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Performance, behavior, and welfare of turkey poults reared under different housing conditions

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ABSTRACT

Turkey's production is very profitable due to the growing demand for its products worldwide, however, poultry farming incurs significant economic losses throughout its production life cycle due to various stressors and high energy costs, particularly during the brooding period. Battery cages save housing space that can drastically reduce broodiness energy costs however, it can make birds suffer. Nowadays, Customers demand products derived from poultry reared in the optimal environment to ensure their welfare. However, the producers care about maximizing performance with the lowest production costs. This study was designed in a trial to reduce broodiness energy costs by rearing turkey poults in batteries and evaluate the performance, behavior, and welfare of caged and floor-reared birds. One thousand turkey poults were housed either on the floor or in battery post-hatching at a stocking density of 52 turkey poults/m^2. Behaviors, body weight, weight gain, and some welfare indicators were studied. The results revealed that battery-reared turkey poults have significantly increased 4th week weight, weight gain, and cumulative weight gain. It also showed increased body care and drinking behavior, while eating behavior significantly decreased. Additionally, they have a better feather cleanliness score but were more stressed and fearful as indicated by longer tonic immobility (TI) duration, greater fluctuating asymmetry (FA) value of middle toe length, and increased sitting, latency to ambulate in open field test (OFT) as compared with floor reared ones. However, serum levels of cortisol or oxidative stress markers (MDA, GSH) as well as mortality % didn't differ significantly among the two systems. In conclusion: using batteries in rearing turkey poults may be an applicable strategy to decrease broodiness energy costs, but with some welfare concerns.

Introduction

Turkey's production is significant and very profitable due to the growing demand for its products worldwide, they are more tolerant of heat, perform well in dry climates, extend ultimately, and produce meat of superior quality used for human consumption (Yakubu *et al*., 2013). In the entire world turkey production experienced an improvement; it has witnessed a significant increase since 1980, growing from 122 million to 226 million turkeys raised in 2006 in the member states of the European Union (FAO, 2012).

The commercial turkey industry inevitably suffers significant economic losses due to the numerous stressors that arise during production (Gernat, 2022) and high energy costs that make producers struggle to keep their farms in operation (Tabler *et al*., 2008). In the poultry farming industry, it is vital to use a significant amount of fuel to maintain a specific internal temperature. This temperature is essential for ensuring that the birds are healthy and able to produce at the desired level (Cui *et al*., 2021). Livestock production incurs a substantial cost for supplemental heat energy required for brooding, especially in colder climates (Poole *et al*. 2018). Turkey brooding heat energy accounts for up to 8% of the total production cost (German *et al*., 2017). The poultry industry's expansion demands that producers reduce production costs and enhance profit margins with urgency (Noonari *et al*., 2015). However, keeping high-efficiency production is also an important concern since customers now demand poultry products derived from birds reared in the optimal environment to ensure their welfare (Bartussek, 1999; Ferrante *et al*., 2019).

Despite the multiple systems that could be used to house poultry, it was obvious that no optimal housing system was present since each possesses disadvantages and advantages in terms of welfare and health (Lay *et al*., 2011; Hartcher and Jones, 2017). For multiple causes, the outdoor or indoor conventional methods for rearing poultry didn't suit expansion, including higher labor demand, spread of diseases, and poor hygiene. Rearing poultry in either cages or floors may experience good and detrimental consequences on their health, production, and reproduction (Duncan, 2001; Alam *et al*., 2022). An animal's physical and mental health are both included along with its welfare. The welfare of poultry may be impacted by housing in a variety of ways. Measures such as mortality rate, physiological responses (primarily stress markers), diseases, general condition, behavior, and production should all be considered to evaluate the welfare of an animal in a particular housing (Wenger, 1992; Shields and Duncan, 2009).

By describing the advantages and disadvantages of battery cages; it was obvious that battery advantages include improved sanitary conditions such as birds' separation from their droppings (Duncan, 2001), reduced ammonia and dust concentration (Koerkamp and Drost, 1993) resulting in lower morbidity and mortality (Arbona *et al*., 2009; Al-Bahouh *et al*., 2012). In addition to facilitating the managerial practices by the availability of smaller group sizes, less labor needed (fully automated), and the possibility of higher stocking density in cage houses (Duncan, 2001).

On the contrary, battery cages had several disadvantages, which were represented in the lack of physical space that prevents birds from performing behaviors (Shields and Duncan, 2009; Alam *et al*., 2022). It has been found that the absence of exercise in cages can cause bones to become fragile and weak (Rowland and Harms, 1970; Meyer and Sunde, 1974). In addition, a lack of opportunities for dust bathing and suitable foraging (Blokhuis, 1989) can also lead to suffering in birds. Furthermore, hyperkeratosis of the toe pads (Tauson, 1981) can develop, which can cause further distress to the birds.

Nowadays, millions of birds are reared in cages under an environmentally managed system (Habibullah *et al*., 2015). Minimal tries to cage turkeys in research have been effective enough to justify building commercial cages, and most studies on caged turkeys have had limited results (Manley and Muller, 1973). Raising turkeys in cages beginning from one

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day old was observed to decrease leg abnormalities and concerns with egg production (Manley and Muller, 1973). The lack of published studies on caged and different floorings rearing of turkeys reveals that housing systems, as well as a scarcity of research on the influence of the physical and social surroundings on the behavior, performance, and welfare of turkeys, should be studied (Marchewka *et al.*, 2013). The primary objective of this study was to decrease the high energy brooding cost by using a battery cage system during the brooding period and answering the question from a welfare point of view; Are battery cages suitable for rearing turkey poults?

Materials and methods

This study was conducted in the Beni-Suef turkey project, Beni-Suef Governorate, Egypt using 1000 one-week-old turkey poults.

Experimental design

A total number of one thousand bronze turkey poults with an average weight of 66.67±1.41 g. were housed either on the floor or in battery (cage dimensions: 45x65x100 cm) post hatching at stocking density of 52 turkey poults/m^2, then the stocking density was adjusted according to the age of the birds. They were used to investigate the effect of different housing systems on behavior, performance, and some welfare indicators. Indoors, food and water were freely available. Every day, probable instances of mortality and other problems were pointed out. The research study was authorized by the Institutional Animal Care and Use Committee (ICAUC), Beni-Suef University number (022-416).

Performance recording

Weight and weight gain were recorded weekly; weight gain was calculated as the following formula,
Weight gain (WG) = weight of current week - weight of the previous week

Behavioral measurements

Behavioral observation

The observation of turkey poults' behavior occurred weekly for four successive weeks, with each session lasting 15 minutes, ensuring comprehensive documentation. Scan methods of observation were adopted at 30-second intervals (Giersberg *et al.*, 2020) using the ethogram illustrated in Table 1.

Behavioral tests

Tonic immobility (TI)

After the rearing period, a tonic immobility (TI) assessment was done using the modified methodologies outlined by Noble *et al.* (1996), where turkey poults were carefully removed from their enclosures at randomness and rated separately just one time in a separate location free of various outside factors to assess TI. The bird was quickly caught and positioned on a flat table covered in cloth material. Then, the bird was secured on its left side by gently grasping its legs with the observer's right hand and putting the left hand over the bird's right wing. The observer eventually took his hands off the turkey after roughly 15 seconds, followed by calculating the length of the bird's sitting posture in seconds via observation of the bird from a one-meter distance. Percentages for one induction (OI, the percent of birds display TI response in the first test application), vocalizations (V, percent of sound-making throughout the test), defecations (D, percent of birds' waste throughout the test), TI percent (TI%, percentage of the birds standing up freely through 600 seconds lacking any enforcement), and TI duration (TID, length of time bird standing up freely lacking any enforcement) were recorded. The above measurements have been recorded as percentages for each bird's behavior.

Open field test (OFT)

The experiment was precisely executed in strict accordance with the methodology proposed by Erasmus and Swanson (2014) and Taskin *et al.* (2018), every single turkey was moved separately to an empty room adjoining the experimental room. The OF testing field was a 1.5 m1.5 m square field with a cement ground and bounded by 1.5-meter-high solid black partitions. On the testing area concrete floor, a grid containing sixty-four squares (each of them 0.04m^2) has been drawn with black tapes. For ten minutes, each bird was put in the middle of the field. Standings, sittings, ambulation, vocalizations, defecations, and escape behaviors have all been tracked. As the birds displayed various behaviors including, Standing (ST): Standing on the ground with legs apart from the belly; Sitting (SI): Sitting with breast and belly touching the ground; Ambulation (A): Two or more legs moving quickly; Flying (F): Flapping their wings, without any contact with the ground; Vocalization (V): Creation of sounds by birds; Defecation (D): Number of defecations throughout the test; Escape (E): attempting to jump from the testing phase. Each displayed behavior was estimated in percentages and the total number of birds that engaged in the behavior. Additionally, ambulation latency (seconds) and vocalization latency (seconds) were measured.

Health parameters determination

Feather condition

A single person inspected the condition of the feathers over the four major regions of the bird (breast, back, wings, and tail). Feather quality was assigned a score on a 1-4 scale accepted by Davami *et al.* (1987) and Sarica *et al.* (2008). The scores meant that; 1: the bird had no feather cover, 2: over fifty percent of the plumage had been lost, 3: fifty percent of the plumage had been removed, and 4: the bird had complete undamaged plumage.

Feather cleanliness

The cleanliness of the feathers was assessed by a single observer using a modified scale of the broiler scoring system implemented by Wilkins *et al.* (2003), and rated on a scale of 1-4. The scores referred to the degree of cleanliness of feathers as follows; 1: extremely clean (more than 75% of feathers are devoid of soiling), 2: slightly clean (50-75% of the feathers are devoid of soiling), 3: slightly dirty (25-50% of the feathers

Table 1. Behavioral Ethogram.

Behavior	Description
Active	Engaging or ready to engage in physically energetic pursuits, like walking in pen
In active	Resting in sitting or standing idle
Eating	Pecking at feed or their heads are over the feeder
Drinking	Pecking at water in drinkers or nipples
Body care\ Grooming	Scratching, Preening Wing stretch, and Dust bathing.

are devoid of soiling), and 4: extremely dirty (25% of the feathers are devoid of soiling).

Determination of leg health

Gait score

Employing the gait scoring system developed by Garner *et al*. (2002) and Vermette *et al*. (2016), birds were scored from 0 to 5 and both scores were finally averaged to every bird, with 0: none, 1: recognized, indistinguishable abnormalities, 2: recognizable abnormalities with little or no effect on general function, 3: recognizable abnormalities that interfere with function, 4: serious loss of function but retaining the ability to walk, and 5: full lameness.

Footpad dermatitis (FPD)

According to Knierim *et al*. (2016) and Leishman *et al*. (2021), birds underwent testing for incidence and the degree of FPD as follows: 0 = No clinical signs of FPD. 1 = Tough or thick skin, tiny necrotic patches on less than 25% of the footpad, litter stuck to the footpad and difficult to remove; 2 = Extensive necrotic regions and/or inflammation on more than 25% of the footpad, litter stuck to the footpad and difficult to remove.

Determination of Fluctuating asymmetry (FA)

The physical assessment of traits was done following the collection of the blood samples. The measurements taken included the right (R) and left (L) length of the middle toe (going from the metatarsus to the nail), the length of the leg (metatarsus) (going from the hock joint till the middle toe), and both R and L measurements taken from the same bird at the same time.

The length measurements were recorded in millimeters using a digital caliper. The trait size was recorded as the mean of the right and left traits [(R + L)/2]. The absolute disparities between sides [|R − L|] were used to calculate a trait's FA. As numerous potential confounding variables may hinder the investigation of asymmetry (more information could be observed in the initial investigation by Campo *et al*., 2008), several steps (Palmer, 1994; Knierim *et al*., 2007) were undertaken before determining the shown asymmetry as FA (normal distribution of signed R − L differences with a mean of zero). Relative FA was utilized for all traits [2|R − L|/(R + L)]. Combined relative asymmetry was referred to as the mean of the relative asymmetries of the different traits (Campo *et al*., 2009).

Mortality percentage (%)

Mortalities were recorded daily throughout study, and the mortality percent was calculated.

Biochemical assay

Blood samples were obtained from turkey pullets at the end of the experiment by simple vein puncture of the wing vein, transferred to dry centrifuge tubes without anticoagulant for serum separation and determination of malondialdehyde "MDA", Reduced hepatic glutathione "GSH" and cortisol levels.

Lipid peroxidation estimation (MDA)

Colorimetric measurements of serum malondialdehyde (MDA) levels were utilized for estimating the lipid peroxidation process in the serum, according to the study by Albro *et al*. (1986).

Hepatic Reduced glutathione measurement (GSH)

Reduced hepatic glutathione content was carried out following Ellman (1959).

Serum cortisol estimation

Serum cortisol levels were estimated using commercial ELISA kits.

Statistical analysis

The statistical analysis was conducted using the T-test and Mann-Whitney tests in SPSS v22. The results were presented as mean±SEM. It should be noted that values less than 0.05 ($P<0.05$) were considered statistically significant.

Results

The experiment showed that battery-reared turkey poults had a noticeable increase in body weight and body weight gain during the fourth week, as compared to floor-reared poults. This difference was significant in both cases, with P values of less than 0.05 and 0.01, respectively. However, there was no significant effect observed in the first three weeks of the experiment, as per Table 2.

The data in Figure 1 demonstrated that the cumulative weight gain markedly increased ($P<0.05$) in the battery-reared turkey poults. While the cumulative body weight, average body weight, and weight gain showed no statistical difference present between the two housing systems.

According to the study, there was no notable disparity in the active and inactive conduct of turkey poults observed in both housing systems.

Table 2. The effect of different housing systems on turkey poults performance.

	Turkey poults Performance						
	Weight (Wt)				Weight gain (WG)		
Housing systems	Wt. Wk 1	Wt. WK 2	Wt. WK 3	Wt. WK 4	WG 2	WG 3	WG 4
Battery	66.67±3.33	118.65±4.26	252.88±3.19	581.72±11.29*	51.98±7.57	134.23±2.65	328.84±12.77**
Floor	66.67±1.67	122.82±3.20	263.62±5.46	529.05±11.79	56.15±2.84	140.80±6.34	265.43±10.08

Results are expressed as mean±standard error. *: Superscripts indicate a significant difference between different groups at P-value ($P<0.05$). **: Superscripts indicate a significant difference between different groups at P-value ($P<0.01$). Wt.: weight (g); WG: weight gain (g); WK: Week

Table 3. Effect of different housing systems on turkey poults' behavior.

Housing system	Behavioral patterns				
	Active	Inactive	Feeding	Drinking	Body care
Battery	33.60±1.97	44.22±5.42	6.97±2.64	10.96±4.21*	4.25±0.80*
Floor	36.64±8.12	43.57±9.85	17.58±5.29*	2.20±0.74	0.01±0.01

Results are expressed as mean±standard error. *: Superscripts indicate a significant difference between different groups at P-value ($P<0.05$).

There was a significant increase (P<0.05) in the eating behavior of floor-reared poults to the caged ones, while the drinking and body care behaviors were markedly (P<0.05) increased in caged birds than the floor ones in Table 3.

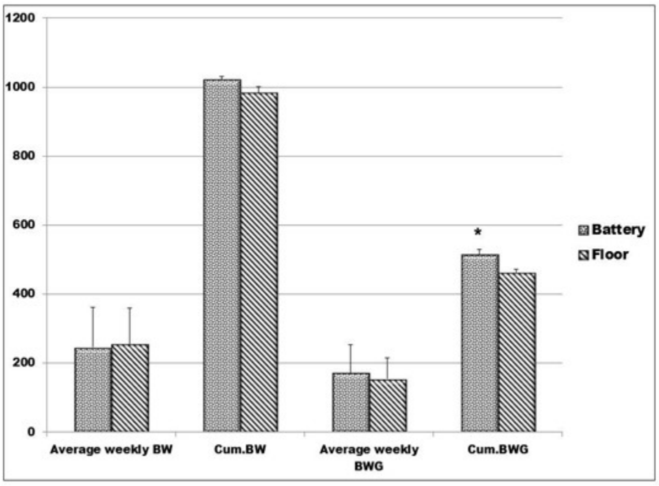

Fig. 1. The effect of different housing systems on the average and cumulative body weight and body weight gain of turkey poults.

The behaviors expressed by the turkey poults in the TI test (Figure 2) revealed that OI% and V% elevated significantly (P<0.01) in the floor-reared poults, while the absence of statistical difference was evident between the two houses in D% and TI%. On the contrary, the TI durations were significantly (P<0.05) reduced in the floor house.

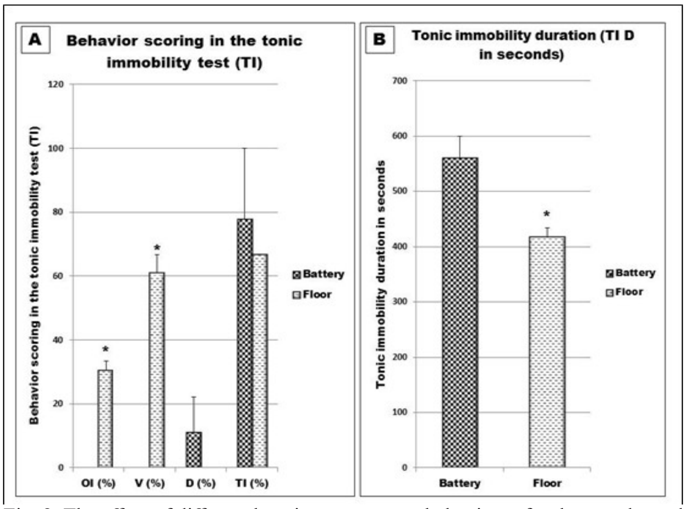

Fig. 2. The effect of different housing systems on behaviors of turkey poults and tonic immobility durations in TI test; (A): Behavior scoring in the tonic immobility test (TI), (B): Tonic immobility duration (TI D in seconds).

In the OFT (Table 4); it was clear that a significant difference was absent among floor and battery-reared poults in the percent of all behaviors performed and in the number of turkeys in the standing, ambulation, defecation, and escape behaviors. Also, the number of squares crossed didn't differ significantly between the two houses. However, there was a significant difference (P<0.05; P=0.05; P<0.01; P<0.05) in order between the two housing systems in ambulation latency, the number of poults sit, and vocalization number and latency in the maze.

The incidence of FPD, gait, and feather condition scoring abnormalities (Figure 3) didn't differ significantly among the floor and battery-reared turkey poults. Meanwhile, the feather cleanliness score increased significantly (P<0.01) in the floor system compared to the battery system.

The results for the trait size, absolute, relative, and combined asymmetry measurements of the leg and middle toe length were presented in Table 5. A statistically significant difference was found only for the middle

Table 4. The effect of different housing systems on open field scores (%) of turkey poults.

Housing systems	Open field test scoring "OFT" (Number "No."; percent "%" and latency)														
	Standing		Sitting		Ambulation			Vocalization			Defecation		Escape		No. of squares
	%	No.	%	No.	%	No.	latency	%	No.	latency	%	No.	%	No.	No.
Battery	69.44±19.4	5.2±2.95	50.00±9.62	0.6±0.22*	50.00±28.87	5.1±3.21	390.9±78.90*	58.33±30.04	34.1±12.39	310±89.27*	41.67±30.05	1.3±0.56	33.33±30.33	0.3±0.15	14.8±8.36
Floor	88.89±11.11	8.2±2.05	16.67±16.60	0.1±0.10	90.00±12.10	9.3±2.36	151.2±55.76	89.70±11.12	90.8±17.93**	84.2±58.76	61.11±5.56	1.4±0.52	41.67±12.73	0.9±0.43	32.5±8.17

Results are expressed as mean±standard error. *: Superscripts indicate a significant difference between different groups at P-value (P<0.05). **: Superscripts indicate a significant difference between different groups at P-value (P<0.01). %: percentage; No.: number.

toe length in terms of the trait size (P<0.01) and absolute asymmetry averages (P<0.05) of the bilateral traits (P<0.01) of caged birds where they showed a greater FA value that may reflect an adverse effect on development of turkey poults during the growth period.

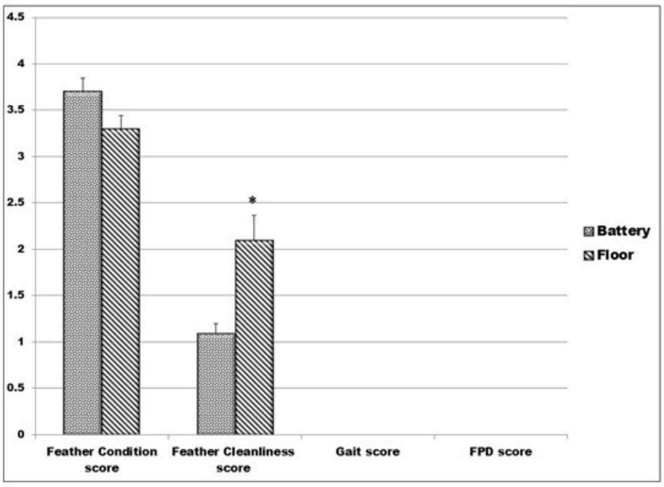

Fig. 3. The effect of housing systems on the health condition of turkey poults.

The morality % had increased in the floor system in comparison with the battery system but with the absence of statistical difference as observed in (Figure 4).

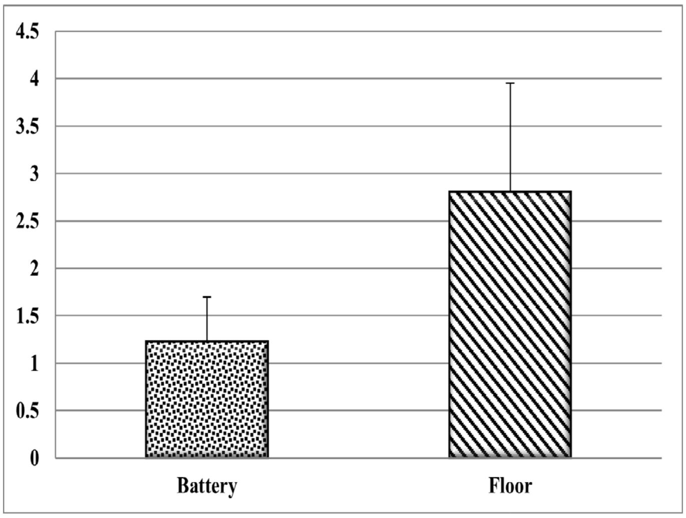

Fig. 4. The effect of different housing systems on the mortality percent of turkey poults.

From Figure 5 it was obvious that the serum cortisol level was increased in battery-reared birds (P>0.05). Similarly, oxidative stress markers (MDA, GSH) didn't differ significantly among the floor and battery-reared turkey poults.

Discussion

Understanding the major factors impacting turkey welfare and finding ways to mitigate their effects will not only enhance the life quality of turkeys but also boost the industry by improving bird performance, raising the quality of the carcass, and decreasing mortality and condemnations (Marchewka *et al*., 2013). El-Deek and El-Sabrout (2019) revealed that the birds' welfare and behavior may be significantly affected by the housing. Efficient, cost-effective production is crucial in the poultry industry.

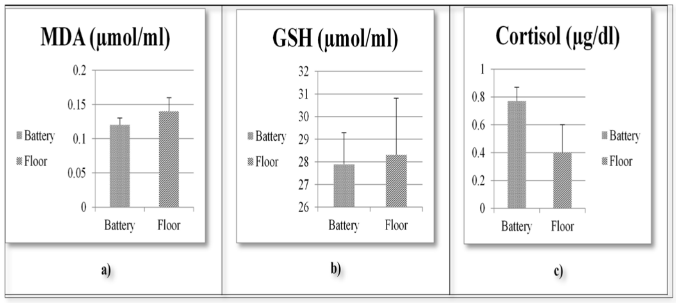

Fig. 5. The effect of housing systems on some biochemical parameters of turkey poults. a) The effect of housing systems on serum malondialdehyde levels (µmol/ml). b) The effect of housing systems on serum glutathione levels (µmol/ml). c) The effect of housing systems on serum cortisol levels (µg/dl).

By observing the turkey poults' behavior in the two housing systems; results revealed that feeding behavior increased significantly in the floor-reared poults which supported the previous studies that reported increased feed consumption in the floor compared to battery-reared layers (Adam, 2017; Ghanima *et al*., 2020; Kogoor *et al*., 2021). On the other side, a significant increase in body weight and weight gain was recorded in the battery-reared poults compared to floor-reared poults which run in agreement with Manley and Muller (1973); Şimşek *et al*. (2014) and El-Deen *et al*. (2020) who reported a significant increase in the weight of caged chickens and turkey in comparison to the floor housing. The in association between higher feed consumption and lower weight gain may be attributed to higher activity behaviors of floor turkey poults that result in more energy expenditure (Kogoor *et al*., 2021).

Regarding the significant increase in drinking and body care\ grooming behavior in the caged turkey; the obtained data partially agreeable with Abdel-Hamid *et al*. (2020) who reported a significant increase in feeding and drinking behaviors in the ducks reared in cages compared to those reared on the floor, the body care\ grooming behavior was recorded to be very common among the caged birds (Scanes *et al*., 2004). The findings of Li *et al*. (2017) indicate that the netting system is an effective means of improving feather cleanliness in chickens. Accordingly, it can be confidently stated that the feather cleanliness of caged poults is significantly better than that of floor poults. On the contrary, Wang *et al*. (2021) observed a higher feather quality in the broilers reared in the floor system in comparison with the caged ones. The reduced feather cleanliness score in the caged turkey may be returned to frustration and stress of caged birds that indicated increased grooming behavior and reflect poor birds' welfare (Zimmerman *et al*., 2000; 2011), also it may be due to incidence of dust bathing behavior that resulted in an improved feather condition in floor reared birds (Grebey *et al*., 2020).

Most scientists agree that tonic immobility (TI) is a reliable indicator of fearfulness (Gallup, 1979; Beuving *et al*, 1989), it is an automatic response marked by immobility, muscle rigidity, and suppressed vocalization (Marx *et al*. 2008). Concerning behavioral tests to evaluate fearfulness in poults; the tonic immobility test demonstrated a significantly increased OI and V, while FD significantly decreased in the floor-reared poults which indicate less fear in the floor than cages (Zapletal *et al*., 2011; EL-Kazaz, 2018). Another probability for increased TI duration with the absence of fear may be returned to the heavier weight of birds (Noble *et al*., 1996).

In addition, in the open field test, the behavior of animals has commonly been studied to measure fear and exploration (Durosaro *et al*., 2021). The turkey poults reared in cages exhibited increased sitting, and latency to ambulate and vocalize significantly than floor-reared poults, moreover, the number of squares explored did not significantly decrease

Table 5. The effect of housing systems on fluctuating asymmetry in turkey poults.

	Fluctuating asymmetry							
	Leg			Middle toe			Combined AFA	Combined RFA
Housing systems	Trait size	AFA	RFA	Trait size	AFA	RFA		
Battery	6.09±0.07	0.35±0.05	0.06±0.01	4.81±0.09**	0.54±0.08*	0.11±0.02	0.89±0.09	0.17±0.02
Floor	5.81±0.13	0.35±0.11	0.06±0.02	4.52±0.06	0.25±0.01	0.06±0.02	0.60±0.02	0.12±0.04

Results are expressed as mean±standard error. *: Superscripts indicate a significant difference between different groups at P-value (P<0.05). **: Superscripts indicate a significant difference between different groups at P-value (P<0.01). AFA: absolute fluctuating asymmetry; RFA: Relative fluctuating asymmetry.

in caged poults indicating fear in caged poults as previously reported by Jones (1989); Huff *et al*. (2007) and Durosaro *et al*. (2021).

Open field and tonic immobility tests are used to evaluate fear, activity coping ability, and welfare of poultry in a novel environment (Erasmus and Swanson, 2014). From this point of view, it can be expected that the fear response that occurred in tests in the caged poults may be a mechanism for coping with the novel environment (moved from a closed cage to an open arena in the open field and heavier weights in tonic immobility) rather than expressing fear which could be confirmed by the absence of statistical difference between caged and floor reared poults in the activity and inactivity behavioral patterns in their environment. Moreover, the blood profile also demonstrated a non-significant difference between oxidative stress (MDA, GSH) and stress markers (cortisol) measured parameters in the two rearing environments as previous studies reported that different housing systems had no effect and didn't change the oxidative stress markers and cortisol concentration (Zhang *et al*., 2019; Soliman and Hassan, 2020).

Turkey's welfare is also impaired by FPD and musculoskeletal abnormalities, which may hinder the ability of turkeys to walk and obtain both water and food (Berg, 1998; Erasmus, 2018). There was no observed manifestation of FPD between the battery and floored poults which coincide with Idrus *et al*. (2021) reported absence of FPD in the caged chickens.

Research conducted by Knierim *et al*. in 2007 has shown that fluctuating asymmetry (FA) can be used as a reliable indicator of an animal's ability to handle the various challenges it faces during its developmental stage. Stress can be used as an indicator of bird welfare due to its correlation with fear levels, gait impairment, and deviations from symmetry (Møller *et al*., 1999; Buijs *et al*., 2012). Proper housing conditions are crucial for the well-being of animals of all ages. However, it's important to note that substandard housing can have a significant impact on the development of young animals, leading to physical changes that may be either temporary or permanent (Buijs *et al*., 2012).

The cage system adversely affects bird welfare through behavioral restriction, skeletal weakness problems, and leg disorders that are considered a great concern from the welfare standpoint (Meseret, 2016). The results of the current study revealed that cage system rearing adversely affects the turkey poults' development by increasing absolute fluctuating asymmetry (AFA) of the middle toe length. These results were more or less similar to results obtained by Narinç and sabuncuoğlu (2022) who found the highest mean value of relative asymmetry of birds reared in conventional battery-type cages but for the wing length.

Furthermore, the increased middle toe length and asymmetry in battery-reared turkey poults could be attributed to results previously reported by Buijs *et al*. (2012) that the middle toe length increases because of high stocking density in birds. Moreover, Campo *et al*. (2008) reported a middle-toe length asymmetry in layers due to vent pecking. The gait score showed a non-significant difference between the two housing systems which indicates the absence of difference in the walking ability between birds (Wang *et al*., 2021).

Mortality is the hallmark feature of poor welfare (Blokhuis *et al*., 2007). It was clear that the mortality rate was higher on the floor than in the battery despite of absence of statistical difference that agreed with Setiadi *et al*. (2021); Alam *et al*. (2022) demonstrated that the mortality rate reduced either in caged broilers compared to floor reared and open house caged broilers.

Conclusion

Housing systems were found to influence the turkey poult's behavior, performance, and welfare. The battery system could be an applicable strategy to decrease broodiness energy costs but with some welfare concerns.

Acknowledgments

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Conflict of interest

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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