IN-FLOOR HEATING EFFECTS ON THE GROWTH AND LEG INJURIES IN BROILER CHICKENS

MERGEDUS, A., LEVANIC , M. & BRUS, M.

Abstract: *The aim of the study was to investigate whether in-floor heating affects growth rate, barn micro environment, litter quality and incidence of footpad dermatitis (FPD) in broiler chickens. The study was conducted in two barns, with and without in-floor heating, both of them with the same litter – wood shavings. Measurements were performed at six locations during the trial. We found that that the weekly weighing of the broilers showed significant differences ($P \leq 0.05$) in body mass, however the final body weight did not differ between the two barns. The in-floor heating in our study affected the moister content and expectably the quality of bedding material, resulting slower quality deteriorated in barn with in-floor heating. No FPD and hock burns were observed in either barn during all weeks of feeding. From the obtained results, we can easily conclude that the construction of the barn affects the microclimatic and litter conditions and thus significantly contribute to improving the welfare quality of chickens.*

Key words: *In-floor heating, broilers, growth rate, food pad dermatitis, litter quality*

Authors' data: Dr. Sc. **Mergedus**, A[ndrej]*; **Levanic**, M[atic]*; & Assist. prof. dr. Sc. **Brus**, M[aksimiljan]*. *University of Maribor, Faculty of Agriculture and Life Sciences, Pivola 11, 2311 Hoce, Slovenia, andrej.mergedus@um.si, matic.levanic12@gmail.com, maksimiljan.brus@um.si.

This Publication has to be referred as: Mergedus, A[ndrej]; Levanic, M[atic] & Brus, M[aksimiljan] (2023). In-floor Heating Effects on the Growth and Leg Injuries in Broiler Chickens, Chapter 04 in DAAAM International Scientific Book 2023, pp.051-064, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-902734-39-6, ISSN 1726-9687, Vienna, Austria
DOI: 10.2507/daaam.scibook.2023.04

1. Introduction

Housing and management are significant factors regarding animal health and welfare in poultry (Chuppava et al., 2018). Broiler growth depends mainly on correct nutrition during the feeding period and equally important environmental indoor conditions (Berg, 2002). To establish and maintain correct environmental management is quite a challenging factor. Farm facilities can have a dramatic impact on animal production and their health (Janzekovic and Mergedus, 2016). Environmental parameters such as ventilation rate, humidity and temperature balance affect production (Cui et al., 2020; Gurler et al., 2021).

The optimum ambient temperature for metabolic efficiency in broilers ranges from around 33 °C at birth to around 23 °C at 4 weeks (Jones, at al., 2005). At each stage of the birds' development there is one optimum temperature zone. In this zone the birds make the best performance in terms of the use of feed energy for growth and meat yield. Therefore, an efficient heating system is necessary for any broiler house to maintain the required temperatures all around the year (El-Zanaty, 2014). In this regard, in order to provide suitable conditions in the houses, it is necessary to spend energy and mainly fossil energy to heat the houses. How the barn is heated depends on barn design and the type of heating system that's installed. The traditional gas and electrical power are the primary sources for space heating within poultry houses. However, in the last period, poultry growers experienced the change in the running costs because of the rise in fuel prices. The importance of energy saving in production of animal products is great due to climate change and rising energy costs. Therefore, recent researches are moving towards consumption lower energy heating alternatives and use of renewable energy (Singh et al., 2002; Gholami et al., 2020). Various types of poultry heaters have been developed, seeking the best way to provide heat and thermal comfort with lower energy consumption. The in-floor heating system, also called underfloor or radiant heating, is an important alternative for obtaining thermal comfort and increased efficiency in energy consumption (Consantino at al., 2018).

In-floor heating has an effect on the quality of the litter. Good litter management is vital to maintain animal welfare including the absence of footpad dermatitis (FPD) and other dermatological problems. They are an important source of economic loss and also to welfare considerations linked to the potential associated pain and discomfort during the feeding time (Mayne et al., 2007). Different authors have found positive correlations between good litter quality, particularly low moisture, and the incidence of FPD (Ekstrand et al., 1997; Youssef et al., 2011).

In-floor heating systems have been used since ancient times due to their advantages compared to other heating systems. In-floor heating systems that use a fluid flowing through pipes. The pipes are cast in a concrete floor slab or they may be placed under some form of floor covering. The pipes are made of polyethylene, copper or steel. Most hydronic systems utilize water as the heat transfer fluid. Depending on the location pure water or a mix of water and anti-freeze may be used (Simiyu, 2015). In-floor heating systems, a more comfortable environment can be obtained, because the temperature distribution in indoor air is more homogenous than that of the other heating systems.

Other advantages are that the pipe work in this systems is hidden therefore all floor space is used by the animals. Gas heaters, and fens take up space in the room. Also, the use of low temperature heat and hidden pipes reduces fire risk, and has a lower maintenance costs. In-floor heating systems are also less affected on cold days when sudden temperature drops occur because heat is accumulated on the floor (Karadağ et al., 2007). The use of renewable energy is a suitable solution to heat the water for in-floor heating. Air, solar, ground source heat pump or biomass energy applications are sustainable and effective solutions for high fossil fuel consuming of the gas boiler in the poultry houses (Jalali at al., 2023).

The objective of this study to investigate the effects of in-floor heating. The study included a barn with and a barn without in-floor heating with the same litter – wood shavings. Firstly, parameters of the micro environment and the litter quality in different barns were observed. Secondly, the most important objective, we investigate whether in-floor heating of the barn influences the growth rate and the incidence of leg injuries in broilers.

2. Materials and methods

2.1 Location and type of housing

The research took place at the Helbl family farm. The farm is located in the municipality of Radlje ob Dravi, more precisely in the town of Dobrava. Poultry has been bred on the farm for more than 40 years. The experiment was conducted in two barns for broilers located in close proximity to each other. The older barn was built around 1975, is 14 m wide, 100 m long and can accommodate about 25,000 broilers. The old barn is heated with biomass burned in a large wood-burning stove that heats the entire building through the pipes and then through fan heaters (Solveno RMX-ACV; Fig. 1) installed in several places in the barn and hanging from the ceiling. Biomass (wood cheaps) are used to heat the barn. It has drip drinkers for water and an automatic control feeding system. The animals receive light through lighting with LED bulbs and also some natural light through windows equipped with remote-controlled blinds. The microclimate in the barns is regulated by fans placed under the ceiling, which are turned on or off when the parameters on the computer are met. Wood shavings is used as litter in the floors.

Vertical fan heaters are equipped with distribution system. Even temperature is distributed throughout the poultry house true six-sided air diffuser system. The heated air is distributed over the birds' heads, creating a comfortable environment and drying the litter. As the birds grow, the height of the fan heater are adjusted. The design of the air diffuser allows regulating air flow in six directions. The fan heater takes air from the ceiling, where it is the warmest, and delivers it to the bird area, spending less energy to finish heating (Fig. 2). The heaters are installed in the center of the barn at equal intervals from each other.

Fig. 1. Solvento fan heater (Solveno equipment catalog).

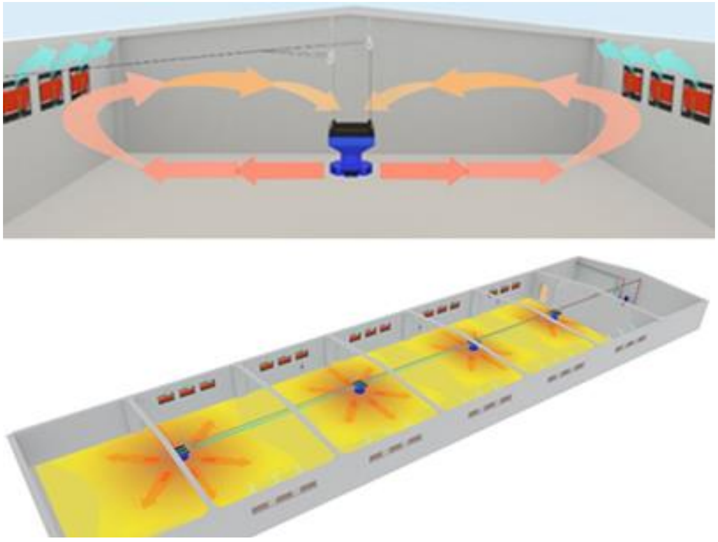

Fig. 2. Installation of fan heater and hot air distribution (Solveno equipment catalog).

The new facility for poultry breeding on the Helbl farm is 20 metres wide and 110 metres long. It has room for 35,000 broilers. The new barn is also heated with biomass burned in a large wood-burning stove that heats the entire building through the pipes. Hear pipes are installed inside floors (in-floor). A lower temperature flows in these pipes (Fig. 3). Precise control and regulation of the required temperature is managed via a computer system. Problems oh high temperature in the summer are solved by ventilation, aided by a cooling system on the building wall through which water flows and (hot) outside air enters the building. It cools the building by a good 10 °C so that the animals can live at a comfortable and normal temperature. This system is Agri Supply's ECO unit.

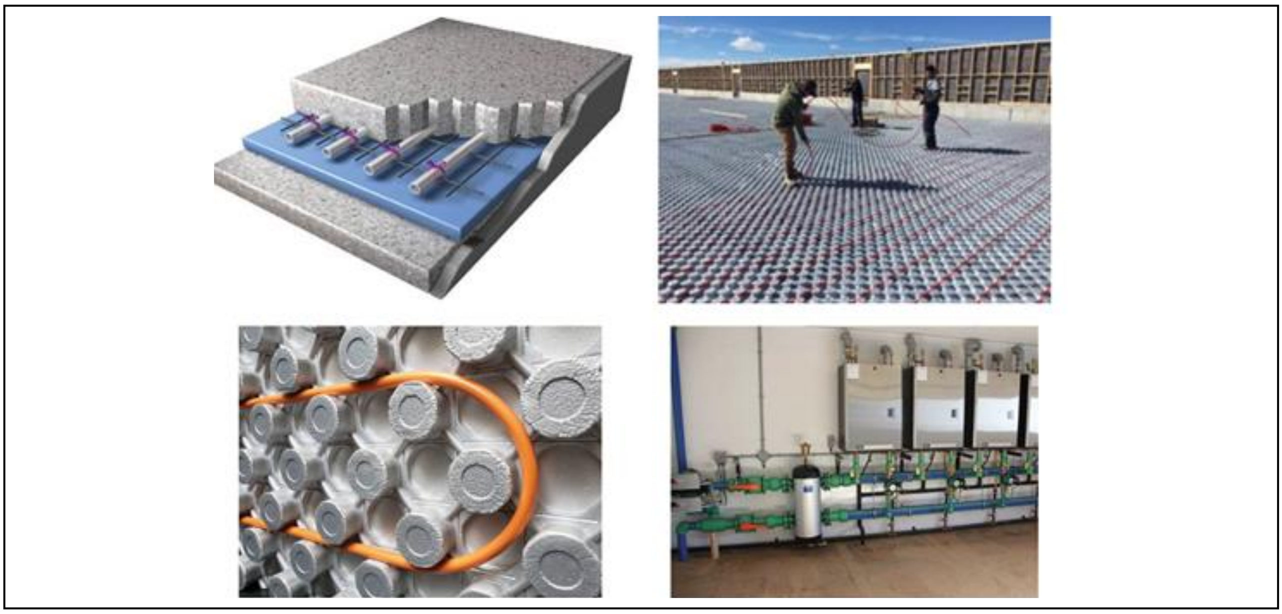

Fig. 3. In-floor heating system (Canadian Poultry Magazine).

2.2 Experiment design and measurements

The trial at the Helbl farm took place from November 5, 2021 to December 18, 2021. This indirectly involved approximately 60,000 broiler chickens. Since we investigated leg injuries and growth of the chickens in the main part, we established fixed measurement points in both barns before the first measurements (Fig. 4). We made sure that they were approximately the same distance from the control equipment, power supplies, and each other. There were 6 measurement points in each coop, which were 2 m × 2 m in size. We did not fence the chickens at these points. Ten broiler chickens were examined at each measurement point.

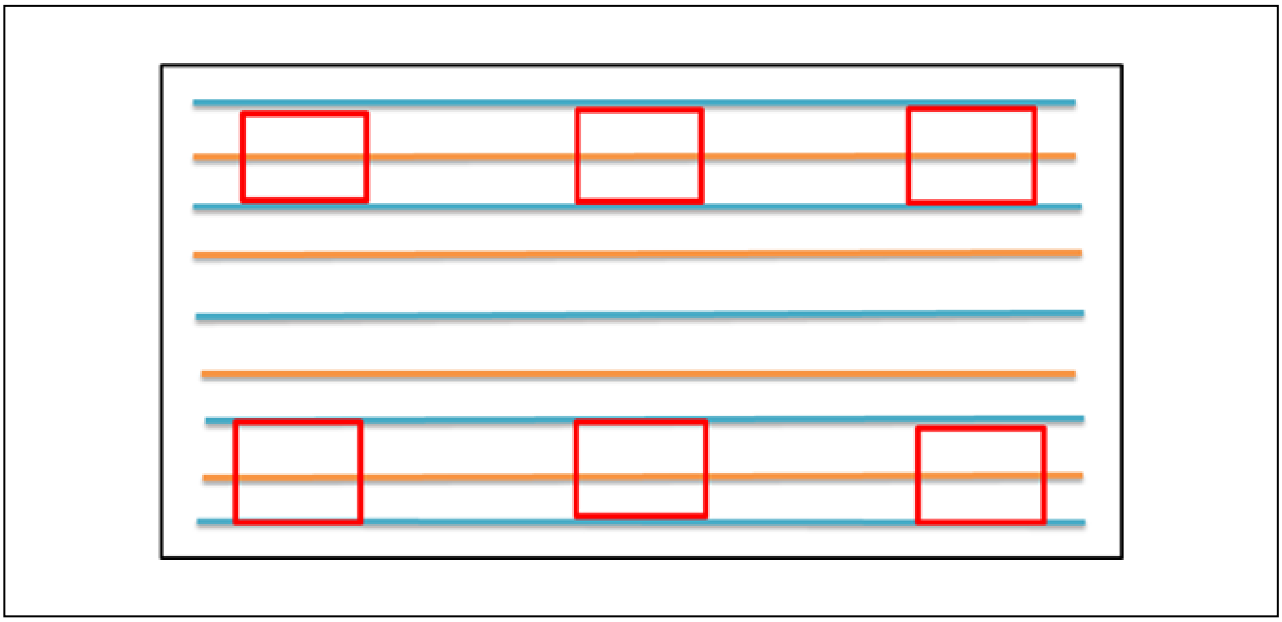

Fig. 4. Scheme of the stable with the locations of the measuring points (blue lines represent drinkers, orange lines represent feeders, and red squares represent measuring points).

As for the equipment, a scale, a thermal imaging camera, and a Kastrel moisture sensor were used.

To determine the average body weight and weekly gain, 10 animals were weighed in 6 different areas (Fig. 4). The animals were weighed at the same time each week (until the 35th day of age), the same number of chickens in the same predetermined locations of the house.

The Kestrel DROP D2AG sensor (Fig. 5) was used to obtain air temperature and humidity data of the barn. The sensors were protected in a plastic pot to prevent damage from the chickens. The phone application recorded all data during the measurement period.

Temperature of litter material rating were also recorded. Wood shavings were used as litter material in both houses. Temperature was measured using a thermal imaging camera by pointing the camera at the floor and spreading the bedding material to determine the internal temperature of the bedding.

The litter of barn was visually evaluated according to a 5-point score system (score 0 = completely dry and flaky litter, score 1 = dry, but not easy to move with foot, score 2 = leaves imprint of foot and will form a ball if compacted, but ball does not stay well together, score 3 = sticks to boots and sticks readily in a ball if compacted, score 4 = sticks to boots once the cap or compacted crust is broken) (Welfare Quality Assessment protocol for poultry, 2009). In this study, litter is defined as a mixture of the bedding material (wood shavings), bird excreta, and feathers.

Fig. 5. The Kestrel DROP D2AG humidity and temperature air sensor (Levanic, 2021).

The incidence of foot pad dermatitis (FPD) and hock burn in broilers was assessed once a week at each weighing. Evaluation was done according to a 5-point score system (score 0 = no lesions, score 1 and 2 = minimal evidence of lesions, score 3 and 4 = evidence of lesions) (Welfare Quality, 2009).

2.3 Statistical analysis

Statistical analysis was performed with the statistical software package SPSS 25.0. GLM univariate analysis was used to analyse the data and the Tukey test was used to compare the differences between the tested groups. The observed statistical differences at $P \leq 0.05$, were denoted by a, b, c.

3. Results

The results of the weekly weighing of the broilers showed that in the old barn were statistically significant ($P \leq 0.05$) heavier since first to the last week of fattening (Fig. 6). However, at the end of the experiment, there were no significant differences in the weight of the animals between the two barns (Fig. 7). This is due to standard deviations, especially in the old barn. On the end of the experiment, the animals reached an average body weight of 2181.7 g in the new stable and 2558.0 g in the older stable. At the first weighing (on the first day) there was no difference between broilers.

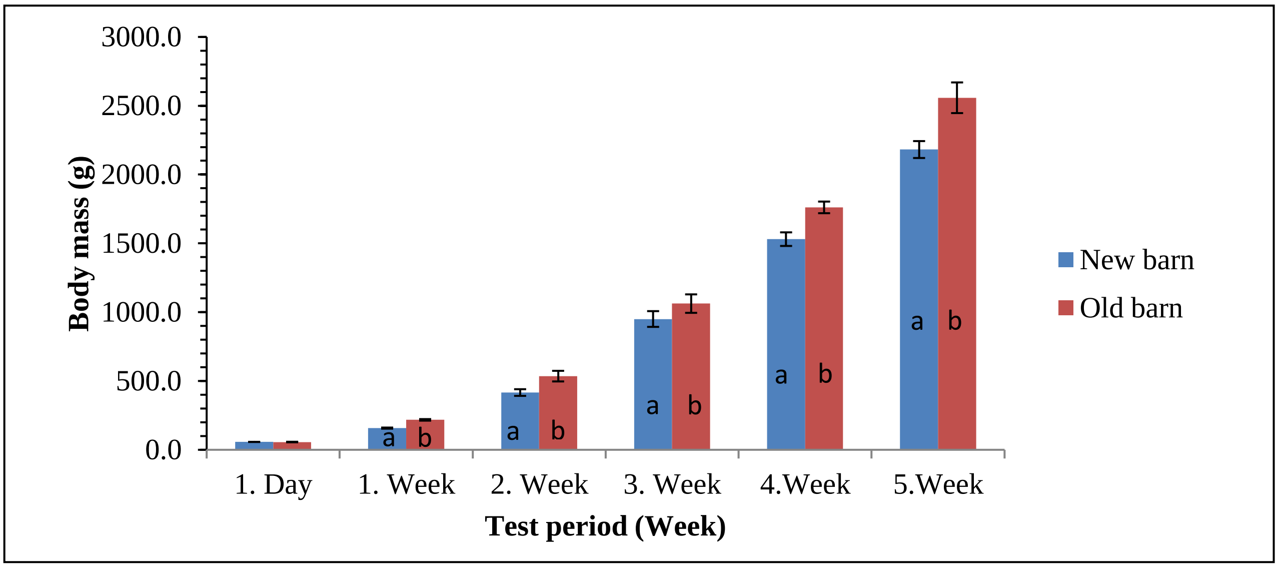

Fig. 6. Average body weight after weeks of fattening for both barns, “a, b” differ significantly ($P \leq 0.05$).

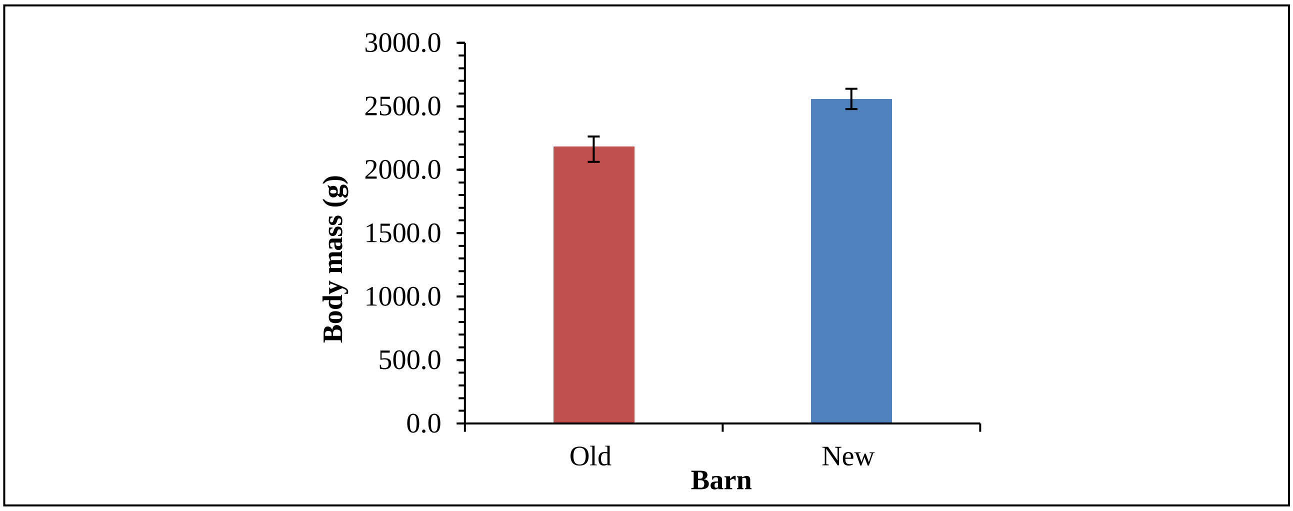

Fig. 7. Average body weight at the end of trial period (35 days) for both barns.

In our study, the temperature data measured with the sensor, we find significant differences ($P \leq 0.05$) in 1st, 3rd, 4th and 5th week of measurements (Fig. 8). In the barn with the in-floor heating the temperatures were slightly higher at the beginning of the study period than in the old barn with fan heaters. At the end of fattening, the temperatures in the new barn were lower than in the old barn. The differences are attributed to the more modern and more uniform heating and ventilation system in the newer barn.

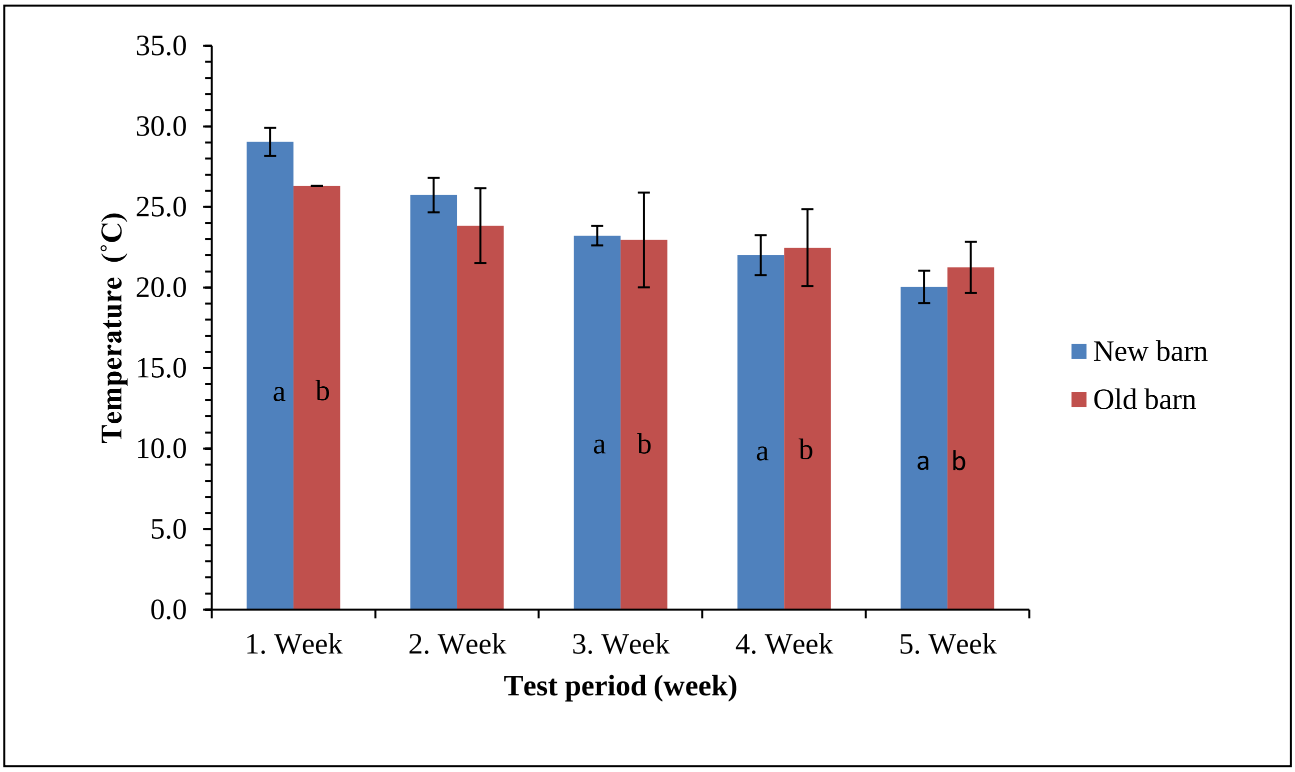

Fig. 8. Average weekly temperature of air measured with the sensor, "a, b" differ significantly

Figure 9 shows the average weekly temperature of the bedding material in both barns. It was noted that statistically significant differences ($P \leq 0.05$) were found between certain weeks, occurring between the two barns on day 1 and in weeks 1, 4, and 5 of feeding. In general, the higher temperature of the bedding was measured in the new barn with in-floor. There were no differences between the two barns in the 2nd and 3rd weeks of measurements.

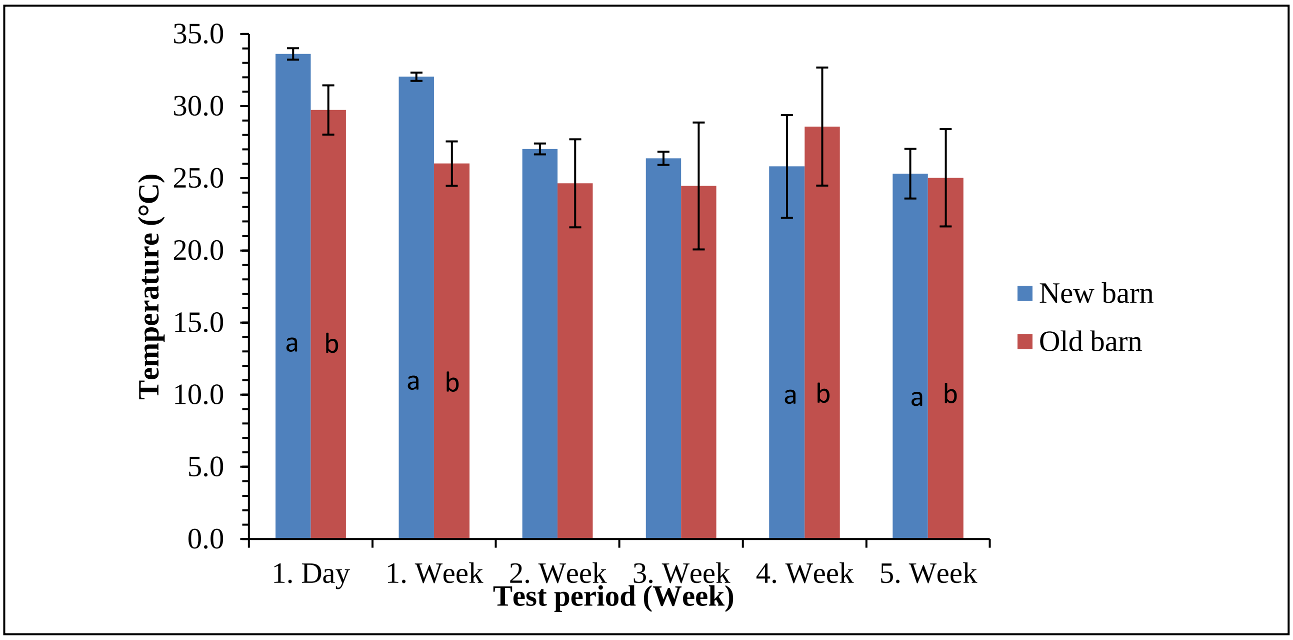

Fig. 9. Average weekly temperature of the bedding material, “a, b” differ significantly ($P \leq 0.05$).

In figure 10, the data of air moisture is presented. It is observed that the difference in air moisture occurred at every weighing, except in the 4th week. Higher moister were measured in old barn.

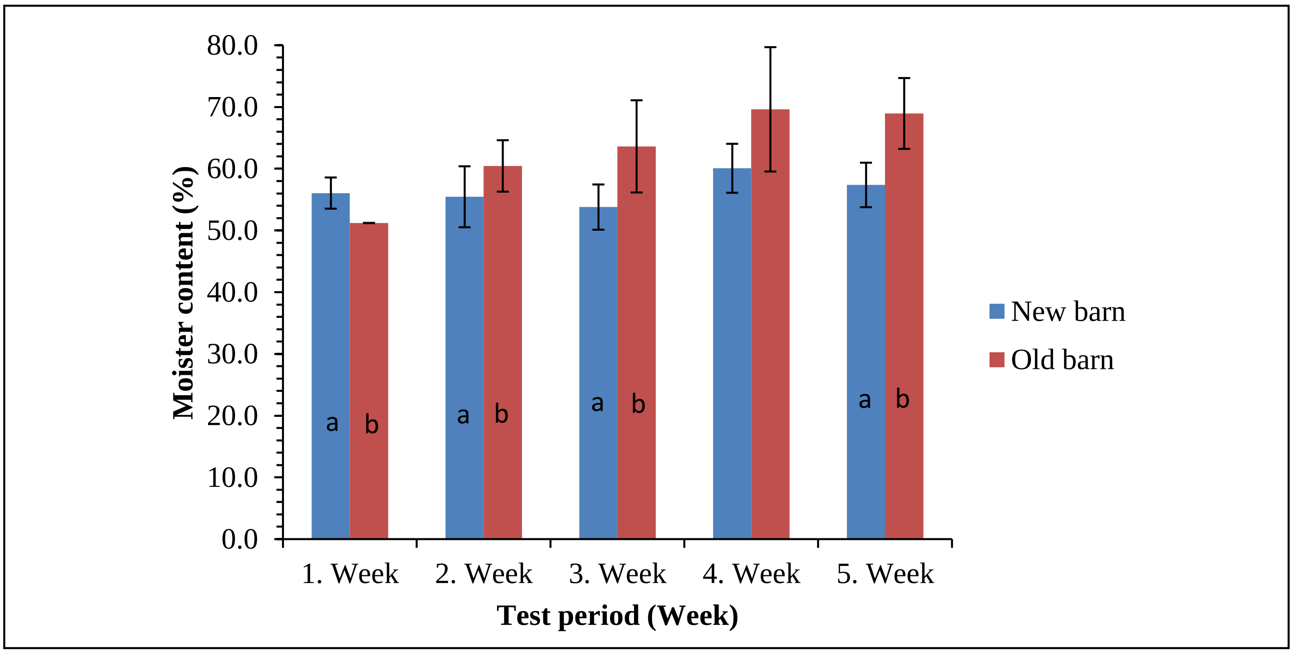

Fig. 10. Average weekly percentage of moisture in the air after weeks in both barns, “a, b” differ significantly ($P \leq 0.05$).

The quality of the litter is presented as percentage of scores (Fig. 11). The litter quality was found significant ($P \leq 0.05$) different between the barns, for value 1 and 4. In new barn the values were 0, 1, 2 and 3 in the old barn values were 0, 2 and 4. The graph shows that the condition of quality of litter deteriorated faster in the older barn than in the newer barn.

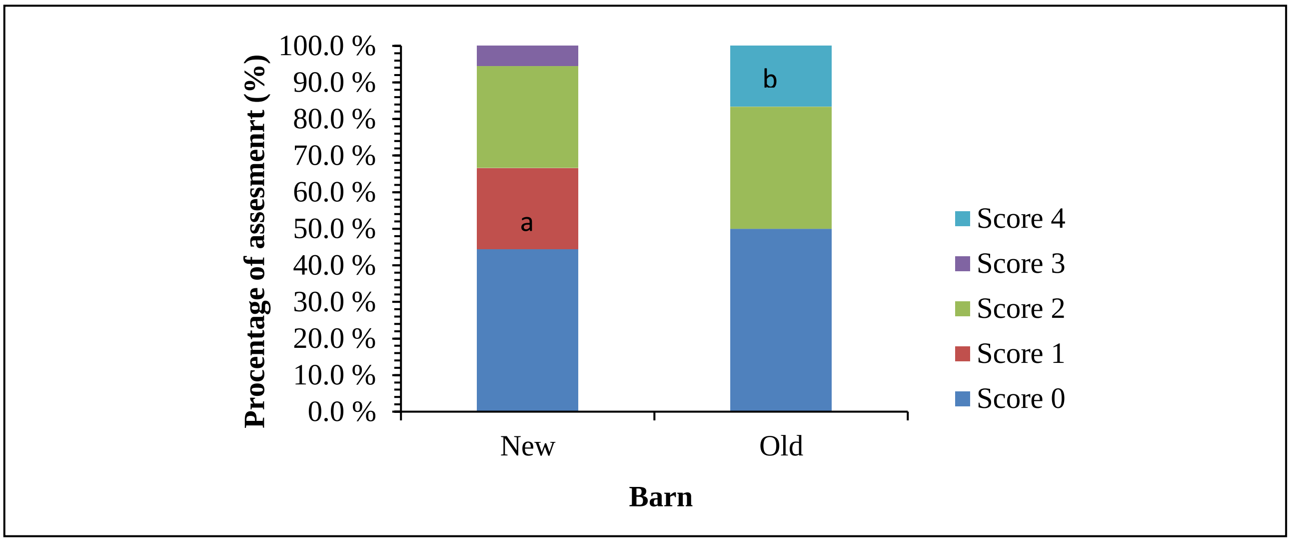

Fig. 11. Ratings of litter quality in both barns, “a, b” differ significantly ($P \leq 0.05$).

As can be seen from the Figure 12 and 13, the condition of FPD and hock burns were negligible. No differences ($P > 0{,}05$) in both bars by the condition of FPD and hock burns were detected in old and new barn.

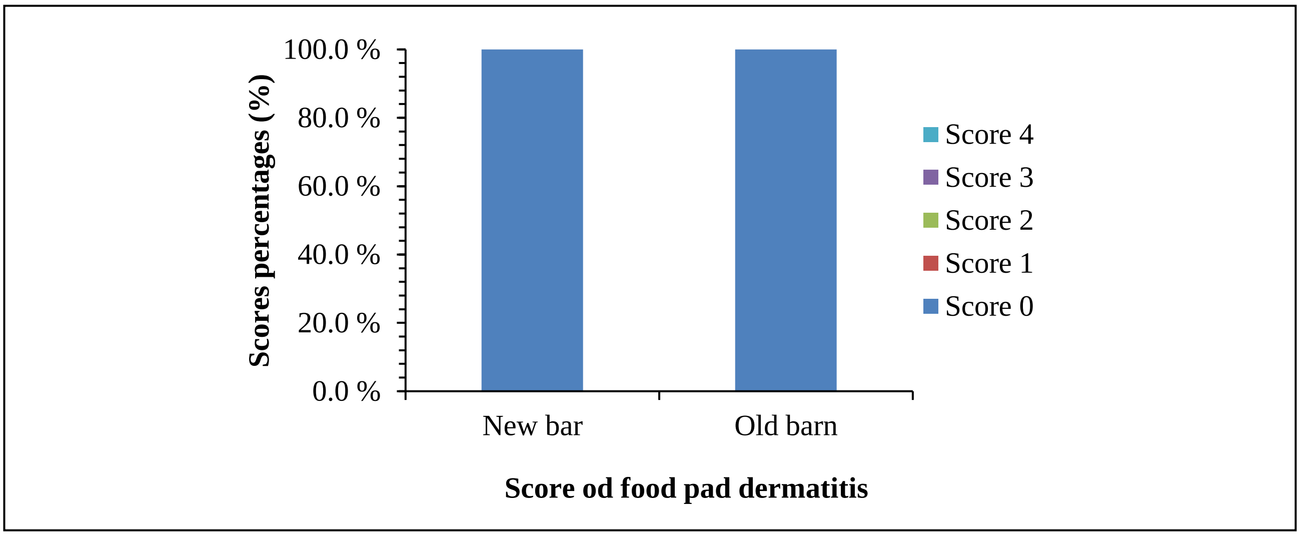

Fig. 12. Scores of FPD of broilers in both barns.

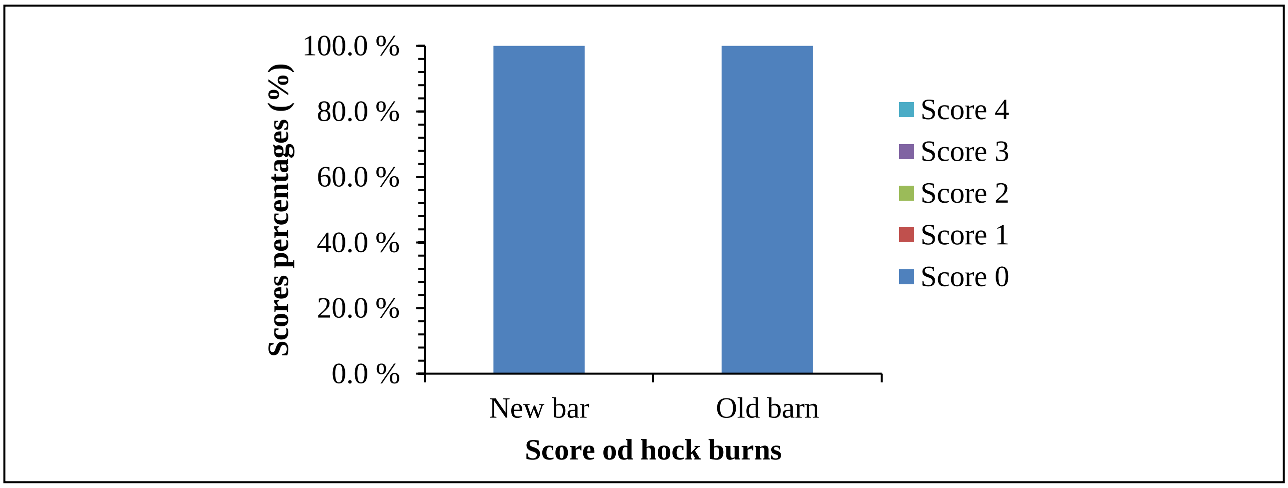

Fig. 13. Scores of hock burns of broilers in both barns.

4. Discussion

The aim of the study was to investigate whether in-floor heating affects growth rate, barn micro environment, litter quality and incidence FPD in broiler chickens.

Although the results of the weekly weighing of the broilers showed statistically significant differences, the final body weight did not differ between the two barns. No differences were detected of FPD and hock lesions between two barns. We attribute this to the fact that the well-balanced diets, correct stocking density and control of the water use.

However, significant differences did occur between two barns. Lower quality of litter was measured in older barn. Also, it was observed that the difference in air moisture occurred at every weighing, except in the 4th week. Higher moister were measured in old barn. The in-floor heating in our study affected the air moister content and the quality of bedding material, resulting slower quality deteriorated in barn with in-floor heating.

As motioned, in our study we detect lower air moister in the new barn with in-floor heating. The microclimate in poultry buildings has a substantial influence on the productivity and health of the bred animals and, therefore, its control is of particular importance. As a key environmental factor, humidity it plays an important role in air quality (Gurler et al., 2021). Poor control of moisture in the house environment can lead to health and welfare issues. If environmental relative humidity is lower than 50% there is a higher production of dust and an increase in the number of air borne micro-organisms which might increase susceptibility to respiratory diseases, but this situation is not very common. High air humidity (up to 80%) and wet litter increases the incidence of FPD and high production of ammonia. High levels of ammonia are responsible for the onset of respiratory diseases and negative environment impact (Meluzzi and Sirri, 2009). In our case, the in-door heating system in the barn has a positive effect on the microclimate due to the lower moisture content of the air.

We didn't detect any differences of FPD and hock burns between two barns, however, the notable differences have appeared in our study in quality of the litter. Health problems related to fast growth rate are a common animal welfare issue in modern broilers and this applies to systems with long rearing periods. The aetiology of FPD and hock lesions is a complex interaction several different factors. The severity of these injuries can depend on genetics, stocking density, and diet (Martland 1984; Piller at al., 2020), but the primary cause is wet litter (Weber Wyneken et al., 2015). The most common cause of disease is attributed to the quality of flooring substrate, especially contact with moisture and irritants in the litter (El-Wahab et al., 2013; Jacobs at al., 2021). It has been reported that moisture content in litter exceeding 35% often results in a higher incidence of FPD (Martland, 1984). A study by Van Wicklen and Czarick (1988) show, that the in-floor heating by electric resistance, can be used to adjust the moisture content of the bed, which can reduce the production of ammonia. It has been noted by Berg and Algers, (2004), that the prevalence of FPD for in-floor heating groups was 21.5% 6 3.7 vs. 45.0% 6 7.1 for groups not using in-floor heating by turkeys poults. Results indicated that using in-floor heating resulted in significantly lower FPD scores. El-Wahab et al. (2011) observed the effects of in-floor heating and litter quality on the development and severity of FPD in young turkeys. In-floor heating resulted in lower moisture, pH levels and lower NH_3 concentrations compared to the groups without in-floor heating. In addition, in-floor heating resulted in significantly lower FPD scores in comparison to the groups without in-floor heating. The study concluded that in-floor heating increases litter quality and prevents dermatitis in poultry (El-Wahab et al. 2011). However, some reports observed that heating temperature above 35 ºC on the top of the litter layer in in-floor heating systems can roast the litter, which may have negative effects (Leva et al., 2013). Litter quality is of great importance for the welfare of broiler chickens as they generally spend their entire life in contact with it. We can conclude, that the slower quality deterioration of the bedding material in in-floor barn had a positive effect on the welfare of the chickens.

5. Conclusion

The results of our study demonstrate that in-floor heating has a positive effect in broiler management, especially by improving the quality of the litter material. From the obtained results, we can easily conclude that the construction of the barn affects the microclimatic conditions during the rearing period (autumn - winter period), but with an efficient heating system, we can better control living condition needed for broiler chickens and thus significantly contribute to improving the welfare quality of chickens.

Future work and research must focus on similar detailed studies, especially during the autumn temperature changes. It would also be advisable to investigate the use of in-floor heating system for cooling of bedding material during the summer production cycle. The system can also be used for this purpose (cooling) and could prevent excessive temperatures during the summer months and the related heat stress in broiler chickens.

6. Acknowledgements

The authors acknowledge support and are grateful for the hospitality of the Helbl family farm.

7. References

Berg, C. (2002). Health and welfare in organic poultry production. Acta Veterinaria Scandinavica, 43(1), 1-9, ISSN: 1751-0147.

Berg, C., & Algers, B. (2004). The effect of floor heating and feed protein level on the incidence of foot pad dermatitis in turkeys poults. In EAAP-55th Annual Meeting, ISBN: 9076998450, Annual meeting of the European Association for Animal Production, September 2004, Bled, Slovenia.

Chuppava, B., Visscher, C., & Kamphues, J. (2018). Effect of different flooring designs on the performance and foot pad health in broilers and turkeys. Animals, 8(5), 70, PMID: 29751573, ISSN: 2076-2615.

Costantino, A., Fabrizio, E., Ghiggini, A., & Bariani, M. (2018). Climate control in broiler houses: A thermal model for the calculation of the energy use and indoor environmental conditions. Energy and Buildings, 169, 110-126, ISSN:1872-6178.

Cui, Y., Theo, E., Gurler, T., Su, Y., & Saffa, R. (2020). A comprehensive review on renewable and sustainable heating systems for poultry farming. International Journal of Low-Carbon Technologies, 15(1), 121-142, ISSN - 1748-1325.

Ekstrand, C., Algers, B., & Svedberg, J. (1997). Rearing conditions and foot-pad dermatitis in Swedish broiler chickens. Preventive Veterinary Medicine, 31(3-4), 167-174, ISSN: 1873-1716.

El-Wahab, A. A., Beineke, A., Beyerbach, M., Visscher, C. F., & Kamphues, J. (2011). Effects of floor heating and litter quality on the development and severity of foot pad dermatitis in young turkeys. Avian diseases, 55(3), 429-434, ISSN: 0005-2086.

El-Wahab, A., Radko, D., & Kamphues, J. (2013). High dietary levels of biotin and zinc to improve health of foot pads in broilers exposed experimentally to litter with critical moisture content. Poultry science, 92(7), 1774-1782, ISSN: 1525-3171.

El-Zanaty, H. (2014). A Techno-Economic study for heating poultry houses using renewable energy [Master's Thesis, the American University in Cairo]. AUC Knowledge Fountain.

Gholami, M., Chamani, M., Seidavi, A., Sadeghi, A. A., & Aminafschar, M. (2020). Effects of stocking density and environmental conditions on performance, immunity, carcase characteristics, blood constitutes, and economical parameters of cobb 500 strain broiler chickens. Italian Journal of Animal Science, 19(1), 524-535, ISSN: 1828-051X.

Gurler, T., Elmer, T., Cui, Y., Omer, S., & Riffat, S. (2021). Performance evaluation of a novel PVT-GSHP heating system on energy-efficient poultry houses: long-term monitoring. International Journal of Low-Carbon Technologies, 16(2), 393-406, ISSN - 1748-1325.

Jacobs, L., Melick, S., Freeman, N., Garmyn, A., & Tuyttens, F. A. (2021). Broiler chicken behavior and activity are affected by novel flooring treatments. Animals, 11(10), 2841, ISSN: 2076-2615.

Jalali, M., Banakar, A., Farzaneh, B., & Montazeri, M. (2023). Reducing Energy Consumption in a Poultry Farm by Designing and Optimizing the Solar Heating/Photovoltaic System. Sustainability, 15(7), 6059, ISSN: 2071-1050.

Janzekovic, M., & Mergedus, A. (2016). From Conceptual Idea to Construction of New Free Stall for Dairy Cows Using Autodesk Autocad Program, Chapter 04 in DAAAM International Scientific Book, 2016, pp.039-048, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-902734-09-9, ISSN 1726-9687, Vienna, Austria.

Jones, T. A., Donnelly, C. A., & Dawkins, M. S. (2005). Environmental and management factors affecting the welfare of chickens on commercial farms in the United Kingdom and Denmark stocked at five densities. Poultry Science, 84(8), 1155-1165, ISSN: 1525-3171.

Karadağ, R., Teke, İ., & Bulut, H. (2007). A numerical investigation on effects of ceiling and floor surface temperatures and room dimensions on the Nusselt number for a floor heating system. International Communications in Heat and Mass Transfer, 34(8), 979-988, ISSN: 0735-1933.

Leva, F. F. D., Camacho, J. R., & Oliveira Filho, D. (2013). Evaluation of the heating of broilers in shed by means of gas hoods and underfloor heating. Engenharia Agrícola, 33, 844-856, ISS: 0100-6916.

Martland, M. F. (1984). Wet litter as a cause of plantar pododermatitis, leading to foot ulceration and lameness in fattening turkeys. Avian Pathology, 13(2), 241-252, ISSN: 0307-9457.

Mayne, R. K., Else, R. W., & Hocking, P. M. (2007). High litter moisture alone is sufficient to cause footpad dermatitis in growing turkeys. British Poultry Science, 48(5), 538-545, ISSN: 1466-1799.

Meluzzi, A., & Sirri, F. (2009). Welfare of broiler chickens. Italian Journal of Animal Science, 8, 161-173, ISSN: 1828-051X.

Piller, A., Bergmann, S., Schwarzer, A., Erhard, M., Stracke, J., Spindler, B., ... & Louton, H. (2020). Validation of histological and visual scoring systems for foot-pad dermatitis in broiler chickens. Animal welfare, 29(2), 185-196, ISSN: 0962-7286.

Singh, H., Mishra, D., & Nahar, N. M. (2002). Energy use pattern in production agriculture of a typical village in arid zone, India—part I. Energy conversion and management, 43(16), 2275-2286, ISSN: 0196-8904.

Simiyu, M.N. (2015). Temperature profiles in a floor heated brooder. Department of Mechanical and Manufacturing Engineering, University of Nairobi: Nairobi, Kenya.

Van Wicklen, G. L., & Czarick, M. (1988). Design of a PVC pipe system for brooding chickens. Transactions of the ASAE, 31(2), 552-0557, ISSN: 0001-2351.

Weber Wyneken, C., Sinclair, A., Veldkamp, T., Vinco, L. J., & Hocking, P. M. (2015). Footpad dermatitis and pain assessment in turkey poults using analgesia and objective gait analysis. British Poultry Science, 56(5), 522-530, ISSN: 1466-1799.

Welfare Quality 2009. The Welfare Quality® assessment protocol for poultry (broilers, laying hens), The Welfare Quality® Consortium, ISBN: ISBN/EAN 978-90-78240-06-8, Lelystad, The Netherlands.

Youssef, I. M. I., Beineke, A., Rohn, K., & Kamphues, J. (2011). Effects of litter quality (moisture, ammonia, uric acid) on development and severity of foot pad dermatitis in growing turkeys. Avian diseases, 55(1), 51-58, ISSN: 0005-2086.

***Solveno equipment catalog - https://solvenoequipment.com/en/services/poultry-house-heating/, Accesed on: 2023-08-28.

***The benefits of in-floor heating - Canadian Poultry Magazine - https://www.canadianpoultrymag.com/the-benefits-of-in-floor-heating/, Accesed on: 2023-08-28.