2002)** and deteriorated air quality in the form of increase in temperature, humidity, Co2 and ammonia levels **(Yardimci and Kenar, 2008)** leading to polluted air in the broiler house and causing harmful exposure to both the livestock and human carers **(Zhang et al., 2011)**. Therefore, Monitoring the environmental conditions becomes a critical need; so in recent years, poultry producers and integrators have made many improvements to make more control on the house environmental conditions making them more comfortable for broilers and enable the improved house to accommodate more birds with no loss in welfare **(Yardimci and Kenar, 2008)**, on the other hand, increasing stocking density in conventional uncontrolled environment house considered as a great challenge in which stocking density for rearing broilers is shouldn't exceed 10-11birds/m^2 (**Ibrahim, 2017).**

The aim of this study was to investigate the effect of increasing the stocking density from 10 to 15 birds / m^2 in conventional uncontrolled environment house on the feed intake and quality of microclimate of the bird inside the house.

MATERIAL 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.

Birds' accommodation 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 divided randomly into two groups. The first group (control), the birds were reared 10 bird / m^2 (48 bird/pen), while the second group (HSD) the birds were 15 birds/ m^2 (74bird/pen) in the same floor area which was 4.8 m^2.

Each group was brooded at 33ºC using electric heaters for the first week of age, then they were transferred and the litter was changed with a new wood shaving litter material to overcome the possible deteriorated air and litter quality during the brooding period. Then the birds were divided into three replicates for each group and 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 2 ºC 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 ad-libitum 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

Measurements

Feed intake (FI)

The diets were offered daily at fixed time in the morning, then the feed intake was calculated according to **Beg et al., (2011)** by difference between the amount offered and the amount remained as following

Daily FI/ bird= amount of feed offered- amount of feed remained

Then the feed intake was calculated as weekly feed intake per bird as following

Weekly FI/bird= the sum of feed consumed throughout the week/number of birds

Air quality measures

The temperature and relative humidity was measured using digital thermo hygrometer. Co_2 was measured using digital Co_2 monitor, Ammonia was measured using Hydrion -Ammonia Test Paper®. This was done twice daily at 8:00am to 9:00am and at 3:00 to 4:00 pm.

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 different stocking density on the weekly feed intake of broilers:

Treatments:	Weekly FI/bird (gm)					Cumulative FI (2nd to 6th wk.) (gm)
	2nd wk.	3rd wk.	4th wk.	5th wk.	6th wk.	
10 birds/m^2	297.81 ± 0.81	603.42 ± 3.61	818.08 ± 3.18 *	955.75 ± 1.91 *	1096.25 ± 5.07 *	3771.32 ± 12.77
15 birds/m^2	309.37 ± 0.69**	609.02 ± 3.74	800.26 ± 4.62	928.70 ± 8.30	1074.58 ± 3.01	3721.93 ± 19.61
P- value	<0.001	Ns	<0.05	<0.05	<0.05	Ns

Results are expressed as Means ± Standard Error (S.E.).

Figure (1): The cumulative feed intake per bird (gm):

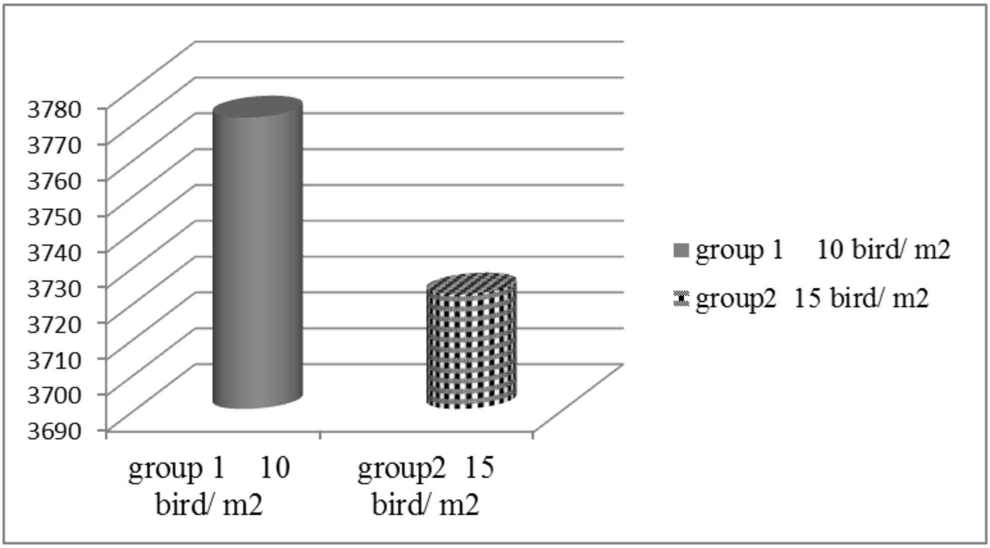

Table (2): the effect of different stocking densities on the indoor daily temperature and RH:

		Temperature (ºC)			Relative Humidity (RH %)		
		Min.	Max.	Mean	Min.	Max.	Mean
10 birds/m^2	Wk2	30.90 ± 0.10	31.83 ± 0.19	31.37 ± 0.15	47.05 ± 1.60	54.05 ± 0.69	50.55 ± 1.07
	Wk3	28.54 ± 0.16	29.77 ± 0.11	29.15 ± 0.08	52.55 ± 0.78	57.33 ± 0.56	54.94 ± 0.67
	Wk4	27.50 ± 0.12	28.45 ± 0.12	27.97 ± 0.12	55.86 ± 0.68	59.14 ± 0.92	57.50 ± 0.78
	Wk5	26.52 ± 0.16	27.68 ± 0.18	27.10 ± 0.17	57.38 ± 0.67	63.19 ± 1.28	60.29 ± 0.97
	Wk6	26.16 ± 0.15	27.24 ± 0.16	26.70 ± 0.15	61.37 ± 0.56	66.52 ± 0.56	63.95 ± 0.56
15 birds/m^2	Wk2	31.43 ± 0.30	32.71 ± 0.08*	32.07 ± 0.19*	52.95 ± 0.48*	56.52 ± 0.42*	54.74 ± 0.44*
	Wk3	30.17 ± 0.27*	30.98 ± 0.21*	30.57 ± 0.24*	58.05 ± 1.89	61.36± 0.75*	59.70± 1.32*
	Wk4	28.99 ± 0.042*	30.54 ± 0.14*	29.76 ± 0.09*	62.95 ± 1.65*	72.06 ± 0.57*	67.51 ± 1.11*
	Wk5	28.84 ± 0.11*	30.36 ± 0.26*	29.60 ± 0.18*	65.71 ± 0.84*	71.14 ± 0.66*	68.43 ± 0.75*
	Wk6	29.03 ± 0.17*	30.50 ± 0.19*	29.77 ± 0.18*	71.3 3± 0.47*	77.14 ± 0.72*	74.24 ± 0.59*

Figure (2): the effect of different densities on mean indoor temperature:

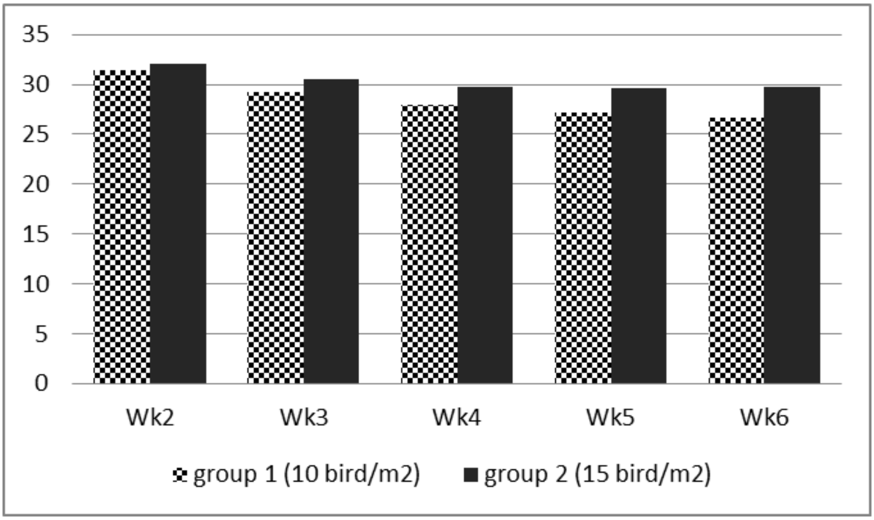

Figure (3): the effect of different densities on mean indoor R.H.:

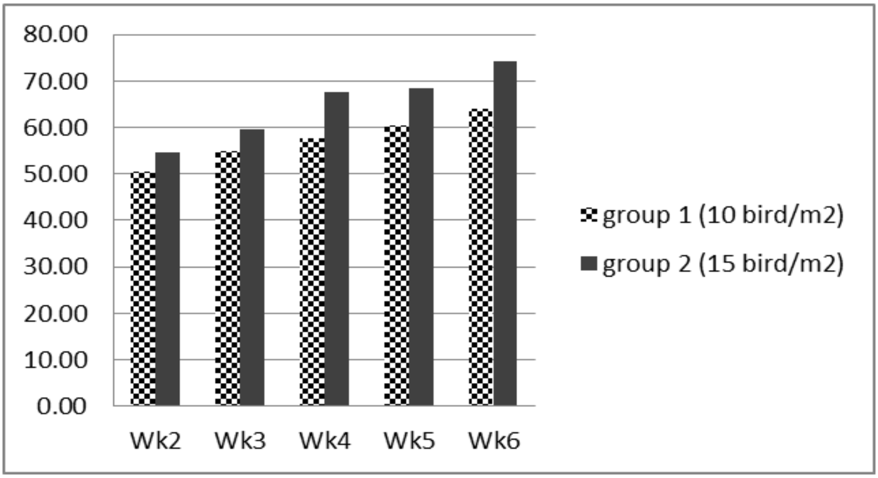

Table (3): The effect of different stocking density on Co_2 levels and Ammonia emission:

		Co_2 (ppm)			Ammonia (PPM)		
		Min.	Max.	Mean	Min.	Max.	Mean
10 birds/m²	Wk2	444.57 ± 3.88	478.00± 2.98	450.5714 ± 7.65	ND	ND	ND
	Wk3	539.97 ± 7.54	623.57 ± 6.04	584.1190 ± 8.27	3.81 ± 0.24	6.19 ± 0.86	5.00 ± 0.41
	Wk4	634.13 ± 8.54	671.00 ± 7.98	656.2143 ± 3.23	6.43 ± 0.71	9.05 ± 0.95	7.73 ± 0.833
	Wk5	668.38 ± 9.98	714.86 ± 6.36	691.6190± 7.92	11.19 ± 0.86	12.62 ± 1.19	11.90 ± 1.01
	Wk6	785.95 ± 9.90	826.90 ± 8.04	673.8024 ± 7.36	13.53 ± 1.078	17.86 ± 1.09	15.83 ± 1.33
15 birds/m²	Wk2	501.90 ± 7.93*	526.05 ± 9.99*	513.9762 ± 8.89*	3.09 ± 0.24*	4.52 ± 0.63*	3.81 ± 0.43*
	Wk3	648.00 ± 10.53*	714.95 ± 2.70*	681.4762 ± 5.88*	7.86 ± 1.49	9.29 ± 0.72	8.57 ± 1.09*
	Wk4	847.38 ± 10.61*	959.62 ± 20.25*	903.5000 ± 15.42*	9.52 ± 86	11.43 ± 0.41	10.48 ± 0.31*
	Wk5	980.00 ± 11.56*	1104.43 ± 23.14*	1042.2143 ± 17.17*	13.33 ± 0.63	15.95 ± 0.48	14.64 ± 0.55
	Wk6	1036.52 ± 23.98*	1131.33 ± 46.82*	1083.93 ± 35.01*	19.52 ± 24*	20.00 ± 00.00	19.76 ± 0.12*

Figure (4): The effect of different densities on mean indoor Co_2 (PPM):

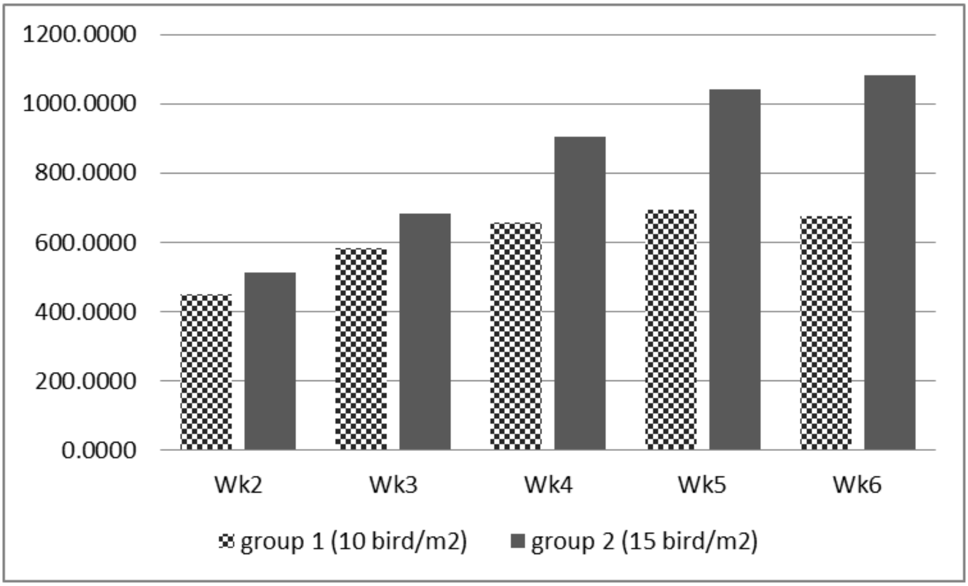

Figure (5): The effect of different densities on mean Ammonia emission levels (PPM):

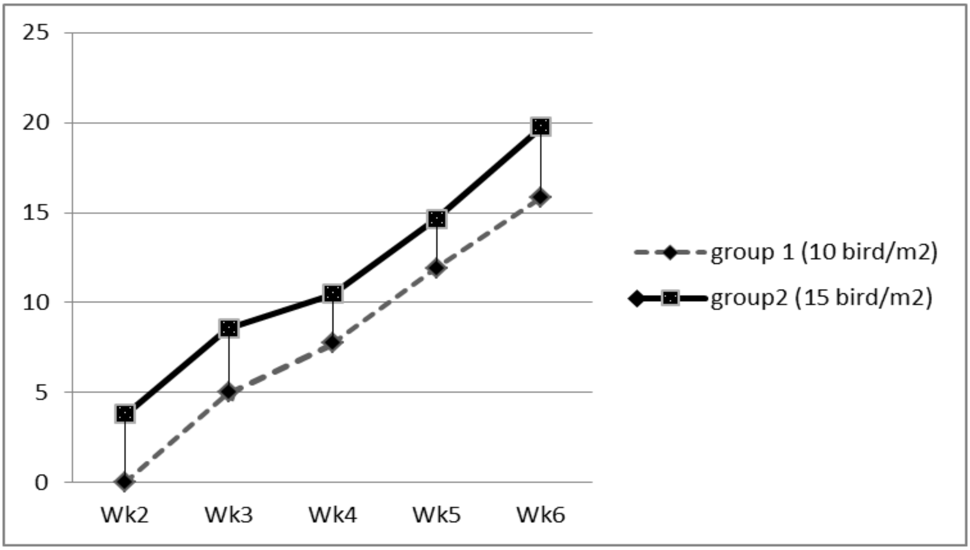

Table (4): A summarized effect of stocking density on weekly feed intake and air quality:

		Weekly FI/bird (gm)	Mean temperature (ºC)	Mean Relative Humidity (%)	Mean Co_2 (ppm)	Mean ammonia level (PPm)
10 birds/m²	2nd wk.	297.81 ± 0.81	31.37 ± 0.15	50.55 ± 1.07	450.5714 ± 7.65	ND
	3rd wk.	603.42 ± 3.61	29.15 ± 0.08	54.94 ± 0.67	584.1190 ± 8.27	5.00 ± 0.41
	4th wk.	818.08 ± 3.18 *	27.97 ± 0.12	57.50 ± 0.78	656.2143 ± 3.23	7.73 ± 0.833
	5th wk.	955.75 ± 1.91 *	27.10 ± 0.17	60.29 ± 0.97	691.6190 ± 7.92	11.90 ± 1.01
	6th wk.	1096.25 ± 5.07 *	26.70 ± 0.15	63.95 ± 0.56	673.8024 ± 7.36	15.83 ± 1.33
15 birds/m²	2nd wk.	309.37 ± 0.69 **	32.07 ± 0.19 *	54.74 ± 0.44 *	513.9762 ± 8.89 *	3.81 ± 0.43 *
	3rd wk.	609.02 ± 3.74	30.57 ± 0.24 *	59.70 ± 1.32 *	681.4762 ± 5.88 *	8.57 ± 1.09 *
	4th wk.	800.26 ± 4.62	29.76 ± 0.09 *	67.51 ± 1.11 *	903.5000 ± 15.42 *	10.48 ± 0.31 *
	5th wk.	928.70 ± 8.30	29.60 ± 0.18 *	68.43 ± 0.75 *	1042.2143 ± 17.17 *	14.64 ± 0.55
	6th wk.	1074.58 ± 3.01	29.77 ± 0.18 *	74.24 ± 0.59 *	1083.93 ± 35.01 *	19.76 ± 0.12 *

DISCUSSION

The effect of stocking density on weekly and cumulative feed intake (FI) was presented in the table 1 and figure 1: The weekly feed intake was significantly ($p<0.001$) increased in high density group by 3.88% as compared by the other group this increase continued but in a non-significant way for the second week by 0.9%. This agrees with the findings of **Dozier et al., (2005)** who found an improvement of food consumption during the starter period when the stocking density was increased from 9 to13 birds/m^2 and disagree with the findings of **Farhadie et al., 2016** who found non-significant effect of density on feed consumption from day 1 to day 21. The food consumption was significantly decreased from 4th week till the end of the growing cycle. These findings were similar to that of (**Shanawany, 1988 and Dozier et al., 2005)**. Similarly **Farhadie et al. (2016)** found a significant decrease of FI from 21 to 42 days as the stocking density increased.

However**, Coenen et al. (1996)** found that FI was reduced in groups with decreased stocking densities. These findings are in contrast with that detected by **Feddes et al. (2002)** who reported that the birds in the treatment with 11.9 birds /m^2 consumed the least feed and those in the 14.3 birds/m^2 treatment consumed the most feed. The decreased feed intake with the progress of age was attributed to inhibited access to feeders and drinkers (**Dozier et al., 2005 and Estevez, 2007).**Concerning the cumulative feed intake (CFI), it was reported that Stocking density had no significant effect on total feed intake (**Thomas et al., 2004 and Turkyilmaz, 2008),** this is confirmed in this study inspite of the 1.31% reduction in CFI as the density was increased, similarly **Puron et al. (1995)** found 2.3% reductions in 49-d cumulative feed consumption as stocking density increased from 10 to 12 birds/m^2.

Regarding the effect of stocking density on microclimatic conditions table 2, figures 2 and 3 showed its effect on temperature and humidity. Increasing environmental temperature above 27ºC in the last week of rearing is considered heat stress (**Fernandes at al., 2013)** which results from a negative balance between the net amount of energy flowing from the animal's body to its surrounding environment and the amount of heat energy produced by the animal; this could be aggravated by increasing relative humidity, above 70% **(Donald, et al. 2004)**, due to the in ability to dissipate extra heat to the surrounding environment. From this point of view, heat stress is considered as the most environmental stressor challenging poultry production worldwide **(Lara and Rostagno, 2013)**. The temperature and R.H. were significantly ($P< 0.05$) high in HD group throughout the growing cycle than the other group. Due to the higher number of birds housed in the same unit area, all ventilation trials by the traditional ways including windows, fans and suction fans failed to decrease heat stress in high density group in this study. These results are supported by **Yardimci and Kenar. (2008)** who found that an increase in the housing density usually results in a corresponding increase in temperature and humidity.

Carbon dioxide is primarily a result of bird perspiration, metabolism and biological decomposition of manure; its level is largely dependent on the number of birds and ventilation **(Reece and Lott, 1980, Almuhanna et al., 2011 and Brouček and Čermák, 2015)**. High CO2 result in hypoxia and with high environmental temperature may lead to Ascites syndrome which result in high mortalities and economic losses **(Shlosber et al., 1992; Balog, 2003 and Scheele et al., 2003)**. In this study the minimum, maximum and mean Co_2 levels illustrated in table 3 and figure 4 were significantly ($P<0.0$) higher in HD group due to the higher number of birds (**Brouček and Čermák, 2015)**. These findings are supported by **Yardimci and Kenar. (2008)** who found that an increase in the housing density usually results in a corresponding increase in CO2 and ammonia levels. Co2 levels in this study inspite of being increased and reached to 1083.93 PPM as mean value in HD group; they didn’t exceed the threshold level of ≥3000 PPM **(Talukder et al., 2010 and Broucek and Cermak, 2015)** which may exclude a harmful effect on bird.

These findings showed that the air quality was deteriorated with increasing density particularly the temperature and humidity; this is in line with the findings of **Yardimci and Kenar (2008**) and disagrees with **Perkins et al. (1995)** who concluded that Air quality was not affected by stocking density.Ammonia is considered the most abundant and famous toxic gaseous pollutant in broiler houses **(Almuhanna et al., 2011 and Abouelenien et al., 2016)** which could harmfully affect bird performance and welfare **(Dawkins et a., 2004 and Costa et al., 2012)**. Table 3 and figure 5 illustrate the ammonia emission levels in the broiler house with the two different densities starting from the 2nd till the 6th week of age. Ammonia firstly wasn't detectable in the SD group (10 birds/m^2), then was detected starting from the third week of age till the end of the experiment with mean levels of 5, 7.73, 11.90 and15.83 ppm at Wk3, Wk4, Wk5 and Wk6 respectively, these values were significantly ($P<0.05$) lower than that of the HSD group (15birds/m^2) in which the ammonia was detectable starting from the second week with an increasing level till the end of 6th week of age with mean values, 3.81, 8.57, 10.48, 14.64 and 19.76 ppm. Ammonia may be not detected firstly in the SD group due to the replaced new litter after brooding period as Ammonia is the product of microbial decomposition of urea and uric acid in poultry litter mixed with chicken manure **(Nahm, 2002).**

The obtained results showed an increase in the ammonia emission with increasing age as mentioned by **Haper et al. (2010) and Meda et al. (2011)** who stated that ammonia emission was increased after the 3rd week of age. Moreover the increased ammonia with increasing density come in agreement with, who declared that high stocking density has been reported to increase ammonia production (**Lewis and Hurnik, 1990; Bessie and Reiter, 1992; Cravener et al., 1992; Tasistro et al., 2007; Brouček and Čermák, 2015, Zhao et al., 2015 and Abouelenien et al., 2016)**. Other studies announced that SD has no significant effect on the Ammonia levels (**Dozier et al., 2005)**. With the progress of age and with increasing SD more manure will be produced, consequently more decomposition occure and release more ammonia **(Abouelenien et al., 2016)** which explain the increased ammonia emission with increased age and density. The ammonia levels in this study were yet less than 25 ppm which is considered the threshold level above which a deleterious effects on broilers occurred **(Malone, 2005),** while the ultimate goal of 10 PPM suggested by the **National Chicken Council Welfare Guidelines, (2003)** failed to be achieved in this experiment event at 10 bird/m^2 SD.

Increasing density in broiler housing from 10 to 15birds/m^2 may have beneficial effect on FI, as summarized in table 4, during the starter period but also having adverse effect on both feed consumption and air quality especially during the last rearing weeks. The gaseous pollutant were lower than threshold levels which make it possible to house this number of birds with more advanced technology of ventilation to relieve heat stress that was the main cause of decreasing food consumption.

CONCLUSION

Air quality was deteriorated with increasing rearing density particularly the temperature and relative humidity which in turn adversely affect the feed consumption.

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