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Original Article

The Influence of Different Production Systems on the Welfare of a New Commercial Layer Hen Hybrid

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ABSTRACT

This study was conducted to investigate the influence of two different production systems on the welfare of a new Turkish egg-laying hybrid known as Akbay. A total of 180 Akbay hens at the 80th week of production either reared in a free-range system or conventional cages were used. Live body weight at the 80th week of production was recorded, as well as the weight of immune organs and liver. Plumage damage, foot lesions, stress, and fear were examined. It was observed that the live body weight at the 80th week of production was significantly ($p<0.05$) higher in the free-range birds as compared to those housed in cages. The rectal temperature was statistically higher ($p<0.05$) in hens reared in the free-range systems than in those housed in the conventional cages. The percentage of hens with mild to severe foot lesions was higher in the free-range system than in the conventional cages. Plumage damages were more common and severe among hens in cages than among free-range hens. No significant differences were recorded for tonic immobility (TI), the duration of the first head movement, and the number of inductions during TI. The fluctuating asymmetry of the leg and the weight of immune organs and liver were also not significantly different between the housing systems. The housing of laying hens in free range systems improved live body weight with a reduction in stress and feather damage. However, it is suggested that further research should aim at improving the foot lesion issues associated with this housing system.

INTRODUCTION

Chicken egg is the most consumed egg among poultry species worldwide. This high consumption is mainly due to the lack of religious and cultural prohibitions or taboos that inhibit its consumption, unlike meat or eggs from other livestock or poultry species. Furthermore, eggs are one of the cheapest sources of protein, especially in third-world countries (Abdallah *et al.*, 2022), and this has increased the overall global production and consumption of chicken eggs. The increased consumption of chicken eggs has also increased the demand for eggs, which has led to a capacity expansion of numerous commercial farms, making it a fast-growing industry. It has been reported that about 5 billion chickens are produced annually for eggs and meat (Mallick *et al.*, 2020).

Lately, the health and welfare of laying hens have become an increasing concern among egg consumers, especially in Europe and other developed regions. The welfare of laying hens is extremely important, since it influences the overall growth, cost of production, and livability of hens, while also damaging the public opinion on commercial poultry production. It has been reported that although the current intensive system of egg production aims to maximize profit with a reduction in labor costs, it does not meet the natural needs of laying hens (Sosnówka-Czajka *et al.*, 2010). In 2012, there was a ban on the use of conventional cages for egg production in the EU. Janczak & Riber (2015) reported that the sales of eggs produced in conventional cages were banned in California in 2015. Conflicting results have been reported among birds raised in different production systems, and interaction studies between rearing and egg-laying environments have reported a significant production, physiological, and behavioral changes in laying hens. For example, Struwe *et al.* (1992) stated that laying hens housed in a floor system during the rearing phase and later kept in cages during the egg production phase had paler adrenal glands than those kept in cages during the rearing phase. Contrary to the study above, Moe *et al.* (2010) reported no significant influence of the production system on adrenal responsiveness at 50 or 70 weeks of age. However, heterophil-lymphocyte ratios were significantly higher in birds reared on litter systems and later housed in furnished cages during the production phase, when compared to those housed in battery cages during the laying phase. The authors further reported that the production of antibodies in response to immune challenges was higher in birds reared in the litter system. The authors suggested that effects on immune response might have been associated with the pathogenic load in the litter systems and furnished cages rather than stress from the type of rearing or egg-laying environment. In a different research conducted by Roll *et al.* (2009), where birds were either raised in a cage or litter system during the rearing phase, and housed in furnished cages during the egg production cycle, the authors observed poorer plumage coverage among birds reared on the floor system at the end of the production season. Gunnarsson *et al.* (2000) reported that at 16 weeks, birds reared with access to perches from the time of hatch were more likely to reach the higher tiers compared to those exposed to perches from 8 weeks. Fail landing and collision during perching may be common among hens with no access to perching materials during the rearing phase, which could increase the severity and frequency of keel damages among those birds. Roll *et al.* (2008) reported the use of dustbathing susbtrates in enriched cages during the period of the egg-laying cycle to be higher in hens raised in a floor system during the rearing phase than in those raised in cages during the rearing phase. It was also reported that hens reared in the aviary system during the rearing phase coped better after transfer to production facilities (furnished cages) than those raised in cages during the rearing phase (Tahamtani *et al.*, 2014). The authors further reported that hens housed in the aviary system during the rearing phase had higher mortality compared to those reared in cages during the production phase, which indicates the long-term negative effect of keeping aviary-reared birds in furnished cages during the production phase. Furthermore, production systems are also known to influence the growth of immune and other body organs, as well as increase stress and fear among laying hens.

In this study, it was hypothesized that birds in a free-range system would have better general performance than those ın cages in terms of all measured parameters.

Therefore, the aim of this study was to assess the influence of the two different production systems (free-range and conventional cages) on growth performance, immune organ weight, prevelance of footpad dermatitis/bumble foot, plumage condition, fear, and stress for the new Turkish laying hen hybrid called Akbay.

MATERIALS AND METHODS

This experiment was approved by the ethics committee of Cukurova University. Euthanasia and other practices were all carried out in husbandry practices with full consideration of animal welfare.

Animal material

The animals used in this study were Akbays, a new Turkish egg laying hybrid hen, which has undergone several genetic selections for many years and was registered in 2019. Akbay hybrid hens are white layers like the Atabey hybrid, but while sex determination cannot be done at daily age for the Atabey hybrid, it can be done for the Akbay hybrid. The Akbay is currently not available to farmers. This is the first project reporting the welfare status of the Akbay on two different production systems (free range and conventional cages).

Experimental design

A total of 180 new Turkish laying hybrids (Akbay) at 80 weeks of egg production were used in this study. The hens were either raised in traditional cages or a free-range production system. The dimensions of the conventional cage were 57cm x 57cm x 40cm (Length, width, height), with 4 hens/cage and an adequate space of 5m^2/hen. The dimensions of the free-range system were 981cm x 853cm x 282cm (Length, width, height). The free-range birds had access to metallic perches and an outdoor ranging area of 800 m^2. The indoor space per bird was 6 hens/m^2 and the outdoor space was 10 m^2/ bird. Each of the production systems was replicated three times (30 birds/ replicate= 90 birds/ production system). A photoperiod of 16L; 8D was used in all poultry units. Feed and water were provided *ad libitum* in this experiment. The average temperature and humidity in the poultry houses were maintained at the optimum levels (22 °C and 56%), and automatic ventilators were used to regulate the odor concentration (NH3 and H2S) in the house, as well as the rising ambient temperature.

Measures of welfare indicators

Fear responses

• Tonic immobility (TI) test

Tonic immobility was used as the indicator of fear in this experiment. A total of 20 birds from each production system were tested for TI responses. To induce tonic immobility, the experimenter restrained the hens by holding them on their backs on a table. A mild force was exerted on the chest with the right hand and the left hand was used to close the head of the bird for 15s. After 15 seconds of holding the birds upside-down, with mild pressure on the sternum, the experimenter then carefully and slowly removed their hand from the bird. If the bird stayed immobile after the 15s restraint was initiated, the TI duration was recorded from that moment using a stopwatch until the bird righted itself. The 15s restraining was repeated 5 times and after 5 unsuccessfully restraints, TI for those birds was recorded as zero (0). The maximum TI duration was 300s. The time for the first movement of the head was recorded, and hens that took longer to show their first head movements and also to right themselves up were considered more fearful. The tonic immobility test was performed in a different chamber within the production facility.

Stress responses

Both rectal or cloacal temperature and the measure of fluctuating asymmetry were used as indicators of stress in the experiment.

• Rectal / cloacal temperature

In this study, the rectal temperature was measured in all the experimental birds. The rectal temperature was measured using a digital thermometer inserted approximately 3 cm into the cloaca of the hens for approximately 30-50 seconds.

• Fluctuating asymmetry (FA)

It is measured as the difference between the left part of the trait minus the right part of the same trait measured using a digital caliper (Archer *et al.*, 2009).15 hens/ replicate were randomly selected for FA measurement. FA was measured after the bird was slaughtered and the legs were separated from the rest of the body.

$$\text{Mathematically FA: } \frac{\text{MTL(L-R) + ML(L-R) + MW(L-R)}}{3}$$

MTL (Middle Toe length); ML (Metatarsal length); MW (Metatarsal width); L(Left); R (Right).

Clinical conditions

• Foot lesions (footpad dermatitis /bumblefoot)

All the experimental birds (90 birds/ production system) were examined for the presence or absence of foot lesions using the guidelines of the Welfare Quality Assessment Protocol for Poultry (2009). The clinical condition was recorded as absent or present. Both legs were examined, and the condition was still recorded as ‘present’ if appearing in just one foot. The condition was only recorded as ‘absent’ when the were no signs of it on either feet. The presence or absence of the condition was recorded in percentages; mathematically:

$$\text{\%Foot lesions} = \frac{\text{(Amount of hens with specific footpad conditions)}}{\text{(total number of birds in that production system)}} \times 100$$

• Feather/plumage damage (FD)

All the experimental birds (90 birds/ production system) were scored for plumage damage using a three-scale scoring system (0-2), according to the guidelines of the Welfare Quality Assessment Protocol for Poultry (2009);

0 = No wear or little wear.

1 = Moderate wear (damaged feathers or one or more featherless areas <5 cm).

2 = At least one featherless area ≥ 5 cm in diameter.

The FD condition was examined at 3 distinct points; point 1 was from the head to the neck, point 2 was from the back to the ramp, and point 3 was the cloacal region.

Mathematically: %FD = (Number of birds with a particular FD score/total number of birds in that production system) x 100.

Immune and other visceral organs

At the end of the experiment, the birds were slaughtered (5 birds/ replicate = 15/birds production system), and the weight of the lymphoid organs (spleen and cloacal bursa) and the liver were recorded and expressed as percentages.

$$\text{Mathematically: \% visceral organs: } \frac{\text{Organ weight}}{\text{slaughter weight}} \times 100$$

Statistical analysis

The collected data were first entered into Microsoft Excel for data arrangement, and t-test analysis in SPSS version 22 was subsequently used to compare the means of the two groups for statistical difference.

RESULTS

The influence of the production systems on body weight, cloacal bursa, spleen, and liver at the 80th week of production is shown in Table 1. The production systems had no significant effect on the immune organs (cloacal bursa and spleen). However, the body/live weight at the 80th week was significantly higher ($p \geq 0.05$) for the hens reared in free range system compared to those reared in the conventional cages.

Table 1 – Effect of the production systems on body/live weight, cloacal bursa, spleen, and liver at 80 weeks of production.

Parameters	Production systems		*p* Values
	Free range	Conventional cage	
Body/live Weight (g)	1813.97±191.62	1694.89±121.38	<0.001
Cloacal Bursa (%)	0.153±0.105	0.160±0.105	0.863
Spleen (%)	0.080±0.021	0.095±0.023	0.064
Liver (%)	2.072±0.40	2.021±0.33	0.704

The influence of the production systems on stress (rectal temperature and fluctuating asymmetry) and fear (TI, time of first head movement during TI, and the number of inductions during TI) is shown in Table 2. The production systems had no influence on the duration of TI, the number of inductions during TI, or the time of first head movement during TI; neither did it have a statistical influence on FA values. However, rectal temperatures were significantly ($p<0.05$) higher among free-range birds compared to those in conventional cages.

Table 2 – Effect of the production systems on stress and responses to fear.

Parameters	Production systems		*p* Values
Stress indicators	Free range	Conventional cage	
Body temperature (°C)	40.92±0.27	40.78±0.30	0.031
FA	2.28±0.633	2.79±1.83	0.321
Fear indicators			
Duration of tonic immobility (s)	3.23±1.69	3.20±1.98	0.964
Number of inductions	1.0 ±0.54	2.0±1.67	0.057
Time of first head movement during TI (s)	1.80±1.64	1.36±1.42	0.381

S: seconds; FA: Fluctuating assymetry; TI: Tonic immobility.

Furthermore, the effect of the production systems on plumage or feather damage (FD) is shown in Table 3. The majority (91.11%) of the free-range hens had a score of zero (0), indicating no wear or slight wear of their plumage, while 7.78% had moderate plumage damage, and very few (1.11%) hens had a score of two (2), indicating that those birds had at least one featherless area ≥ 5 cm in diameter. Contrary to the hens on the free range system, 52.22% of the birds raised in the conventional cages had slight or no wear, with 26.67% having at least one featherless area ≥ 5 cm in diameter, and 21.11% having moderate plumage damage.

Table 3 – Effect of the production systems on plumage or feather damage (FD).

Categorization of FD	% of hens Production systems	
	Free range	Conventional cages
0 = No wear or slight wear.	91.11%	52.22%
1 = Moderate wear.	7.78%	21.11%
2 = At least one featherless area ≥ 5 cm in diameter	1.11%	26.67%

FD: feather damage.

The influence of the production system on the presence or absence of foot pad dermatitis/bumblefoot is shown in Table 4. All the birds in the free range system had some form of foot pad dermatitis or bumble foot, ranging from mild to severe either on one foot or both feet. However, only 55.56% of the birds in conventional cages had the clinical condition ranging from mild to severe, either on both feet or a single foot, and 44.44% had intact feet with no sign of conditions on either feet.

Table 4 – The influence of the production system on the presence foot lesions.

Categorization of foot lesions (foot pad dermatitis/bumblefoot)	% of hens Production systems	
	Free range	Conventional cages
Present	100%	55.56%
Absent	0.00	44.44%

DISCUSSION

This study assessed selected health and welfare variables in a new Turkish egg-laying hybrid hen, the Akbay, under two production systems: conventional cages and free-range.

In the current study, it was observed that the live weight of the hens at 80th week of production was statistically higher ($p<0.05$) for the hens reared in the free range system compared to those in the conventional cages (Table 1). Birds in cages are known to be stressed due to the limitation of their movement and also the lack of opportunity to exhibit their natural behaviors. Stress in general is also known to increase corticosterone secretion, which in turn increases body temperature, resulting in heat stress. Furthermore, Holik (2015) reported that genetically modified laying hens produce more heat due to high metabolic activities. So, under severe stress conditions, birds normally reduce their feed intake to decrease metabolic heat production. This reduction in feed intake causes a huge decline in body weight gain. Irshad *et al.* (2013) also reported that heat stress resulted in stunted growth coupled with a decrease in egg production and an increased rate of mortality. Vandana *et al.* (2021) reported that the reduction in productivity as a result of the direct decline in feed intake could be regarded as an adaptive approach to maintaining heat balance within the body, since lower feed intake reduces the heat increase due to feeding. Furthermore, it has been reported that poultry compromise their productive potential when coping with heat stress (Rojas-Downing *et al.*, 2017). Vandana *et al.* (2021) further explained that a decreased feed conversion efficiency among chickens is one of the effects of heat stress on productivity. Another reason may also be that the access to various types of pasture plants by the free-range hens might have improved growth and boosted the immune function of the hens. Zheng *et al.* (2021) indicated that grazing mixed-grass pastures could positively affect the intestinal microbiota, which may contribute to the overall growth and immunity of free-range chickens. It has also been reported that the supplementation of forage products regulates the intestinal microbiota by enhancing the proliferation of lactic acid bacteria, which may act as a shield against pathogens and therefore enhance the growth performance of chickens (Zheng *et al.*, 2019a, 2019b). An additional reason could also be that hens in the free range system had access to several insects, which are considered a huge source of nutrients for growth. It has been reported that the inclusion of black soldier fly larvae in chicken diets enhanced feed efficiency and growth performance (DiGiacomo & Leury, 2019). Other authors (Detilleux *et al.*, 2022) have further explained that the inclusion of black soldier flies in poultry diets could improve their growth performance traits by influencing the microbiota of the gut. Malematja *et al.* (2023) have also reported that insects are made of bioactive compounds and valuable nutrients that are known to influence the functionality and the microbiota of the gut, which could subsequently impact the health and the growth performance of birds. Similar to our results, Sekeroglu *et al.* (2010) also reported that at 5% egg production, hens in a free range system had some advantages over those in the floor and cage systems in terms of body weight. Shimmura *et al.* (2010) also reported a numerically higher live weight gain in free-range birds compared to those in small and large conventional cages, although it was statistically not different from the other groups. However, Yang *et al.* (2014) reported a better live weight gain in hens housed in conventional cages compared to those with outdoor access (free-range). Also, a better average weekly live weight gain in birds raised in conventional cages than in those reared in the deep litter system was reported by Yakubu *et al.* (2007). The difference in these results could be attributed to several factors, such as the breed/ strain of the hens, stocking densities, litter quality and management, and ventilation in the production systems.

Hens kept in cages are known to be stressed, causing a rise in the blood levels of corticosterone (heat stress) that could cause a reduction in the size of the immune and other visceral organs. However, in the current study, the influence of the housing systems on the weight of the immune organs and liver was not significant (Table 1). However, some authors have stated that birds experience a decline in the weight of the lymphoid organs and thymus when under stress due to heat, leading to a significant reduction in T and B lymphocytes with a subsequent decline in the production of antibodies (Zulkifli *et al.*, 2000; Ghazi *et al.*, 2012). Other authors (Felver-Gant *et al.*, 2012) reported that during heat stress, the weight of the liver decreases, coupled with a reduction in IgM and IgG. Yang *et al.* (2014) observed higher spleen and liver weights among free-range hens compared to those reared in conventional cages. Denying hens access to exercise can cause fatty liver hemorrhagic syndrome, which may cause hens to die as a result of a ruptured liver. In a research conducted by Shini *et al.* (2019), 74% of birds in cages died due to fatty liver hemorrhagic syndrome. We concluded that the severity of the effect of the production system on the hens' performance may vary from strain to strain, coupled with other factors such as the degree of discomfort experienced by the animal and stocking densities. These factors may explain the differences in the results observed by different authors.

The production system in the present study had a significant effect ($p<0.05$) on the rectal temperature of the laying hens (Table 2). Although Miele (2011) reported that conventionally confined animals are known to be stressed, birds in conventional cages had lower rectal temperatures than the free-range hens in the present study. Other studies (Yakubu *et al.*, 2018) observed no effect of the production system on the rectal temperature of hens. However, the pulse rate, respiratory rate, and heat stress index were higher in hens housed in cages than in those in the deep-litter system. The higher rectal temperature observed among hens reared in the free range system in the present study system could be due to the excessive chasing to catch birds for the measurement of multiple parameters, which increases corticosterone secretion and further increases body temperature. Furthermore, in the present study, the fluctuation asymmetry of the leg was observed to be higher among the hens in cages, although it did not statistically differ from those of hens housed in the free-range system (Table 2). Campo *et al.* (2008) have confirmed that birds with access to outdoor areas are less stressed than those without access to outdoor areas. This indicates that the provision of an adequate stocking density that enables birds to exhibit their natural behaviors is among the crucial parameters influencing stress. Furthermore, hens in cages are also known to have higher levels of corticosterone due to stress; and Eriksen *et al.* (2003) proved that increased corticosterone levels increased FA in the tarsus length, showing increased stress levels and poor welfare. Moreover, other authors also reported a lower relative asymmetry of toe lengths among hens housed in the free-range system than in those housed in a floor system (Campo *et al.*, 2008).

The production system in this study did not have any significant effect on fear indicators such as the duration of tonic immobility, the number of inductions, and the time of the first head movement during tonic immobility (Table 2). Similar to our findings, other studies (Campo *et al.*, 2008) also did not observe any significant influence of the production on the duration of tonic immobility; however, Shimmura *et al.* (2010) reported less fear behavior in free-range birds as compared to those in other production systems.

Plumage or feather damage was worse among birds reared in the conventional cages when compared to those reared in the free-range system (Table 3). There have been reports of a correlation between feather pecking and fear (de Haas *et al.*, 2014a, 2014b). We assume that the higher level of stress among the birds in the conventional cages might have increased agonistic behaviors such as feather pecking and other forms of cannibalism in comparison to birds in the free range system. Also, the lack of environmental enrichment in conventional cages such as perches and dust baths may limit the hens' ability to exhibit some playful or natural behaviors, which may increase frustrations and lead to agonistic behavior and subsequent damage to the plumage. In conventional cages, less dominant and aggressive birds might also not have a safe space such as perches to hide, so they may continuously remain under aggressive pecking by the dominant individuals, which may lead to severe feather or plumage damages. Roll *et al.* (2009) also reported that laying hens housed in the floor system during the rearing phase and later kept in furnished cages during the production phase were found to have poor plumage at the end of the production cycle. Contrary to our results, other authors observed poorer plumage conditions in free-range birds than in those kept in other production systems (Shimmura *et al.*, 2010).

Foot lesion was worse among the free-range hens (Table 4), with all the birds in that production system having some form of foot lesions ranging from mild to severe, either on one or both feet. Bell drinkers were used in the free range system, with constant water spillage caused by the hens leading to the litter materials being wet and sometimes forming cakes. These wet litter/cakes serve as a favorable environment for the growth of microorganisms. The movement of hens in and out of these wet litters/cakes causes bacteria infestation of the feet, resulting in foot swelling and inflammation. It has been reported that the quality and type of bedding materials affect the prevalence of foot lesions (The Poultry Site, 2013). Furthermore, it has been reported that wet litter conditions can increase the production of ammonia, which can create a micro-environment of around 11 pH in direct contact with the feet, leading to the development of foot lesions (Zinpro, 2020). Other authors have also observed higher foot damage among free-range hens than among those reared either in conventional or furnished cages (Shimmura *et al.*, 2010). Another reason for the high prevalence of foot lesions in the free range system could be the frequent contact of the foot with fecal matter on the floor. Furthermore, hens in the free-range system were provided with access to perches, which is another factor known to increase the prevalence of bumble foot (Tauson & Abrahamsson, 1994).

It was therefore concluded that the welfare and growth performance of hens are severely affected by the production system. The cage system was observed to increase stress by increasing the fluctuating asymmetry of the leg, coupled with a reduction in the body/live weight. Furthermore, plumage conditions were better among the free-range hens, indicating that the use of the free-range system can reduce stress and the incidence of aggressive feather pecking leading to severe plumage damage. The overall results indicated that laying hens can be housed in the free-range production system without adverse effects on welfare. However, we recommend that further studies focus on the improvement of foot lesion-related problems associated with this housing system. Furthermore, we also recommend that other advanced non-evasive methods of measuring rectal temperature, are used rather than using the evasive method (chasing-catching-restriction), especially for birds in the non-cage production system.

DECLARATIONS

Competing interests: The authors declare no competing interests.

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