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EVALUATION OF FLOOR *VS.* CAGE SYSTEM OF BROILER CHICKENS REARED IN THREE DIFFERENT AREAS OF ENCLOSED HOUSES ON PRODUCTIVE AND PHYSIOLOGICAL PERFORMANCE

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ABSTRACT: This study was conducted to evaluate the effects of two housing systems cage *vs*. floor on productive performance and physiological response of broiler chickens reared in three rearing areas in enclosed houses including side cooling (vent area) , middle and at the end of the house (fan area). A total number of 3120 chicks were randomly chosen for both housing systems, where enclosed houses of cage battery and floor systems having 83200 and 22500 birds respectively.The number of 3120 chicks were divided into two groups: the first was housed in cages (n=1560) and the second was housed on the floor house (n=1560). Birds were placed in three different rearing areas containing 520 birds each. Each area per housing system was replicated four times containing 130 birds each. Results showed that LBW, BWG, FI, FCR, livability and EPEF recorded significantly ($P \leq 0.05$) higher values for birds housed in cages than birds housed on floor. However, the former traits showed better ($P \leq 0.05$) results for birds placed in vent area than birds placed in middle and fan area. Housing systems or rearing areas significantly ($P \leq 0.05$) affected total faecal microbial count, where the birds housed on floor and placed in fan area exhibited ($P \leq 0.05$) higher values than birds housed in cages and placed in middle and vent areas. Antibody titer response detected against NDV for birds placed in vent and middle areas showed higher values than birds placed in fan area. It may be concluded that, rearing broiler chickens in cage system and placed in vent area were better in obtaining the highest productivity and physiological response compared with those reared on floor system and placed in middle and fan areas.

Key words*:* Broiler chickens, rearing area, productive and physiological response.

INTRODUCTION

It is well known that in recent years animal production has considerably increased worldwide to sustain an ever-growing human population. However, broiler meat production has increased markedly due to its low fat and high protein content, where broiler meat is considered as a high quality food by consumers (Kryeziu *et al.,* 2018). The development of broiler housing has been accompanied in recent years by a substantial attention to temperature and humidity which, may vary in different areas of the house. Thus may ultimately affect the growth performance of broiler. Limited information has been published regarding rearing birds in different areas of the house, because the intensive system may cause stress and behavioral and physiological abnormalities, which adversely affects productivity and health (Bessei, 2005). Therefore, broiler rearing system is a crucial factor affecting bird's comfort, health and production efficiency (Fouad *et al.,* 2008). Interestingly, Çavusoglu *et al.* (2018) indicated that a litter-bedded floor system is most common for commercial broiler meat production. Although cage and slat floor housing have been available for many years, they have not been widely adopted because of poor leg health and poor meat quality of broiler (Shields and Greger, 2013). A study by Pakage *et al*. (2015) indicated that a cage system in closed housing enables the control of the microclimate inside the facilities, improves productivity, land and labor efficiency, and renders broiler production more environmentally friendly. Therefore, Olawumi (2015) stated that superiority of cage system over that of deep litter in all the evaluated production traits, where body weight of cage birds were higher than those on deep litter. If litter and inside air quality are not optimal, there will be a considerable risk of the birds developing respiratory diseases and contact dermatitis on their feet and breast (Petek *et al.,* 2015). However, keeping litter dry and in good condition in deep-litter floor housing is very difficult due to drinker type, bedding material, outdoor and indoor temperature and humidity, the ventilation system, and high stocking density (Petek *et al.,* 2014). Although, Bilal *et al.* (2014) revealed that performance of broiler was best when reared on floor than those reared on the cages. In general, limited information has been published regarding air quality at bird level within different rearing area. Therefore, this study planned to evaluate the productive and physiological response of broiler maintained under two housing systems with three different rearing area of enclosed houses.

MATERILAS AND METHODS

To compare the productive performance and physiological response of broiler chickens maintained on floor and cages systems and reared in three different rearing areas of enclosed houses, the following approach was followed:

Site and aim of the experiment: This field study was conducted in a commercial farm (Golden Broiler Breeder Company), which is located in the desert back of Sadat city of Monufia governorate, during the summer season from the first of August to the beginning of September 2017. The main purpose of this study was to evaluate the effects of two housing systems, cage *vs*. floor of broiler chickens reared in three different rearing areas in enclosed houses on productive performance and some physiological response.

Birds, husbandry and experimental procedure: To determine the examined parameters a total number of 3120 chicks were randomly chosen for both housing systems, where enclosed houses of floor and cage systems having 22500 and 83200 birds respectively.The number of 3120 chicks were divided into two groups: the first was housed in cages (n=1560) and the second was housed on the floor (n=1560). Each group were reared in three different rearing area containing 520 birds each, where each area per housing system was replicated four times containing 130 birds each in fully environmentally controlled house. In each housing system, there were three different rearing area including: side cooling area (vent area), middle area and at the end of the house (fan area), where the three areas of each house differ in temperature, humidity and ventilation conditions. Environmental conditions in two housing systems were organized according to the needs of broiler, where temperature and relative humidity were between 22.4 to 30.4 ℃ and 52 to 61% in side cooling area (vent), while it was 25.3 to 30.6 ^{o}C and 50 to 56 % in middle area and were 26.1 to 30.6 ^{o}C and 50 to 58% for the end of the house (fan area). House temperature was set through the automatic control system to be 32^{o}C at the first day of age which was daily reduced 0.4°C till reaching temperature required for both systems. Birds in both houses were allowed free access to fresh water and feed of starter, grower and finisher rations which were given to satisfy the strain requirements stated in the broiler management guide (Aviagen, 2016). For the first 14 days a starter ration (23.0% CP and 2960 ME /kg) was offered. Subsequently, a grower ration (22% CP and 3040 ME /kg) was offered from day 15 up to day 28. While, finisher ration (20% CP and 3139 ME /kg) was offered from 29 to 35 days of age. All birds were fed the same commercial rations which offered *ad libitum*. Adequate numbers of designated feeders and drinking nipples were provided to ensure similar feeding and drinking space, regardless of the housing system. A light: dark pattern of 23L: l D was provided with light intensity of 10 lux/m^2. Both housing systems received the same managerial condition. The dimensions of the enclosed cage house were (130 x 13 x 4.3 m), and contained 4 longitudinal batteries consisting of 4 vertical tiers with 640 cage unit. Each unit measuring 4.930 m^2 containing 130 birds each with a stocking density in cages 26 birds per m^2 so that each unit contains the number of 130 birds each, to ensure not to exceed the threshold of 58 kg/m^2. While broiler floor house measuring (110x 12x 2.6 m), where birds housed at a stocking density of 17 bird/m^2. In the floor house system, barriers were made in each area to ensure the presence of selected birds in the same area, where each group contained a number of 520 birds which further divided into 4 replicates of 130 birds each. Wheat straw was used as litter material and was uniformly distributed to cover the floor area to a depth of 5 cm. Each house had identical cooling and ventilation equipment's with an environmental controller. All exhaust fans were monitored with current magnetic sensors and fan ON/OFF status was recorded with a four-channel data logger. Ventilation rates of the houses were measured using fan status, fan curves (airflow rate *vs*. static pressure). The in situ calibration of the exhaust fans was conducted with a handheld anemometer with traverse measurement, from which an overall ventilation curve for each house was established. The east side of both houses had 3 sections of 132 m^2 experimental cooling pads on the wall with a thickness of 15 cm. The cooling pad openings were covered by 2 rows of static pressure-controlled sliding doors on the inside when not in use. Temperature and relative humidity sensors were evenly distributed in each house at 60 cm height with 5-min sampling intervals to measure the thermal environment of the houses. Portable monitoring units (PMUs) housing NH_3 and CO_2 sensors were used to continuously monitor air quality data from the two broiler houses. The flocks were vaccinated against common diseases indicated in the vaccination programs, like Newcastle disease virus (NDV), infectious bronchitis (IB) and Gumboro (infectious bursal disease) at the appropriate age as recommended by veterinarians.

Data collection

Productive performance: The body weight of birds was recorded individually at start of experiment and at the end of every week. For this purpose, all the birds from each replicate were weighed by using an electrical weighting balance. From the individual weights, the mean weight of all the groups was calculated separately. Feed intake was calculated at the end of each week. Record of weekly feed intake and weight gain was used to compute FCR of each experimental group (FCR = feed intake / weight gain). However, livability was observed visually and recorded daily throughout the experimental period. Also, European production efficiency factor (EPEF) calculated as described by (Marcu *et al.,* 2013).

Hematological parameters: At the end of experiment approximately 2 mL of blood was randomly taken from 3 birds from each rearing area for each housing system to study some hematological traits. Blood samples were collected with Ethylene Diamine Tetra Acetate (EDTA) to examine Pack cell volume (PCV), hemoglobin (Hb),white blood cell counts (WBCs), red blood cell count (RBCs), hetrophils (H) and lymphocyte (L) and H/L ratio. The values of PCV was manually recorded through capillary tubes of a microhaematocrit by centrifuging for 5 minutes at 2500 rpm (Campbell, 1988). While, Hb concentration, RBC and WBCs were determined using colorimetry cyanomethaemoglobin method and improved Neubauer haemocytometer respectively (Young, 2001; Natt and Herrick, 1952). One drop of fresh blood was smeared on a clean microscope glass slide. The dried smear slides were stained with Giemsa for 2 min. Hetrophils and lymphocytes were enumerated in 100 cells per field, and their ratio was calculated according to standard techniques as reported by Jain (1986).

Carcass traits, lymphoid organ weights and antibody titer response: At the end of the experiment 6 birds (3 females and 3 males) from each rearing area for each housing system were randomly chosen whose body weights were closest to the mean weight of each rearing area. Lymphoid organs including spleen, thymus and Bursa of Fabricius were removed and weighed to subjected statistical analysis. However, the antibody titer response was measured against Newcastle disease virus (NDV), where blood samples were collected from right Jugular vein at 35 d of age for Haemagglutination Inhibition test according procedure outlined in OIE (2012). Antibody titer response was expressed as the $\log^2$ of the reciprocal of the highest dilution giving visible Haemagglutination. The reciprocal of the last serum dilution showing inhibition of hemagglutination of the 4 hem-agglutinin units of the NDV was considered as the HI antibody titer of the serum (log^2 value of HI titer).

Total faecal bacterial count (TFBC): For a determination of TFBC one gram of faecal samples were taken from each rearing area for each housing system and enumerated on plate count agar after incubating at 37°C for 48 h (Jang *et al.*, 2007). The microbial counts were determined as colony forming units (CFU) per gram of samples.

Statistical analysis: All data were subjected to an analysis of variance (ANOVA) using the SPSS software 16.00 (SPSS, 2010). A 2 x 3 factorial arranged in a randomized complete design was used in this study. All percentages were first transformed to arcsine being analyzed to approximate normal distribution before ANOVA. Differences were considered statistically significant at ($P \leq 0.05$). Data for antibody titers response were normalized using logarithmic transformation prior to analysis. The following model was used for data analysis: $Y_{ijk} = \mu + \alpha_i + ß_j + (\alpha_i \times ß_j)_{ij} + e_{ijk}$ Where, Y_{ijk} : Observation on the ij individual, μ = overall mean., α_i = effect of housing system, $ß_j$ = effect of rearing area, (α_i x $ß_j$) = interaction between housing and areas and e_{ijk}= random error.

RESELTS

Productive performance

Live body weight (LBW) and body weight gain (BWG): Table 1 summarizes the effects of housing systems and rearing area on LBW and BWG of broiler chickens. It is observed, when comparisons were made across sexes in both housing systems data indicated that there were insignificant differences in LBW at 1, 14 and 28 days of age. While, at the end of experiment (35 days) birds reared in cages showed significantly ($P \leq 0.05$) higher values of LBW than birds reared on floor. Also, the analysis of variance indicated that there were insignificant differences in BWG observed during the periods 1-14 and 29-35 days due to housing systems, while during 15-28 and 1-35 days of age birds housed in cages recorded ($P \leq 0.05$) higher BWG than birds housed on floor. However, LBW of birds differed ($P \leq 0.05$) significantly due to rearing area, where birds placed in vent area and nearing from pad cooling exhibited significantly ($P \leq 0.05$) higher values than those recorded for birds placed in middle and fan areas respectively along the experimental period. The same trend was also observed for BWG, where birds placed in vent area gained more ($P \leq 0.05$) weight than those birds reared in middle and fan areas, except with values observed during 29-35 days, where the values were insignificant. Data revealed that there were a significant interactions detected for LBW and BWG suggesting that the highest ($P \leq 0.05$) values observed for birds housed in cages and placed in vent area (cage x vent) compared with other interaction groups. It appears through this result that housing systems affects LBW and BWG this can be taken into consideration when researchers and farmers are seeking for means of improving productive performance, therefore birds raised in vent area performed better than those raised in middle and fan areas.

Feed intake (FI) and feed conversion ratio (FCR): Results presented in Table 2 shows the effects of housing systems and rearing area on FI and FCR. It is noted that birds reared in cages consumed more ($P \leq 0.05$) feed than birds housed on floor system on a daily and weekly basis during 29-35 days of age, while during 1-14, 15-28 and 1-35 days birds housed in cages also consumed more feed than birds housed in floor but this differences were insignificant. However, the values of FCR differed (P ≤0.05) significantly between the two housing systems, where birds raised in cages exhibited better FCR than birds housed on floor system. Furthermore, FI recorded significantly (P ≤0.05) higher values when birds present in vent area, followed birds placed in middle and fan areas during 1-14, 15-28 and 1-35 days, while during 29-35 days of age insignificant differences were observed due to rearing area. However, birds placed in vent area showed better (P ≤0.05) FCR than birds placed in middle and fan areas during 1-14, 15-28 and 1-35 days, while insignificant differences detected during 29-35 days of age. Data obtained in this study denotes that interaction group (floor x vent) showed higher (P ≤ 0.05) FI during 1-14 days, while during 15-28 and 1-35 days interaction group (cage x vent) exhibited the highest values compared with other interaction groups. Moreover, during 29-35 days the interaction group (cage x fan) have higher (P ≤0.05) FI than those recorded for other interaction groups. On the other hand, FCR calculated among the interaction groups differed (P ≤0.05) significantly during 1-14, 15-28 and 1-35 days, while insignificant differences observed during 29-35 days of experiment.

Livability, European performance efficiency factor (EPEF) and total faecal bacterial count (TFBC): Table (3) shows the effects of housing systems and rearing area on livability, EPEF and TFBC count. It is observed that either livability or EPEF significantly (P ≤0.05) differed between both housing systems, where birds raised in cages have higher values than birds housed on floor. Conversely, TFBC exhibited the converse trend, where birds housed in floor showed higher values than birds housed in cages (P ≤0.05). However, birds present in vent area recorded significantly higher (P ≤0.05) livability and EPEF values than birds placed in middle and fan areas. While, the highest TFBC was detected for birds placed in fan area followed by birds present in middle and vent areas respectively (P ≤0.05). The results of interaction indicated that the lowest values of livability and EPEF recorded for interaction group (floor x fan) compared with other interaction groups. Moreover, data revealed that the highest TFBC was detected for interaction group (floor x fan) as compared with other interaction groups (P ≤0.05).

Hematological parameters: Table 4 illustrate the data of hematological parameters as affected by both housing systems and rearing area. It is interesting to note that there were insignificant differences in most hematological parameters measured at 35 days of age due to housing systems, except with H/L ratio, where birds housed on floor have higher (P<0.05) value than birds housed in cages. However, the analysis of variance indicated that there were insignificant differences in PCV, hetrophiles, lymphocytes and H/L ratio due to rearing area, while WBCs, RBCs and Hb showed the converse trend. The highest (P ≤0.05) values for WBCs and RBCs observed for birds placed in vent area followed by birds placed in middle and fan areas. While Hb exhibited higher (P<0.05) levels of birds placed in fan area, followed in descending order by birds placed in middle and vent areas respectively (P ≤0.05). Further data indicated that there were significant differences observed for all former traits due to interaction effect (P<0.05). Results indicated that WBCs, RBCs, PCV and hetrophils % showed the highest values for interaction group (floor x vent) compared with other interaction groups. While, Hb values recorded higher values for (floor x middle and floor x vent) interaction groups than those recorded for other groups. On the other hand, the values of lymphocyte % showed higher (P ≤0.05) values for (cage x vent) interaction group than those observed for other groups. However, the H/L ratio exhibited higher (P ≤0.05) values for (floor x middle) interaction group than those observed for other groups.

Carcass traits, lymphoid organs and antibody titer response: Table 5 illustrated that heart, liver and gizzard weights insignificantly affected by the housing systems, while the abdominal fat weight was significantly (P ≤0.05) increased, when birds housed in cages compared with birds reared on floor. Also, the lymphoid organ weights including spleen and thymus insignificantly affected due to housing systems, while bursa weight showed the converse trend where it significantly (P ≤0.05) increased when birds housed in cages than birds housed on floor. However, the difference between the two housing systems regarding antibody titer response against NDV was insignificant. Data revealed that there were insignificant differences were observed among rearing area concerning heart, liver, abdominal fat, spleen, bursa and thymus gland weights, while gizzard and antibody titer against NDV recorded significantly (P ≤0.05) higher values for birds placed in vent area followed by birds placed in middle and fan areas respectively. Further data indicated interaction group (cage x vent) showed the highest values of liver, gizzard, abdominal fat and spleen weights compared with other interaction groups. While, insignificant differences observed for bursa and thymus weights due to interaction effect. Moreover, heart weight recorded higher values for (cag x vent, cage x middle and cag x fan) interaction groups than those recorded for other interaction groups. However, the lowest antibody titer against NDV detected for interaction group (floor x fan) compared with other interaction groups.

DISCUSSION

Productive performance

Live body weight (LBW) and body weight gain (BWG): It is well known that LBW is a qualitative trait, controlled by few pairs of genes, highly heritable and influenced also by the environment. For more details birds bred in the cages were significantly superior in LBW and BWG at the end of experiment than birds bred in floor system. The difference in growth performance is most likely attributed to the fact that birds in the cage are not as free as those on the floor; where birds in cages were able to utilize feeds given optimally and converted same into more meat than the floor birds (Olawumi, 2015). Also, the birds in floor system tended to eat more feed than birds in cage system to provide energy for heat production (Preisinger, 2000). This finding was similar with Çavusoglu *et al.* (2018) found that the average body weight of broilers was significantly higher in the slatted-floor and the litter slat than birds bred in conventional deep-litter floor housing. In addition, Thanga *et al*. (2001) reported that broiler chicken reared in cage performed better than birds housed in floor system. However, birds placed in the vent area performed better, where the highest LBW and BWG were observed for birds placed in the vent area followed by those of middle and fan areas of house. This improvement in performance may attributed to the increase of ventilation rate and availability of fresh air, which comes directly from the vent area lowers the temperature and creates comfortable environment in this area leading to improved performance. This findings is confirmed by Feddes *et al*. (2002) who verified improved growth of broiler chickens, when exposed to better ventilation conditions. Also, Lott *et al*. (1998) reported that body weight of broiler chickens was positively affected by the air. Similar results were found by Czarick and Fairchild (2012) who reported that any variation in the environment surrounding the birds resulted into stunted growth and major productive losses.

Feed intake (FI) and feed conversion ratio (FCR): It's well known that voluntary feed intake is linked to growth rate (Scott, 2005), therefore, under the current of this study birds showed good performance without any signs of diseases or irregularities concerning their feed intake for both housing systems. Accordingly, the birds in cage system consumed more feed than those kept under the floor house, although the differences between the two systems were insignificant at 1-14, 15-28 and 1-35 days of age. This attributed to birds reared on the floor have ample space, which facilitated the birds for normal physiological and metabolic responses, ultimately resulted into more feed intake as compared to cage system (Bilal *et al.*, 2014). While, Khan and Khan (2018) indicated birds housed in the floor consumed 10% more feed than birds housed in cage on a daily basis. Also, Rodriguez *et al*. (2005) reported that broiler reared in cage consumed less feed than birds housed in floor system. However, feed intake significantly affected due to rearing area in the house, where the birds placed in vent area consumed more feed than those present in middle and fan areas. This may be due to the optimum temperature and availability of fresh air in the ventilator area as compared to the elevated temperature and accumulation of obnoxious gases in the other two areas of the house, which resulted into less feed intake. In this context, Liberati *et al*. (2009) reported that lowering down the temperature in the house increases the feed consumption of broiler chickens. On the other hand, broiler reared on the floor showed significantly worst FCR as compared with those reared in cages. This attributed to birds housed in cage utilized feed more efficiently than floor housed birds. Further, birds grown in the vent area exhibited significantly better FCR, followed by birds placed in middle and fan areas respectively. This improvement in FCR of birds placed in vent area may attributed to the good environmental conditions, which were conducive for the birds to exploit their genetic potential by increasing feed intake and body weight resulting into better FCR. In other words it is assumed that better feed utilization by caged birds might be due to higher weight gain of caged bird and minimum expenditure of energy on physical activates (Swain *et al.,* 2002). These results are similar with Alam *et al.* (2008) who demonstrated that birds reared on cage showed superior efficiently of feed compared to birds reared on floor. In addition, Katersky and Carter (2007) who reported that FCR was adversely affected when temperature exceeds towards the critical temperature limit as it was observed in the fan area of the house.

Livability, European performance efficiency factor (EPEP) and total faecal bacterial count (TFBC): Interestingly, cage system are commonly used in poultry houses to provide some commercial and health benefits (Vits *et al.*, 2005).Therefore, flooring system apart from litter may be attributed to one of a number of major factors, where chickens contact with faecal material and its hazardous effect (Petek *et al*., 2015). The results illustrate very clearly the survival rate was higher in cage than floor housing. Accordingly, data obtained in this study denotes that housing system had also a marked effect on mortality rate, where the total mortality was lower in cage than floor system. The better survival rate may be attributed to several management factors that favored health and hygiene. Cage housing increased birds" spatial density, eased the control of microclimate, simplified waste disposal, reduced labor costs and eased the supervision of individual birds for health and production status additionally (Pistikova *et al*., 2006). In addition, frequent manure removal facility in multitier cage ensured cleanliness and uniform feed allowance per bird, being more particularly required for the nutrition of less active birds to maintain sound health. This finding similar with Khan and Khan (2018) indicated that survival rate was higher for broiler reared in cage than floor housing. However, livability significantly improved for birds placed in vent area followed by those placed in middle and fans areas. This attributed to the increase of ventilation rate and availability of fresh air, which comes directly from the vent area lowers the temperature and creates comfortable environment in this area leading to reduced mortality and improved health and vigor of the birds. Moreover, EPEF showed higher value for broiler housed in cages than those in floor system, this attributed to uniform altitude and community conditions of living. However, birds placed in vent area recorded high value of EPEF, followed by middle and fan areas respectively. In this context, Thanga *et al*. (2001) reported that broiler chicken reared in cage system performed better, higher survival rate and finally more profits per bird than floor rearing system. In contrast, **Santos *et al*. (2012)** who reported that birds reared on floor showed better production efficiency than birds reared in the cages.

3-Hematological parameters: Clearly, blood parameters were affected by different environmental conditions (Onbaşilar *et al.,* 2007), therefore, blood parameters are an important measure as diagnostic tools indicators in birds (Hauptmanova *et al.*, 2006). Also, blood is profiled to judge the flock health status and is one of the trusted indicators for health status assessment (Ladokun *et al*., 2008). Accordingly, it is observed from the present results that housing systems insignificantly affected most hematological traits, except with H/L ratio, where birds housed in floor recorded higher values than those housed in cages. Variations in H/Lt ratio due to housing systems is considered as stress factor (Puvadolpirod and Thaxton, 2000), therefore the present results indicated there were significant differences for H/L ratio due to housing systems. In this context, it is observed H/ L ratio of 0.2 indicates low, 0.5 medium and 0.8 high stress, thus H/L ratio has proved to be a valuable measurement in stress (Gross and Siegel., 1993; Post *et al*., 2003). It is noted that, the immune response was not altered negatively by the housing system as observed in the values of the WBCs, which were within the normal range of blood birds (Simaraks *et al*., 2004). In general, the results indicate that the studied hematological blood profile of the present experiment were not adversely affected by the housing systems (Mench 1992), and depicted equally sound health status and no infection among the experimental birds as a result of the housing system. This finding are confirmed by Sogunle *et al.* (2008) found that no significant difference observed in the hematological parameters of broiler chickens due to housing system. However, rearing area significantly affected WBCs, RBCs and Hb, while insignificant differences detected for hetrophils, lymphocyte and H/L ratio, although, the values obtained were within the range reported by Sogunle *et al*. (2006). Accordingly, Alabi *et al.* (2015) found that the hematological values of the hens were not significantly affected by the housing system.

4- Carcass traits, lymphoid organ weights and antibody titer response: The results clearly showed that the housing systems insignificantly affected heart, liver and gizzard weights of broiler, while abdominal fat showed higher weight for birds housed in cages than birds housed in floor system. In this context, Swain *et al*. (2002) indicated that organs weights of broiler reared in deep litter did not differ from birds reared in cages. While, Wang *et al.* (2009) indicated significant impacts of housing system on relative abdominal fat weight, where low weights observed for free-range systems. In contrast, Diktaş *et al.* (2015) found that the housing systems insignificantly affected internal organs of broiler chickens. However, rearing area insignificantly affected heart, liver, and abdominal weights, while gizzard showed higher weight of birds placed in vent area than birds placed in middle and fan areas. This finding are consist with, Swain *et al*. (2002) who found insignificant influence for house system on carcass traits of broilers. However, it is well known that the most commonly assessed immune parameters in poultry are the weight of lymphoid organs, where avian immune cells differentiate and which also reflects the body's ability to provide lymphoid cells during an immune response (Yang *et al*., 2011). Therefore it is important to maintain immune function in broilers because poor immune status can decrease disease resistance leading to reduced productivity. It has been well documented that, spleen, Bursa of Fabricius are used for anatomical and physiological stress indicators for birds (Freire *et al.*, 2003), where decreased bursa weight are associated with increased levels of physiological stress. It is expected that birds could survive the ND virus challenge when they show relatively greater titers. In the present study there is no increased in lymphoid organ weights, except with Bursa of Fabricius, and immune response due to housing systems indicating there was no negative effect of housing system on growth of lymphoid organs and immunity. However, rearing area insignificantly affected lymphoid organs, while titer response in birds placed in vent and middle area significantly increased for birds placed in fan area. In this context, Matur *et al.* (2015) showed that thymus and Bursa of Fabricius weights tended to be lower in stressed hens. Data revealed that titer response insignificantly affected due to housing system, while the highest titer response was detected for birds placed in vent and middle area as compared with birds placed in fan area. This attributed to fresh air coming directly from vent area can decrease stress conditions and increase bird comfort, due to the birds being in a more natural environment. In addition, the increased titer response for birds placed in vent and middle area reflects enhanced and ongoing plasma cell involvement in the production of antibodies till at least 18 days' post last antigenic exposure.

CONCLUSION AND APPLICATION:

Based on the findings, it is concluded that broilers reared in cage near vent area exhibited better growth performance and physiological response as compared to birds housed in floor and placed in the middle or fan areas. Therefore, keeping broiler on cage system should be preferred especially in the vent area.

Table (1): The effects of housing systems and rearing area on live body weight and body weight gain of broiler chickens reared in enclosed houses (Means ± SEM)

Items / Treatments	Live body weight (g)				Body weight gain(g)			
	1 days	14 days	28 days	35 days	1-14 days	15-28 days	29-35 days	1-35 days
Effect of housing systems:								
Cages	45.66	448.54	1520	2241.00^{a}	402.88	1071.46^{a}	721	2195.34^{a}
Floor	45.7	420.66	1381	2061.00^{b}	374.96	960.34^{b}	680	2015.30^{b}
SEM	0.23	2.66	7.45	8.76	2.74	7.38	7.52	8.81
Sig.	NS	NS	NS	*	NS	*	NS	*
Effect of rearing area:								
Vent	45.68	455.31^{a}	1513.00^{a}	2230.00^{a}	409.63^{a}	1057.69^{a}	717	2184.32^{a}
Middle	45.81	436.25^{b}	1440.00^{b}	2136.00^{b}	390.44^{b}	1003.75^{b}	696	2090.19^{b}
Fan	45.56	412.25^{c}	1398.00^{c}	2087.00^{c}	366.69^{c}	985.75^{b}	689	2041.44^{c}
SEM	0.28	3.25	9.12	10.73	3.35	9.04	9.21	10.79
Sig.	NS	*	*	*	*	*	NS	*
Effect of interaction:								
Cage ×Vent	45.62	471.75^{a}	1568.00^{a}	2296.00^{a}	426.13^{a}	1096.25^{a}	728.00^{a}	2250.38^{a}
Cage ×Middle	45.87	443.50^{b}	1513.00^{b}	2233.00^{b}	397.63^{b}	1069.5^{ab}	720.00^{a}	2187.13^{b}
C0age ×Fan	45.5	430.75^{b}	1478.00^{bc}	2194.00^{bc}	385.25^{b}	1047.25^{bc}	716.00^{a}	2148.50^{bc}
Floor ×Vent	45.75	439.25^{b}	1458.00^{c}	2164.00^{c}	393.50^{b}	1018.75^{c}	706.00a^{b}	2118.25^{c}
Floor ×Middle	45.75	429.00^{b}	1366.00^{d}	2040.00^{d}	383.25^{b}	937.00^{d}	674.00b^{c}	1994.25^{d}
Floor ×Fan	45.62	393.75^{c}	1318.00^{e}	1980.00^{e}	348.13^{c}	924.25^{d}	662.00^{c}	1934.38^{e}
SEM	0.4	4	12.9	15.17	4.74	12.79	13.03	15.26
Sig.	NS	*	*	*	*	*	*	*

$^{a, b, c \dots}$ Means with different superscripts within column in the same effect are significantly different ($P \leq 0.05$).

Table (2): The effects of housing systems and rearing area on feed intake and feed conversion ratio of broiler chickens reared in enclosed houses (Means ± SEM)

Items / Treatments	Feed intake (g)				Feed conversion ratio			
	1-14 days	15-28 days	29-35 days	1-35 days	1-14 days	15-28 days	29-35 days	1-35 days
Effect of housing systems:								
Cages	495.00	1612.00	1266.00^{a}	3373.00	1.23^{b}	1.50^{b}	1.75^{b}	1.53^{b}
Floor	542.08	1536.00	1220.00^{b}	3298.00	1.44^{a}	1.60^{a}	1.79^{a}	1.63^{a}
SEM	2.78	7.07	10.06	8.89	0.01	0.01	0.02	0.01
Sig.	NS	NS	*	NS	*	*	*	*
Effect of rearing area:								
Vent	525.62^{a}	1611.00^{a}	1250.00	3387.00^{a}	1.28^{c}	1.52^{b}	1.74	1.55^{b}
Middle	521.25^{a}	1569.00^{b}	1239.00	3330.00^{b}	1.33^{b}	1.56^{a}	1.78	1.59^{a}
Fan	508.75^{b}	1542.00^{c}	1240.00	3291.00^{c}	1.39^{a}	1.56^{a}	1.80	1.61^{a}
SEM	3.36	8.67	12.33	10.89	0.01	0.01	0.02	0.01
Sig	*	*	NS	*	*	*	NS	*
Effect of interaction:								
Cage ×Vent	501.25^{c}	1654.00^{a}	1261.00^{ab}	3416.00^{a}	1.18^{d}	1.51^{b}	1.73	1.52^{d}
Cage ×Middle	498.75^{cd}	1606.00^{b}	1260.00^{ab}	3365.00^{b}	1.25^{c}	1.50^{b}	1.75	1.54^{cd}
Cage ×Fan	485.00^{d}	1578.00^{b}	1276.00^{a}	3339.00^{bc}	1.26^{c}	1.51^{b}	1.78	1.55^{bc}
Floor ×Vent	550.00^{a}	1569.00^{bc}	1239.00^{abc}	3357.00^{b}	1.39^{b}	1.54^{b}	1.75	1.58^{b}
Floor ×Middle	543.75^{ab}	1532.00^{cd}	1219.00^{bc}	3295.00^{c}	1.42^{b}	1.64^{a}	1.78	1.65^{a}
Floor ×Fan	532.50^{b}	1506.00^{d}	1204.00^{c}	3242.00^{d}	1.53^{a}	1.6^{3a}	1.82	1.67^{a}
SEM	4.76	12.26	17.43	15.40	0.01	1.63	0.04	0.01
Sig	*	*	*	*	*	*	NS	*

$^{a, b, c \ldots}$Means with different superscripts within column in the same effect are significantly different ($P \leq 0.05$).

Table (3): The effects of housing systems and rearing area on livability, EPEF and total faecal bacterial count of broiler chickens reared in enclosed houses (Means ± SEM):

Items / Treatments	Traits		
	Livability (%)	EPEF*	TFBC (CFU/g)**
Effect of housing systems:			
Cages	96.66^{a}	411.12^{a}	147.22^{b}
Floor	85.41^{b}	315.70^{b}	217.22^{a}
SEM	1.47	5.52	6.83
Sig	*	*	*
Effect of rearing area:			
Vent	95.00^{a}	399.53^{a}	155.00^{b}
Middle	91.87^{a}	361.97^{b}	172.67^{b}
Fan	86.25^{b}	328.73^{c}	219.00^{a}
SEM	1.80	6.76	8.36
Sig	*	*	*
Effect of interaction:			
Cage ×Vent	98.75^{a}	435.22^{a}	116.00^{c}
Cage ×Middle	97.50^{a}	412.60^{ab}	140.00^{c}
Cage ×Fan	93.75^{ab}	385.55^{bc}	185.67^{b}
Floor ×Vent	91.25^{ab}	363.85^{c}	194.00^{b}
Floor ×Middle	86.25^{bc}	311.35^{d}	205.33^{b}
Floor ×Fan	78.75^{c}	271.92^{e}	252.33^{a}
SEM	2.55	9.57	11.82
Sig	*	*	*

$^{a, b, c \ldots}$ Means with different superscripts within column in the same effect are significantly different (P≤ 0.05).
*EPEF=European performance efficiency factor
**TFBC = Total faecal bacterial count

Table (4): The effects of housing systems and rearing area on hematological parameters of broiler chickens reared in enclosed houses (Means ± SEM)

Items / Treatments	Hematological parameters						
	WBCS (k/µ L)	RBCS (k/µ L)	HB (g/d L)	PCV %	Hetrophils %	Lymphocytes %	H/L ratio
Effect of housing systems:							
Cages	7817.00	3498000	10.44	30.77	22.27	74.16	0.30^{b}
Floor	8469.00	3683000	11.47	34.61	30.27	66.83	0.45^{a}
SEM	434.87	66560	0.12	0.51	1.93	1.98	0.04
Sig	NS	NS	NS	NS	NS	NS	*
Effect of rearing area:							
Vent	9050.00^{a}	3852000^{a}	10.67^{b}	31.75	27.16	70.50	0.39
Middle	8267.00^{ab}	3478000^{b}	10.95^{ab}	33.00	27.50	67.66	0.41
Fan	7113.00^{b}	3441000^{b}	11.25^{a}	33.33	24.16	73.33	0.33
SEM	532.60	81520	0.15	0.62	2.37	2.42	0.05
Sig	*	*	*	NS	NS	NS	NS
Effect of interaction:							
Cage ×Vent	8417.00^{ab}	3612000^{b}	10.10^{c}	27.66^{c}	20.50^{b}	76.50^{a}	0.27^{c}
Cage ×Middle	7950.00^{ab}	3425000^{b}	10.60^{bc}	31.66^{b}	21.33^{b}	74.50^{ab}	0.29^{c}
Cage ×Fan	7083.00^{b}	3430000^{b}	10.63^{bc}	33.00^{b}	25.00^{ab}	71.50^{ab}	0.35^{bc}
Floor ×Vent	9683.00^{a}	4092000^{a}	11.25^{ab}	35.83^{a}	33.83^{a}	64.50^{bc}	0.52^{ab}
Floor ×Middle	8583.00^{ab}	3503000^{b}	11.30^{a}	34.33^{ab}	33.66^{a}	60.83^{c}	0.55^{a}
Floor ×Fan	7142.00^{b}	3453000^{b}	11.86^{a}	33.66^{ab}	23.33^{ab}	75.16^{ab}	0.31^{bc}
SEM	753.21	115300	0.22	0.88	3.35	3.43	0.07
Sig	*	*	*	*	*	*	*

$^{a, b, c \ldots}$ Means with different superscripts within column in the same effect are significantly different ($P \leq 0.05$).

Table (5): The effects of housing systems and rearing area on some carcass traits, lymphoid organ weights and antibody titer response of broiler chickens reared in enclosed houses (Means ± SEM)

Items / Treatments	Carcass weights (g)				Lymphoid organ weights (g)			NDV(HI Titer (log - 2)
	Heart	Liver	Gizzard	Abdominal fat	Spleen	Bursa	Thymus gland	
Effect of housing systems:								
Cages	9.11	54.44	33.55	49.44^{a}	2.46	1.42^{a}	9.66	5.66
Floor	7.55	42.77	27.55	29.44^{b}	1.66	1.26^{b}	8.11	5.00
SEM	0.23	1.92	0.74	1.96	0.11	0.05	0.61	0.32
Sig	NS	NS	NS	*	NS	*	NS	NS
Effect of rearing area:								
Vent	8.66	53.33	32.50^{a}	41.66	2.26	1.40	9.5	6.00^{a}
Middle	8.16	46.66	29.50^{b}	38.33	2.01	1.33	9.00	5.66^{a}
Fan	8.16	45.83	29.66^{b}	38.33	1.91	1.3	8.16	4.33^{b}
SEM	0.28	2.35	0.91	2.4	0.13	0.06	0.75	0.39
Sig	NS	NS	*	NS	NS	NS	NS	*
Effect of interaction:								
Cage ×Vent	9.33^{a}	60.00^{a}	35.66^{a}	53.33^{a}	2.66^{a}	1.48	10.33	6.00^{a}
Cage ×Middle	9.00^{a}	53.33^{ab}	33.00^{ab}	46.66^{a}	2.40^{ab}	1.40	9.66	6.00^{a}
Cage ×Fan	9.00^{a}	50.00^{abc}	32.00^{ab}	48.33^{a}	2.33^{ab}	1.40	9.00	5.00^{ab}
Floor ×Vent	8.00^{ab}	46.66^{bc}	29.33^{bc}	30.00^{b}	1.86^{bc}	1.33	8.66	6.00^{a}
Floor ×Middle	7.33^{b}	40.00^{c}	26.00^{c}	30.00^{b}	1.63^{c}	1.26	8.33	5.33^{ab}
Floor ×Fan	7.33^{b}	41.66^{c}	27.33^{c}	28.33^{b}	1.50^{c}	1.20	7.33	3.66^{b}
SEM	0.40	3.33	1.29	3.4	0.19	0.09	1.07	0.56
Sig	*	*	*	*	*	NS	NS	*

$^{a, b, c \ldots}$ Means with different superscripts within column in the same effect are significantly different ($P \leq 0.05$).

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الملخص العربى

تقييم نظام التربيه الأرضية مقابل التربيه فى البطاريات لدجاج اللحم المربى في ثلاث مناطق مختلفة من المسكن المغلق على الاداء الإنتاجي والفسيولوجي

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أجريت هذه الدراسة بهدف تقييم تاثير نظامى التسكين التربيه الأرضية مقابل التربيه فى البطاريات على الأداء الانتاجى والاستجابه الفسيولوجيه لكتاكيت التسمين المرباه في ثلاث مناطق في المساكن المغلقة (الجانب القريب من منطقة التبريد ، وسط المسكن ، نهاية المسكن). تم اختيار عدد 3120 كتكوت بشكل عشوائي لكلا النظامين حيث كان عدد الكتاكيت الكلى فى المسكن الاول نظام البطاريات 83200 ، وعدد 22500 كتكوت للنظام الثانى التربيه الارضيه على التوالي . تم تقسيم العدد المختار عشوائيا إلى مجموعتين لكلا النظامين :النظام الاول التسكين فى البطاريات حيث احتوى النظام الاول (البطاريات) على عدد 1560 كتكوت ، بينما النظام الثانى (الارضى) احتوى ايضا على عدد 1560 كتكوت حيث كانت الطيور في كلا النظامين موجوده فى ثلاث مناطق مختلفة واحتوت كل منطقه على عدد 520 طائر تم توزيعهم على أربع مكررات تحتوي على 130 طائر لكل منهما. أظهرت النتائج أن الأداء الانتاجى والمتمثل فى وزن الجسم، ووزن الجسم المكتسب، والغذاء المستهلك، والتحويل الغذائى، والحيويه ومعامل كفاءه الانتاج الاوربى كان اعلى معنويا للطيور المرباه في نظام البطاريات مقارنته بتلك الطيور المرباه على الارض. ومن جهه ثانيه سجلت الصفات السابقة نتائج أفضل معنويا للطيور الموجوده في منطقة التبريد مقارنه بالطيور الموجوده في المنطقه الوسطى او الاخيره من المسكن لكلا النظامين. كما اشارت النتائج الى ان العد الكلى للبكتريا فى الزرق كان اعلى معنويا للطيور المرباه على الأرض والموجوده في منطقة نهايه المسكن مقارنه بتلك الموجوده في المنطقة الوسطى ومنطقه التبريد من المسكن على التوالي . كما لوحظ ان الاستجابه المناعيه للطيور الموجوده فى منطقه التبريد والمنطقه الوسطى من المسكن حققت قيم اعلى بالمقارنه بتلك الطيور الموجوده فى نهايه المسكن. وعموما ومن خلال هذه النتائج يمكن ان نستخلص ان دجاج التسمين المربى في البطاريات والموجود فى منطقه التبريد أظهر اداء انتاجى واستجابة فسيولوجية افضل من الطيورالمرباه على الأرض والموجوده فى المنطقه الوسطى او الاخيره من المسكن .