Effects of different broiler flooring systems on surface temperature, air quality and carcass characters of broilers

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Abstract
The present study investigated the use of perforated plastic floors with different heights in the broiler performance, surface temperature, air quality, and carcass characters of broilers. Three hundred sixty-seven day-old unsexed chicks randomly divided into 4 groups: control reared on sawdust litter in others used, plastic floors with different heights (5, 10 and 15) cm, for 2nd, 3rd and 4th treatment respectively. The first treatment (sawdust) showed significantly (P <0.05) increase in body surface temperature, as compared to the plastic floors system treatments, and the three plastic floor treatments affected air quality, with less concentrations of ammonia and carbon dioxide compared to the sawdust. The results showed significant differences (P <0.05) in the live relative weight, where the treatments T2, T3 and T4 were increase at the age of 35 days compared to the sawdust treatment. We suggested the perforated plastic floors could be a good alternative to promote a better quality environment and superior production rates with improved surface temperature.

Key words: Broiler, plastic floors, production, sawdust, bedding

1. Introduction
Bedding or its component materials are an important component of poultry production that can affect animal welfare, flock health, feed hygiene, environmental impacts, and production efficiency. [1]. Each type of bedding has its advantages and disadvantages in terms of availability, cost, and absorption. Their density, comfort for birds, insulation efficiency, reusability, chemical and microbiological risks to human and animal health and the environment [2-4]. Litter affects the behaviour and physiology of birds [4-6], which may affect birds’ growth, performance, immune status, and welfare [3,7]. For example, the thermal insulation properties of litter can help reduce temperature variability in poultry houses [1]. Since lower ambient temperatures increase energy demands in birds to maintain body temperature, the ratio of trophic conversion can be negatively affected when temperatures vary [8]. On the other hand, hot conditions cause heat stress which leads to lower production. At high temperatures, bedding materials can release absorbed moisture to contribute to the thermoregulation process [9]. Due to the high cost and low availability of raw materials for poultry litter, producers use the same material for several cycles of rearing in an effort to reduce production costs [10]. However, according to [11], the reuse of these poultry brushes over a number of breeding cycles increases the unwanted effects of ammonia (NH3) accumulation. Exposure to high concentrations of NH3 decreases the productive performance of birds [12], affects the immune system [13], and increases susceptibility to disease [14]. This exposure can also affect the health of workers who are in daily contact with this gas [15]. One of the possible solutions to reduce the negative effects of litter may be the use of a perforated plastic floor, similar to that used in raising pigs, as it is possible to constantly remove poultry droppings from inside the hall, avoiding the decomposition of excreta and thus the production of NH3. The cost of retaining poultry droppings can also be reduced by continuous removal of excreta and not accumulating in large quantities at the end of the rearing cycle. Gas emissions are responsible for a decrease in indoor and outdoor air quality, which arises from the decomposition and fermentation of litter and droppings [16]. Poultry that excrete nitrogen N mainly in the form of uric acid, and it decomposes into the form of ammonia, while bird respiration is the main source of carbon dioxide emission, so there is an increase in the concentration of these two gases in poultry houses [17,18,19]. The objective of this study was to investigate the effects of use perforated plastic floors with different heights in the broiler performance, surface temperature, air quality, and carcass characters of broilers.

2. Materials and methods
This study was conducted in the poultry farm of the Animal Production Department at the College of Agriculture - Tikrit University for the period from 26/2 to 31/3/2020, with the aim of studying a comparison of sawdust mats with three different heights of perforated plastic floors 5, 10 and 15cm respectively.
2.1. Experimental animals:

A total of 360 broiler chicks (Ross 308) at 7 days of age. Average weight 111.9 g. Randomly divided into four treatments at 90 birds per treatment and by 3 replicates (30 birds / replicate) in ground cages and the dimensions of one cage were 2 x 1 m. and chicks were distributed to the parameters at the age of 7 days as follows:

T1  Sawdust
T2  Plastic floor height of 5 cm
T3  Plastic floor height of 10 cm
T4  Plastic floor height of 15 cm

Feeding: Three different diets were used in feeding birds (Starter, Grower, and finisher), and the values of the feeds were calculated according to the reports of N.R.C. [20] and the provision of feed and water to the birds was free, as in Table (1):

Table 1. The components of the diets used in the experiment and the calculated chemical analysis.

| Diet elements      | Starter day 0–10 | Grower days 11–24 | Finisher 25–35 |
|--------------------|------------------|-------------------|----------------|
| yellow Corn        | 46.18            | 50.08             | 53.88          |
| Wheat              | 9.92             | 10.22             | 9              |
| Soybean Meal       | 36.9             | 33                | 29.5           |
| Fat                | 2.8              | 3.1               | 4.2            |
| Premix             | 2.5              | 2.5               | 2.5            |
| Dicalcium phosphate| 1                | 0.5               | 0.2            |
| CaCO3              | 0.3              | 0.3               | 0.5            |
| Methionine         | 0.1              | 0.1               | 0.1            |
| Lysine             | 0.3              | 0.2               | 0.12           |
| Total              | 100              | 100               | 100            |

Chemical analysis

| Metabolism Energy  | 3027.74          | 3099.59          | 3202.42        |
|--------------------|------------------|------------------|----------------|
| Crude protein%     | 23.02            | 21.52            | 20.02          |
| Lysine%            | 1.48             | 1.28             | 1.12           |
| Methionine %       | 0.57             | 0.56             | 0.54           |
| Methionine + cysteine% | 0.92          | 0.89             | 0.85           |
| Calcium %          | 0.97             | 0.84             | 0.83           |
| Available phosphorus % | 0.61          | 0.52             | 0.45           |

2.2. Environmental measurements:

- Concentration of NH3 in the air: The concentration of ammonia gas was measured at the height of the bird's head by means of a type (SMART SENSOR AR8500) sensor.
- CO2 concentration: The carbon dioxide concentration was measured at the height of the bird's head by means of the KKMOON Air Quality Tester sensor.
- Surface temperature: The surface temperatures of birds were measured with a Seesii thermal imaging camera and the images were analyzed by MATLAB software.
- Heat loss

The loss heat by radiation (QR) and convection (QC) from birds to the environment was calculated using a set of equations according to [22].

\[ QT = QC + QR \]

\[ QC = (T_{air} - T_s) * h * As \]

\[ QR = 4(T_{air} - T_s) As * \sigma * e \]

\[ h = 0.336 * 4.184 * (1.46 + \sqrt{V_{air} * 100}) \]

where:
- QT is the total heat (W m\(^{-2}\))
- As is the bird's surface area (m\(^2\));
- h is the heat transfer coefficient, (W m\(^{-2}\) - K\(^{-1}\));
- Vair is the velocity of air
- T\(_s\) is the average surface temperature of birds (Kelvin);
- T\(_{air}\) is the air temperature (Kelvin);
- \(\sigma\) is Stefan Boltzmann's constant, and is equal to 5.6691 x 10\(^{-8}\).

The bird surface area (As) was calculated with the following equation, proposed by [23]:

\[ As = 3.86 * MC^{0.74} \]

Where MC is the mass of live weight (g)

### 2.3. Productive performance
- Body weight: The birds were weighed at the end of each week with a sensitive balance that measures two places after the sorter in order to find the weight gain.
- The carcass percentage: The carcass percentage was calculated according to the equation mentioned by [21], which is as follows:

  \[ \text{The carcass percentage} \% = \frac{\text{Carcass weight (g) without the giblets}}{\text{Live body weight (g)}} \]

  - The carcasses were cut into the main and secondary parts, which included the chest, thigh, drumsticks, back, neck, and wings, and their proportions were extracted from the weight of the carcass.
- Percentage of cuts \% = \frac{\text{cut weight (g)}}{\text{carrass weight (g)}}

### 2.4. Statistical analysis

The results of the experiment were analyzed statistically using a complete random design (CRD) and a general linear model within the ready-made statistical program [24] to study the effect of different types of flooring design on broiler, and Duncan [25] was tested to determine the significant differences between the averages of the factors affecting the traits. The study was studied at a significant level (p < 0.05).

\[ Y_{ij} = M + Ti + e_{ij} \]
3. Results and discussion:

The results presented in Table No. (2) show the effect of the type of flooring system on the surface temperature of broilers. The data showed that birds raised on T1 (sawdust) have higher values (P ≤0.05) for surface temperature compared to birds raised on perforated plastic floor in treatments (T2, T3, T4) at 35 days of age. The temperature of the different parts of the body was not significantly affected by the different flooring system. Exposure of the bird to stress increases blood flow and thus the surface temperature of the bird's body [26]. Therefore, birds raised on sawdust may have been subjected to stress, which led to an increase in their surface temperature due to the bedding system that works to isolate the birds' temperature from the ground and thus reduce the thermal conductivity. The body heat of stressed birds can be dissipated through the soles of the feet [27]. Unlike plastic raised floors, it provides direct contact of the birds' feet with the ground, good thermal conductivity, and also facilitates the movement of air under the birds.

Table 2. The effect of different types of flooring system on the surface temperature of broilers at the age of 35 days.

| Treatments | Surface temperature (ºC) |
|------------|---------------------------|
|            | T1 | T2 | T3 | T4 |
| Head       | 34.81 | 33.53 | 33.34 | 33.51 |
| Chest      | 39.72 ± 0.29 | 38.85 ± 0.39 | 38.98 ± 0.8 | 39.02 ± 0.44 |
| Back       | 34.86 ± 0.06 | 34.04 ± 0.08 | 35.06 ± 0.16 | 34.23 ± 0.08 |
| Foot       | 38.63 ± 0.21 | 36.76 ± 0.61 | 37.43 ± 0.13 | 37.86 ± 0.11 |
| Leg        | 39.76 ± 0.23 | 39.26 ± 0.83 | 38.86 ± 0.5 | 39.16 ± 0.4 |
| Average    | a37.56 ± 0.33 | b36.49 ± 0.32 | b36.73 ± 0.26 | b36.76 ± 0.27 |

The different letters within the same row indicate the presence of significant differences at the (P <0.05) level. T1, T2, T3, T4 sawdust, wire floor height 5, 10 and 15 cm respectively.

No significant differences were noticed between the different treatments of broilers on heat loss by radiation and convection, as in Figure (1). It is important to increase the heat exchange of birds through the difference between the surface temperature of the bird and the air temperature. In this case, when this difference is small, birds increase the heat transfer through evaporation by panting, which requires much energy, leading to a decrease in production performance [28]. Alves et al [29] assessed the surface temperature and the heat loss by radiation of broilers of two different breeds of males and females aged 35 days, and fed them with different fat sources, measured using thermal images. A decrease in surface temperature and a decrease in the amount of heat loss by radiation were found in female birds of the Cobb strain. The thermal production in broilers is relatively high because the growth rate depends on the consumption of feed with the utilization efficiency of the Metabolic Energy (ME), which can reach 40%. This indicates that 60% of the energy represented would be lost by heat [30]. According to [26] heat exchange occurs through the loss of heat by convection and radiation, which depends on the difference between the surface temperature of a bird's body and the ambient temperature, that is, the greater the difference, the greater the efficiency of this exchange. Different areas of the bird's body can contribute in a different way. In the body temperature balance, which can be classified into the areas of regulating and maintaining the temperature of the vessels, such as the areas covered by feathers while the areas without feathers have a greater contribution to the heat exchange between the body surface and the surrounding environment [31].
Figure 1. Shows the effects of different broiler flooring systems on heat loss by radiation and convection of broilers at the age of 35 days, where \( Q_r \) is the heat loss by radiation, \( Q_c \) is the heat loss by convection, and \( Q_T \) is the total heat loss.

Figures (2) and (3) show the concentration of NH\(_3\) and CO\(_2\) respectively in the environment of broilers raised on different types of flooring system from the age of 8 to 33 days, where it is noticed that there is a significant increase in the concentration of NH\(_3\) and CO\(_2\) in the first treatment (sawdust bedding) compared to other treatments, and it is also noticed that there is an inverse relationship between the plastic floor with the concentration of NH\(_3\) and CO\(_2\) in the air. Environmental conditions for farm workers in Poultry facilities are no less important than for animals. NH\(_3\) was measured in the air in sawdust treatment at 33 days of age and reached a concentration of 5 ppm and is within the range recommended by GLOBAL G.A.P [32], which is the main program for farm quality assurance in the world. This program stipulates that the concentration of NH\(_3\) in the air in the production environment should not exceed 20 ppm. Carvalho et al. [33] found NH\(_3\) concentrations approaching 60 ppm when studying the effect of poultry bedding quality on the environment in poultry facilities. They reported that this high concentration of NH\(_3\) in the air was due to the reuse the litter, which led to further degradation of nitrogen compounds in the bedding material and thus increased NH\(_3\) release into the production environment. Traldi et al. [34] also note that there is a higher probability of NH\(_3\) volatilization in reused litter compared to new bedding. According to [35], high concentrations of NH\(_3\) reduce animal comfort, cause health problems, and reduce the safety and efficiency of the production process.

According to the Brazilian Worker Safety Regulations [36] the permissible concentrations of NH\(_3\) for humans are 20 ppm, with exposure permissible up to 8 hours per day. However, Carvalho et al. [37] showed that when the concentration of ammonia gas is higher than 10 ppm, irritation appears in the eyes and nose, and it is recommended to use masks throughout the period of stay in the poultry farm. In this study, ammonia gas concentration appeared within the permissible range for humans, however, the low production of NH\(_3\) obtained in plastic floor treatments is a very important result, as NH\(_3\) was not produced in high concentrations in treatments with perforated plastic floors, This results in less harmful effects on animals and people who live and work in the poultry facility. With regard to the concentration CO\(_2\), it was observed that an increase in CO\(_2\) in the air is linked to the growth of broilers, a result that is consistent with the results of [38] that the observed CO\(_2\) emissions are directly proportional to live weight, and their rates are directly proportional to the weight gain. The concentration of CO\(_2\) in the air in the treatment of sawdust was higher than what was observed in the environment of plastic floors, due to the microbial decomposition process of the organic matter accumulated in the sawdust [39]. Orrico et al. [40] observed that the majority of organic matter in poultry waste is lost in the form of water and CO\(_2\). In this study, even in the treatment of sawdust, CO\(_2\) concentrations remained within the optimal range, which according to GLOBAL G.A.P [32] is 5,000 ppm for broilers, with values higher than this representing a risk to animals. Henn [39] also observed levels (1,260 ppm) below the critical limit for CO\(_2\) concentration in his study of the use of new sawdust in raising broilers.
Figure 2. Shows the effects of different broiler flooring systems on the NH₃ concentration in the broiler environment.

Figure 3. Shows the effects of different broiler flooring systems on the CO₂ concentration in the broiler environment.

The results of this study, as shown in Table No. (3) a significant increase of the live weight and the carcass weight of birds raised on a perforated plastic floor compared to a sawdust, while no significant differences were shown for the relative weight of carcass and the relative weight of the cuts between the different treatments. These results are consistent with the findings of [39], where no significant differences were observed in the relative weight of male and female broiler chicks in a comparison study of perforated plastic floors with sawdust. The improvement in live weight in birds raised on plastic floors may be due to improved environmental conditions such as air quality and thermal comfort for birds, which in turn led to improved production performance.

Table 3. Effect of different types of flooring system on the live body weight relative carcass yield and parts of broilers at 35 day of age.

| Treatments          | Performance |
|---------------------|-------------|
|                     | T1          | T2          | T3          | T4          |
| Live body weight    | b 1758.33   | a2041.67    | a2018.33    | a2103.33    |
|                    | 52.6±       | 16.4±       | 17.4 ±      | 124.1±      |
| Carcass weight      | b1251.67    | a1460       | a1456       | a1513.33    |
|                    | 49.1±       | 5±          | 14.5±       | 107.0±      |
| Carcass weight %    | 71.14       | 71.51       | 72.14       | 71.85       |
|                    | 0.82 ±      | 0.56 ±      | 0.34±       | 0.9±        |
| Chest %             | 31.94       | 33.31       | 34.79       | 34.69       |
|                    | 0.45 ±      | 0.16 ±      | 0.25±       | 1.8±        |
| Thigh %             | 13.38       | 13.01       | 13.03       | 12.78       |
|                    | 0.21±       | 0.81±       | 0.31±       | 0.21±       |
| Drumsticks %        | 13.72       | 14.08       | 13.26       | 13.44       |
|                    | 0.31±       | 0.47±       | 0.19±       | 0.31±       |
| Wings %             | 10.93       | 10.09       | 9.71        | 10.06       |
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Breitly, M.F., Mahrosse, K.M., Ullah, Z., Rehman, Z.U. and Ding, C., 2017. Influence of swimming time in alleviating the effects of acute ammonia on aerobic performance and conditions in broiler chickens. Veterinary, 3(1), pp.18-21.

Iqbal, A., Javed, M.T., Hassann, M., Khan, I.A. and Munir, M.T., 2015. Early biochemical changes induced by various concentrations of ethanol through drinking water in broiler chicks. Veterinary, 3(1), pp.18-21.

References

1. Dunlop, M.W., McAuley, J., Blackall, P.J. and Stuetz, R.M. 2016. Water activity of poultry litter: Relationship to moisture content during a grow-out. Journal of Environmental Management, 172, pp.201-206.
2. Viegas, C., Carolino, E., Malta-Vacas, J., Sabino, R., Viegas, S. and Verissimo, C., 2012. Fungal contamination of poultry litter: a public health problem. Journal of Toxicology and Environmental Health, Part A, 75(22-23), pp.1341-1350.
3. Shao, D., He, J., Lu, J., Wang, Q., Chang, L., Shi, S.R. and Bing, T.H., 2015. Effects of sawdust thickness on the growth performance, environmental condition, and welfare quality of yellow broilers. Poultry science, 94(1), pp.1-6.
4. Munir, M.T., Arif Zafar, M., Mukhtar, N., Yousaf, A., Safdar, M., Umar, S. and Arif, M., 2015. Intramedullary fixation approach to tibiotarsal fracture in ostrich (Struthio camelus). 2 Case Report. Veterinaria, 3(1), pp.28-31.
5. Nowaczewski, S., Rosiński, A., Markewicz, M. and Kontcka, H., 2011. Performance, foot-pad dermatitis and haemoglobin saturation in broiler chickens kept on different types of litter. Archiv für Geflügelkunde, 75(2), pp.132-139.
6. Cabrera, M.L., Kissel, D.E., Hassan, S., Rema, J-A. and Cassity-Duffy, K., 2018. Litter type and number of flocks affect sex hormones in broiler litter. Journal of environmental quality, 47(1), pp.156-161.
7. Umar, S., Nawaz, S., Shahzad, M., Munir, M.T. and Shah, M.A.A., 2015. Emerging issue of gangrenous dermatitis in broilers. J. Avian Res, 1(2), pp.17-19.
8. Iqbal, A., Javed, M.T., HASSAN, M., Khan, I.A. and Munir, M.T., 2015. Serobiochemical changes induced by various concentrations of ethanol through drinking water in broiler chicks. Veterinaria, 3(1), pp.18-21.
9. Farghly, M.F., Mahrose, K.M., Ullah, Z., Rehman, Z.U. and Ding, C., 2017. Influence of swimming time in alleviating the deleterious effects of hot summer on growing Muscovy duck performance. Poultry science, 96(11), pp.3912-3919.
10. Lopes, M., Roll, V.F.B., Leite, F.L., Dai Prá, M.A., Xavier, E.G., Heres, T. and Valente, B.S., 2013. Quicklime treatment and stirring of different poultry litter substrates for reducing pathogenic bacteria counts. Poultry science, 92(3), pp.638-644.
11. Medeiros, R., B. J. M. Santos, M. Freitas, O. A. Silva, F. F. Alves, and E. A. Ferreira. 2008. Adiçao de diferentes produtos quimicos e o efeito da umidade na volatilizaçao e amonia em cama de frango. Ciencerural. 38. 2321–2326.
12. Miles, D. M., S. L. Branton, and B. D. Lott. 2004. Atmospheric ammonia is detrimental to the performance of modern commercial broilers. Poult. Sci. 83: 1650–1654.
13. Wei, F.X., Hu, X.F., Xu, B., Zhang, M.H., Li, S.Y., Sun, Q.Y. and Lin, P., 2015. Ammonia concentration and relative humidity in poultry houses affect the immune response of broilers. Genet Mol Res, 14(2), pp.3160-3169.
14. Beker, A., Vanhooser, S.L., Swartzlander, J.H. and Teeter, R.G., 2004. Atmospheric ammonia concentration effects on broiler growth and performance. Journal of Applied Poultry Research, 13(1), pp.5-9.
15. Rylander, R., and M. F. Carvalheiro. 2006. Airways inflammation among workers in poultry houses. Int. Arch. Occup. Environ. Health. 79: 487–490.
16. Meda, B., Hassouna, M., Aubert, C., Robin, P. and Dourmad, J.Y., 2011. Influence of rearing conditions and manure management practices on ammonia and greenhouse gas emissions from poultry houses. World’s Poultry Science Journal, 67(3), pp.441-456.
17. Lin, X., Zhang, R., Jiang, S., El-Mashad, H. and Xin, H., 2017. Emissions of ammonia, carbon dioxide and particulate matter from cage-free layer houses in California. Atmospheric Environment, 152, pp.246-255.
18. Pereira, J., Garcia, C., Ferreira, S., Pinheiro, V., Trindade, H., Conde, A. and Ferreira, P., 2017. June. Assessment of ammonia and carbon dioxide concentrations in a breeding hen building under Portuguese winter. In 3rd International Conference on Food & Biosystems Engineering (FaBE) (pp. 118-123).
19. Naseem, S. and King, A.J., 2018. Ammonia production in poultry houses can affect health of humans, birds, and the environment—techniques for its reduction during poultry production. Environmental Science and Pollution Research, 25(16), pp.15269-15293.
20. N.R.C. National Research council .1994. Nutrient requirement of poultry. (9th Rev. Ed.). National Research Council. National Academy Press, Washington, D.S., USA.
[21] Alsultani, M., Abed, H., Ghazi, R., & Mohammed, M.A. (2020). Electrical Characterization of Thin Films (TiO2: ZnO)1-x (GO)x / FTO Heterojunction Prepared by Spray Pyrolysis Technique. Journal Of Physics: Conference Series, 1591, 012002. doi: 10.1088/1742-6596/1591/1/012002

[22] Silva, E., Yanagi Júnior, T., Braga Júnior, R.A., Lopes, M.A., Damasceno, F.A. and Silva, G.C., 2009. Desenvolvimento e validação de um modelo matemático para o cálculo da área superficial de frangos de corte. Engenharia Agrícola, 29(1), pp.1-7.

[23] SAS Verson , Statistical Analysis System .2005. SAS Institute Inc., Cary , NC.27512-8000, USA.

[24] Duncan, D.B. 1955. Multiple range multiple F-test-Biometeics., 11:1 –42.

[25] Nääs, I.D.A., Romanini, C.E.B., Neves, D.P., Nascimento, G.R.D. and Vercellino, R.D.A., 2010. Broiler surface temperature distribution of 42 day old chickens. Scientia Agricola, 67(5), pp.497-502.

[26] Ferket, P.R., 1998. Alternative turkey management systems. In Proceedings of the 21st Technical Turkey Conference (pp. 52-58).

[27] Ahmed H. A. Al-Jobouri. (2020). Studying Some The Functional Properties of Tamarind Tamarindus indica L. Mucilage. Al-Qadisiyah Journal For Agriculture Sciences, 10(2), 304-307.

[28] Alves, F.M.S., Felix, G.A., Almeida Paz, I.C.L., Nääs, I.A., Souza, G.M., Caldara, F.R. and Garcia, R.G., 2012. Impact of exposure to cold on layer production. Brazilian Journal of Poultry Science, 14(3), pp.223-226.

[29] Fernandes, G.A.; Fernandes, F. F. D.; Mousquer, C. J. 2014. Nutrição de frangos de corte adequada a regiões de clima quente — Revisão. Revista Eletrônica Nutritime, Viçosa, v. 11, n. 01, p. 3045 – 3069.

[30] Shinder, D., Rusal, M., Tanny, J., Druyan, S. and Yahav, S., 2007. Thermoregulatory responses of chicks (Gallus domesticus) to low ambient temperatures at an early age. Poultry science, 86(10), pp.2200-2209.

[31] GLOBAL, G., 2017. Integrated Farm Assurance: All Farm Base-Crops Base-Fruit and Vegetables: Control Points and Compliance Criteria. http://www1.globalgap.org/north-america/upload/Standards/IFA/v5 0/150901 GG IFA CPCC PY en.pdf.

[32] Carvalho, T.M.R., de Moura, D.J., de Souza, Z.M., de Souza, G.S. and de Freitas Bueno, L.G., 2011. Qualidade da cama e do ar em diferentes condições de alojamento de frangos de corte. Pesquisa Agropecuária Brasileira, 46(4), pp.351-361.

[33] AYEOLOJA Ayodeji Ahmed. (2020). GLIMPSE OF FISH AS PERISHABLE STAPLE. Al-Qadisiyah Journal For Agriculture Sciences, 10(2), 349-375.

[34] MTE - Ministério do Trabalho e Emprego. NR 15 – Atividades e operações insalubres. Segurança e medicina do trabalho 2008. Acessed Apr. 2016. http://www.ccb.usp.br/arquivos/ arq pessoal/1360237303 nr15 atualizada2011ii.pdf.

[35] Santos, C.R.D., 2012. Condições ergonômicas dos trabalhadores em galpões de frangos de corte durante a fase de aquecimento. Revista Brasileira de Engenharia Agrícola e Ambiental, 16(11), pp.1243-1251.

[36] Henn, J.D., Bockor, L., Borille, R., Coldebella, A., Ribeiro, A.M.L. and Kessler, A.M., 2015. Determination of the equation parameters of carbon flow curves and estimated carbon flow and CO2 emissions from broiler production. Poultry science, 94(9), pp.2303-2312.

[37] Henn, J.D., 2013. Modelagem da emissão de dióxido de carbono na produção de frangos de corte.

[38] Orrico Júnior, M.A., Orrico, A.C. and Lucas Júnior, J.D., 2010. Compostagem dos resíduos da produção avícola: cama de frangos e carcaças de aves. Engenharia Agrícola, pp.538-545.

[39] Almeida, E.A., de Souza, L.F.A., Sant’Anna, A.C., Bahiense, R.N., Macari, M. and Furlan, R.L., 2017. Poultry rearing on perforated plastic floors and the effect on air quality, growth performance, and carcass injuries—Experiment 1: Thermal comfort. Poultry science, 96(9), pp.3155-3162.