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Assessment of the Welfare Quality of Commercial Laying Hens Kept in Conventional Cage and Deep Litter Systems at Different Ages

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Abstract

The effects of conventional cage and cage-free systems on the welfare quality of laying hens have been assessed recently, but with conflicting results. This study aimed to identify the welfare issues of laying hens when kept in a battery cage or deep litter system. In the cage system, white hybrid hens were kept in three cage lines, with three hens per cage and two tiers per line. In the deep litter system, hens were equally allocated to three compartments of a barn. A total of 450 hens were randomly chosen from different locations of barn and cages for scoring by one assessor at 5% of laying, peak period, and end of laying with several main health and social behavior parameters according to Welfare Quality (2009). The logistic analysis was applied using a proportional odds model to compare the prevalence of each welfare measure between the two housing systems at 5% significance level using R software. Hens in the conventional cages had worse plumage conditions and keel bone deformations than those in the deep litter system, especially at the end of laying ($P <$ 0.05). In the deep litter system, hens showed a higher prevalence of foot pad dermatitis (46.0% hens scored 1 in the deep litter system compared with 11.33% in cages) and a higher avoidance distance test at the different ages ($P <$0.05) than those in the battery cages. The deep litter system showed more benefits for hen welfare than the battery cages except for foot pad dermatitis.

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Keywords

Battery cages, hen welfare, non-cage systems, laying hens

Introduction

The welfare of laying hens plays a crucial role in the sustainable development of the egg industry, but it is not a concern of producers in many developing countries, including Vietnam. Demand for healthy, high-quality animal products, including table eggs, has been increasing in recent years (Gautron *et al.*, 2021), and this has put pressure on producers to improve or change their production systems (Mench *et al.*, 2011; Van Asselt *et al.*, 2015). The conventional cage system for egg production was introduced in the 1930s and then developed rapidly in the 1950s (Dikmen *et al.*, 2016). In most parts of the world, especially in developing countries, the battery cage system is still being applied nowadays for egg production thanks to its economic efficiency and making farm management easier. However, in some other countries (such as EU countries), battery cages have been banned because of the concern about the negative effects of battery cages on hen welfare (Muir *et al.*, 2014; Dikmen *et al.*, 2016). Egg producers should take animal welfare into account as one of the important aspects for sustainable development in the future.

Each housing system has specific effects on the welfare of laying hens that needs to be assessed for welfare improvement (Lay Jr *et al.*, 2011). Several studies have been implemented to compare the welfare quality of laying hens kept in different housing systems, but the results have been inconsistent. Dikmen *et al.* (2016) found that hens in a free range system have better feather conditions and bone properties, but higher footpad lesions than conventional cages. Sherwin *et al.* (2010) compared the welfare of layer hens in four housing systems (conventional cages, furnished cages, barn, and free-range) in the UK and concluded that hens in the barn system had some of the worst welfare indicators (poor plumage conditions, old fractures, emaciation, and the highest corticosterone levels) than the other systems. The inconsistent findings of the previous studies may due to different reasons because there are many factors that affect the welfare of laying hens. Therefore, the assessment of the welfare of laying hens in different systems is necessary for identifying welfare issues and suggesting solutions for welfare improvement.

Assessing the welfare of laying hens kept in different housing systems has been done in many regions, especially in western or developed countries, but very little information has been published in other parts of the world, where animal welfare topic is rarely a concern. In Vietnam, egg production is mainly from intensive industrial farms. In 2023, about 41.83% of the total laying hens population and 63.18% of the total eggs were produced in intensive farms (General Statiscal Office, 2024). In intensive farms, the battery cage system is widely applied by most egg producers, especially at large-scale farms (Eurogroup for Animals, 2022). Few studies have been implemented on alternatives for the conventional cage system (Hanh *et al.*, 2021). Recently, due to the increasing demand for cage-free eggs, a transition from cage to cage-free systems is now emerging. Several cage-free laying hens in Vietnam have been recently certified under animal welfare standards such as the Certified Humane® program, and about 10 farms have been certified up to the present (Humane Farm Animal Care, 2025). Recently, animal welfare has been put into the Vietnamese regulations such as the Law on Veterinary Medicine (No. 79/2015/QH13) in 2015 and the Law on Animal Husbandry (32/2018/QH14) in 2018. However, limited information comparing the welfare quality of hens kept in these housing systems is available in Vietnam at the present. The objectives of this study were to assess the welfare of commercial laying hens housed in conventional cages and deep litter systems at different weeks of age.

Materials and Methods

Animals and housing

The study was conducted at a commercial laying hens farm in Hung Yen province in Northern Vietnam. The farm has both conventional cage and deep litter systems. In the conventional cage system, a total of 5,836 white hybrid layers were kept in three cage lines, with three hens per cage and two tiers per line. The dimensions of each cage were 48cm in length and 40cm in width (480 to 640cm^2 of space allowance per hen). In the deep litter system, a total of 2,842 hens (same strain and same age with those in the battery cages) were equally allocated to three compartments of a barn (140m^2 of space allowance per compartment or 0.15m^2 per hen). Rice husks were provided (about 10cm in depth) as litter for the hens. A total of 23 communal nest boxes ($1m^2$ per box) were installed evenly in the barn with rice husks as bedding. There were no perches in the deep litter house. Both housing systems were closed houses with cooling pads and suction fans to control the micro-climate at a stable condition (around 22-23ºC). Hens were fed a compound feed (18% crude protein and 2750 kcalME kg^{-1}) by an automatic feeding system in the whole production cycle. Water was provided *ad libitum* through a nipple system. Lighting was regulated automatically to provide 16 hours of light and 8 hours of darkness daily.

Sample collection and welfare assessment

Hen welfare was assessed at 5% of laying (week 19), peak period (week 27), and the end of laying (week 70). Individual hens were randomly chosen for the welfare assessment. In the cage system, we selected random cages in both tiers at the first, middle, and last locations from the front door (near the cooling pads) to the end in each line (near the suction fans). Three cages in five different locations were chosen in each line with a total of 150 hens per line. In total, there were 450 hens that were randomly selected for the welfare assessment. In the deep litter system, hens were captured in the four corners and in the center of the barn with a minimum of 30 hens per location. A total of 150 hens were randomly chosen in each compartment. Therefore, there were 450 hens for the three compartments of the barn for the welfare assessment. To prevent the repeated assessment of any hen, a small fence was used to capture a group of hens, and then individual hens were taken from the group for the welfare assessment before being released.

Welfare assessment was implemented by one assessor with some main parameters, namely plumage damage, skin lesions, keel bone deformations, foot pad dermatitis, comb pecking wounds, and the avoidance distance test according to Welfare Quality® (2009) with some modifications:

(i) Plumage damage was scored based on the feathers covering different parts of the body (head and neck, back and rump, belly, breast, wings, and tail) in which score 0: complete The percentages of hens having different scores was calculated from the number of birds assigned each score out of the total number of birds assessed at each time point. The effects of the housing system and age on the welfare indicators were determined using logistic regression analysis in R software. The logistic regression model was: Logit (P(indice ≤ j)) = α + β1*housing + β2*age, where α is the intercept, and β1 and β2 are the regression coefficient predictors for the housing system and week of age of hens, respectively. Odds were defined as the ratio of laying hens with a good welfare score (score 0) to those with other scores (score 1 or 2). The odds ratio (OR) was calculated by comparing the odds of obtaining a good welfare score (score 0) between the housing system (cage vs. deep litter), and between different laying week of age (week 19 vs. week 27 and week 70) for each welfare indicator with a significance level of 5% (or a 95% confidence interval). For the avoidance distance test, a T-test was used to compare the mean between the two housing systems at a significance level of 5%.

Results and Discussion

Selected health-based welfare parameters

Selected health-based welfare parameters of the laying hens, including keel bone deformations, skin lesions, and foot pad dermatitis, were assessed and the percentages of hens with different scores are shown in **Figure 1, Figure 2**, and **Figure 3**, respectively. The logistic regression of these health-based parameters is presented in **Table 1**.

Keel bone deformations

There were significant effects of the housing system and week of age on the keel bone deformations of the hens. At the beginning of the laying period (5% laying rate or week 19), few hens had keel bone deformations (only 5.33% of hens were affected in both housing systems). At the peak (week 27) and end of the laying period (week 70), the percentage of hens with keel bone abnormalities was significantly higher in cages than those in the deep litter system (0.52 times or half the odds, P <0.001). This was consistent

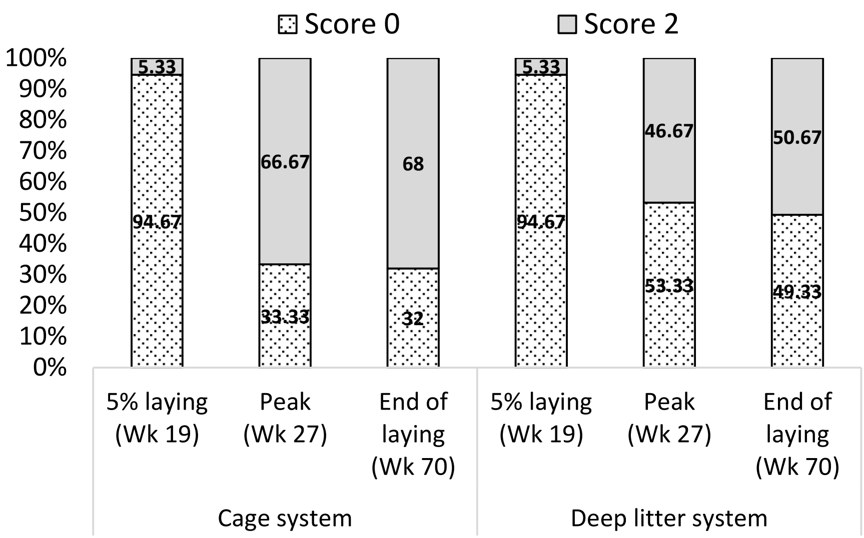

Figure 1. Percentages of hens with different keel bone deformation scores housed in cages or the deep litter system at different weeks of age

with previous results reported by Habig *et al.* (2021) who noted that more deformations of the keel bone were found in caged hens than floor-housed hens. Nalesso *et al.* (2025) also found a higher risk of keel bone deviations in enriched cages compared to a floor housing system. The higher occurrence of keel bone deformations in caged hens can be explained by the poor bone quality of caged hens due to restricted movement in cages (Nalesso *et al.*, 2025) while cage-free hens may have a stronger bones (Rodenburg *et al.*, 2008; Lay Jr *et al.*, 2011). The percentage of hens with keel bone deformations also increased by the week of age (3.68 times higher at the peak and end of laying compared with that at 5% of laying, P <0.001) in both systems. This was consistent with previous findings, which reported an increase in keel abnormalities with the age of hens (Donaldson *et al.*, 2012; Daigle & Siegford, 2014; Blatchford *et al.*, 2016). When hens reach the peak of laying and then at the end of laying, they may have a lack of calcium content in their bones and this may lead to keel deformations (Gebhardt-Henrich *et al.*, 2017).

Skin lesions

Skin lesions were not affected by the housing system (P >0.05), but significantly increased by the week of age (3.32 times higher in hens at the peak and end of laying compared to at 5% of laying, P <0.001). Blatchford *et al.* (2016) reported that there were no differences in skin lesions in hens at 72 weeks of age among the tested housing systems. The development of skin lesions may be related to plumage damage, especially in the back and vent regions. The loss of plumage in these regions may stimulate the injury pecking that may cause skin lesions. Gernand *et al.* (2022) found an increase in the pecking damage of hens when the pullets started laying, especially from 30 weeks of age.

Foot pad dermatitis

Foot pad dermatitis was significantly affected by the housing system and week of age (**Figure 3** and **Table 1**). Hens in the deep litter system had a higher prevalence of foot pad dermatitis than the caged hens at the peak and at the end of the laying period (8.83 times and 3.79 times higher in deep litter housing vs cages and at peak and end of laying vs 5% laying, respectively, P <0.001). Blatchford *et al.* (2016) stated that foot pad dermatitis is commonly seen in non-cage systems. The development of dermatitis in the foot pad may be caused by different reasons such as poor quality litter (wet), a high ammonia content, and an imbalanced diet. Wang *et al.* (1998) reported that the moisture of the litter is a significant factor contributing to foot pad dermatitis (92% of birds reared on wet litter had foot pad dermatitis compared with 38%

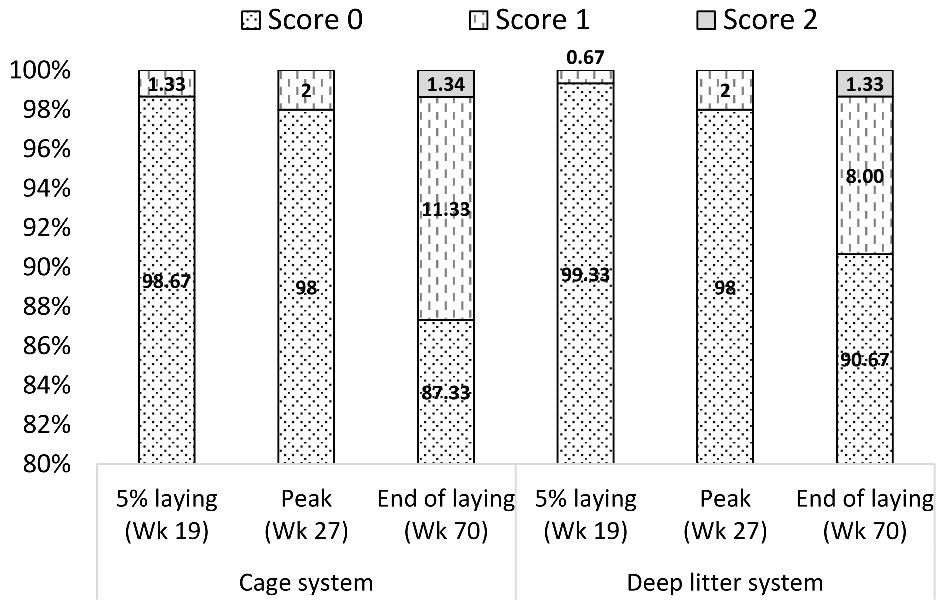

Figure 2. Percentages of hens with different skin lesion scores housed in cages or the deep litter system at different weeks of age

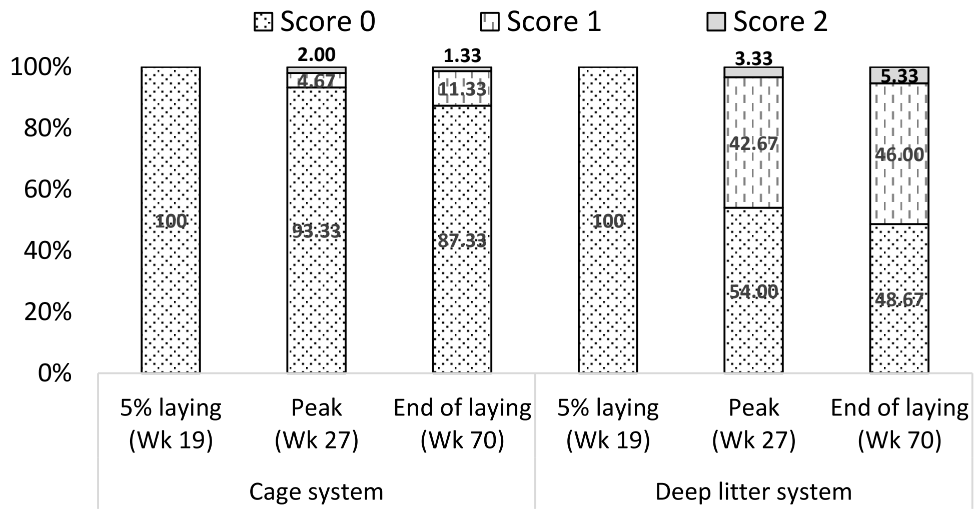

Figure 3. Percentages of hens with different foot pad dermatitis scores housed in cages or the deep litter system at different weeks of age

Table 1. Logistic regression model of good welfare (score 0) of several health and behavior parameters of hens in different housing systems at different weeks of age

Parameters	Housing system			Week of age		
	OR	95%CI	*P*-value	OR	95%CI	*P*-value
Keel bone deformations	0.52	0.38-0.70	<0.001	3.68	3.01-4.52	<0.001
Skin lesions	1.22	0.60-2.51	0.57	3.32	1.95-6.20	<0.001
Foot pad dermatitis	8.83	5.70-14.11	<0.001	3.79	2.91-5.01	<0.001
Plumage damage	0.11	0.08-0.15	<0.001	9.96	7.89-12.74	**<0.001**
Comb pecking wounds	0.99	0.74-1.34	0.98	3.43	2.80-4.24	<0.001

Note: OR: odds ratio; CI: 95% confidence intervals.

of birds reared on dry litter). In this study, we found that the litter was wet and caked that may led to a high percentage of foot pad dermatitis in the deep litter system.

Selected social behavior parameters

Plumage damage and comb pecking wounds were assessed and the prevalence of different scores are presented in **Figure 4** and **Figure 5**, respectively. The logistic regression of these social behavior indicators is presented in **Table 1**.

Plumage damage

The plumage damage of laying hens was significantly affected by the housing system (0.11 times or an 89% higher rate of hens with good plumage in the deep litter system compared to the caged hens, P <0.001) and week of age (**Figure 4** and **Table 1**). The plumage was in good condition at the 5% laying point in both housing systems. The plumage damage was then more serious at the peak and end of the laying period with increases in the percentages of score 1 and score 2 ratings (9.96 times higher in hens at the peak and end of laying compared that at the 5% of laying, P <0.001). This result agrees with previous studies (Sherwin *et al.*, 2010; Sokołowicz *et al.*, 2023), which stated that the plumage damage increased with the bird's age. When comparing the two housing systems, the percentage of score 2 ratings (one or more featherless areas more than 5cm in diameter) of the caged hens was much higher than those of the deep litter system (79.33% at the peak and 64% at the end of laying for the caged hens compared to 0% at the peak and 6% at the end of laying for hens in the deep litter system). The higher prevalence of plumage damage in the cages was explained by the hens rubbing against the cage walls and other hens when turning around in the narrow cages at a high stocking density (Hughes & Black, 1976). Blatchford *et al.* (2016) indicated that the feather loss of caged hens may be caused by the cage design features. However, another study reported a higher plumage damage level in hens reared in barns than other housing systems (Sherwin *et al.*, 2010). The worse plumage condition of hens in a barn system is often related to a high prevalence of feather pecking and cannibalism (Bilcik & Keeling, 1999). In this study, hens were kept in an appropriate stocking density in a climate-controlled house that prevented them from stress and aggression and thus reduced feather pecking and plumage damage.

Comb pecking wounds

The comb pecking wounds were not significantly different between the two housing systems, but it increased by the week of age (3.43 times higher in hens at the peak and end of laying verses at 5% of laying, P <0.001). The percentage

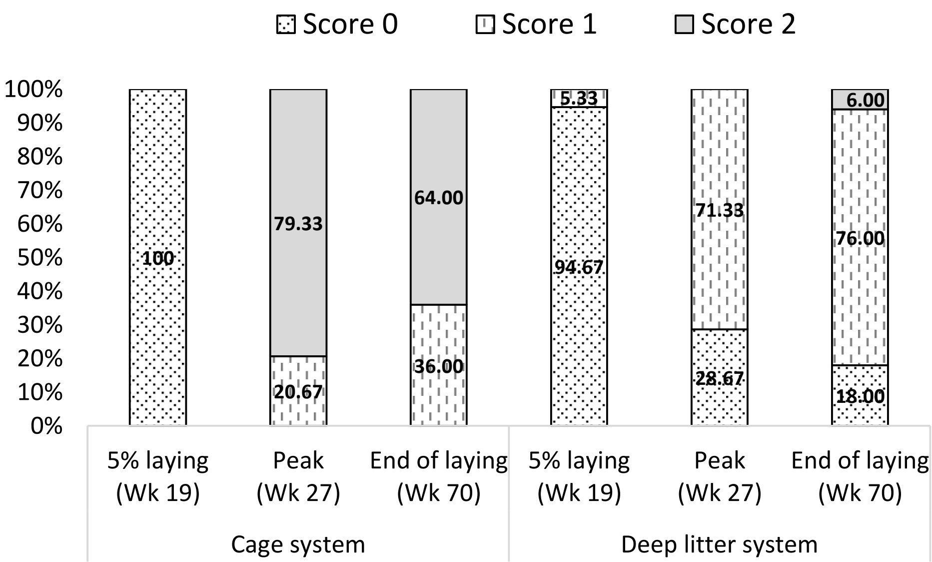

Figure 4. Percentages of hens with different plumage damage scores housed in cages or the deep litter system at different weeks of age

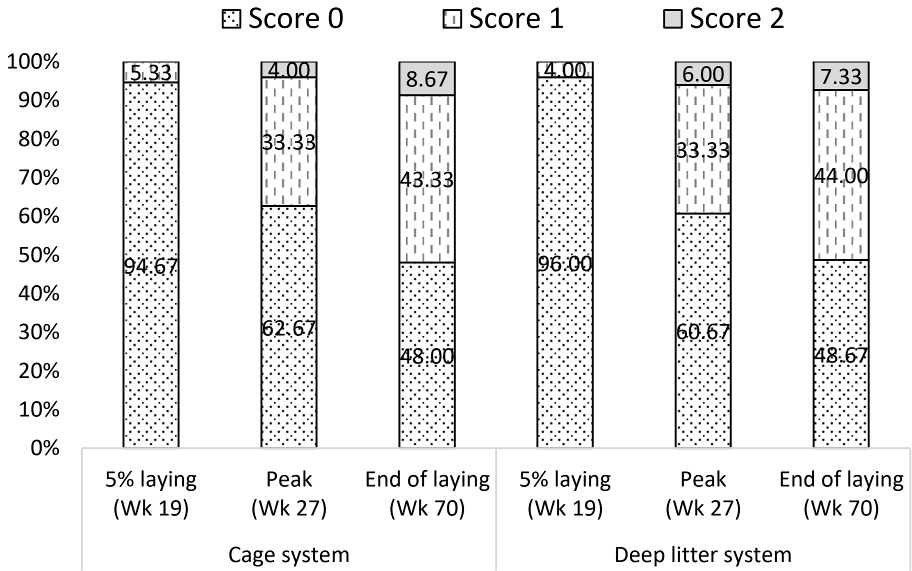

Figure 5. Percentages of hens with different comb pecking wound scores housed in cages or the deep litter system at different weeks of age

of hens performing this abnormal behavior was quite high at the peak of laying (33.33% in both systems) and increased to 43.33% (cage system) and 44% (deep litter system). Blatchford *et al.* (2016) reported no effects of the housing system (conventional cages, enriched cages, and aviary systems) on comb wounds for hens at 52 and 72 weeks of age. Similarly, Jeon *et al.* (2025) indicated that there was no difference in the comb wounds percentage in hens reared in cages and aviary systems. The increase in comb pecking wounds as the hens aged indicated that the hens may have suffered more stress over the rearing period and thus induced aggressive pecking behaviors.

Avoidance distance test

The results of the avoidance distance test of the laying hens at different weeks of age are shown in **Table 2**. The avoidance distances for hens in the deep litter system were significantly higher than those in the cage system at 5% of laying (P = 0.008), peak, and end of laying (P = 0.001), indicating that hens in the deep litter system responded more quickly to avoid the assessor when approached. This result was consistent with a previous study by Jeon *et al.* (2025) stating that hens in an aviary system were quicker to avoid the observer than those in a cage system. Graml *et al.* (2008) also revealed a similar pattern when comparing cage and free-range systems. The narrowed and restricted space in cages may cause shorter avoidance distances (Jeon *et al.*, 2025) compared with those in a deep litter system, where hens have more spaces and abilities to avoid an assessor. Jeon *et al.* (2025) explained that the more intricate environment in a non-cage system provides more opportunities for interactions among hens and enrichment materials can affect the responses of laying hens to approaching humans, however more research is needed to explore the underlying factors contributing to the difference in the avoidance distance between the housing systems.

From the above findings and discussion, improvements of housing conditions should be conducted by producers to enhance the welfare of laying hens. As it has a high risk of poor welfare quality, the conventional battery cage should no longer be used and should be converted into non-cage systems. To improve hen welfare in the deep litter system, priority should be given to litter management to avoid wet or caked litter. Some enrichment materials and perches should be used to reduce the risk of

Table 2. Effects of the housing system on the avoidance distance test of laying hens at different weeks of age

Week of age	Cage system (n = 200, Mean ± SD, cm)	Deep liter system (n = 200, Mean ± SD, cm)	*P*-value
At 5% of laying rate (19 weeks of age)	$76.08^{b} \pm 16.03$	$80.21^{a} \pm 14.97$	0.008
Peak of laying (27 weeks of age)	$73.00^{b} \pm 14.79$	$77.84^{a} \pm 14.47$	0.001
End of laying (70 weeks of age)	$56.52^{b} \pm 19.92$	$63.27^{a} \pm 22.04$	0.001

Note: Means in the same row having different letters indicate significant differences (P <0.05).

food pad dermatitis, feather and comb pecking, and skin lesions. Appropriate handling and care of the hens may benefit their welfare quality by enhancing the animal-human relationship.

Conclusions

Hens kept in the deep litter system had a better welfare in terms of keel bone deformations (OR = 0.52 or 48% lower proportion of hens were affected in the deep litter system than the caged hens) and plumage conditions (OR = 0.11 or 89% lower proportion of hens were affected in the deep litter system than the caged hens), but they were at a higher prevalence of foot pad dermatitis (8.83 times higher) than those reared in cages. No significant differences were found in terms skin lesions and comb pecking wounds between the two housing systems. The avoidance distance was higher in the litter-reared hens compared with the caged hens. The week of age significantly affected all the welfare indicators with an increase in the percentage of affected hens by age. As a trend of transitioning to cage-free systems, the improvement of housing conditions is essential to increase the welfare quality of laying hens in a deep litter system.

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