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Effect of different types of environmental enrichment on some behavioral and production indicators of broilers

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ABSTRACT
This study was conducted in the facilities of the College of Agriculture, Tikrit University, and its purpose was to analyze the effect of environmental enrichment strategies on production performance, behavior, and air quality in broiler houses. The study included 180 Ross 308 chicks in four treatment groups: standard commercial rearing method, plastic dark boxes, wicker baskets, and straw boxes. This work investigated how broiler growth performance, such as body weight, feed intake, and feed conversion ratio, was affected. It observed that environmental stimulation had a minimal effect on the productive performance of broilers**.** With regard to the behavior of birds, it was observed that the use of straw boxes and wicker baskets encouraged various natural behaviors, such as dust bathing and feather cleaning, and reduced other forms of stress, such as feather pecking. Dark plastic boxes were associated with excessive behaviors related to stress and anxiety such as standing, walking, jumping, and feather pecking. Therefore, these results emphasize the need to provide an appropriate type of shelter that better meets the needs of birds , that closely resembles their environment. This study also did not record any differences in air conditions for the parameters with birds subjected to different enrichment treatments; this spread shows that environmental enrichment should be incorporated into broiler houses without compromising the air quality that affects broilers. This result is important because previous studies have shown that poor air quality is a cause of respiratory diseases, reduced worker efficiency, and compromises the welfare of broilers.
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تأثير أنواع مختلفة من الإثراء البيئي على بعض المؤشرات السلوكية والإنتاجية لدجاج اللحم

أحمد نزار الناصري [1]، منى خالد السامرائي [1]، شهد طارق خلف [2]، طارق خلف الجميلي [1]
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الخلاصة

أُجريت هذه الدراسة في حقول كلية الزراعة - جامعة تكريت، بهدف تحليل تأثير استراتيجيات الإثراء البيئي على الأداء الإنتاجي والسلوك وجودة الهواء في مساكن فروج اللحم. شملت الدراسة 180 طيراً من نوع روز 308، موزعة على أربع معاملات: طريقة التربية التجارية القياسية، وصناديق بلاستيكية مظلمة، وسلال خوص، وصناديق قش. بحثت هذه الدراسة في كيفية تأثير أداء نمو فروج اللحم، مثل وزن الجسم، وكمية العلف المستهلكة، ونسبة التحويل الغذائي. ولاحظت الدراسة أن التحفيز البيئي كان له تأثير ضئيل على الأداء الإنتاجي لفروج اللحم. أما فيما يتعلق بسلوك الطيور، فقد لوحظ أن استخدام صناديق القش وسلال الخوص شجع على سلوكيات طبيعية مختلفة، مثل الاستحمام بالغبار وتنظيف الريش، وخفف من أشكال التوتر الأخرى، مثل نقر الريش. وارتبطت الصناديق البلاستيكية الداكنة بسلوكيات مفرطة مرتبطة بالتوتر والقلق، مثل الوقوف والمشي والقفز ونقر الريش. لذلك، تؤكد هذه النتائج على ضرورة توفير نوع مناسب من المأوى يلبي احتياجات الطيور بشكل أفضل، ويشبه بيئتها إلى حد كبير. كما لم تُسجل هذه الدراسة أي اختلافات في ظروف الهواء بالنسبة للمعايير مع الطيور التي خضعت لمعاملات اثراء بيئي مختلفة؛ ويُظهر هذا التباين ضرورة دمج الاثراء البيئي في مزارع فروج اللحم دون المساس بجودة الهواء التي تؤثر على فروج اللحم. تُعد هذه النتيجة مهمة لأن الدراسات السابقة أظهرت أن سوء جودة الهواء يُسبب أمراض الجهاز التنفسي، وانخفاض كفاءة العاملين، ويُضر برفاهية فروج اللحم.

الكلمات الافتتاحية: وزن الجسم، نقر الريش، الأداء الإنتاجي، الأمونيا، ثاني أكسيد الكربون.

INTROUCTION

Environmental enrichment has been described as offering birds complexity, ensuring they make some choices that improve their quality of life. Closely related, level two outcomes include physical and psychological benefits of birds by focusing on activities and physical environs that may help with animal's well-being, feeling of control through awarding appetites, and exercise like foraging, exploration, and even socialization (Mellor, 2016). Moreover, environmental stimulation makes the results of birds' learning processes positive, influences the changes in their emotions (Anderson et al., 2021), and gives them the opportunity to use resources and respond to the changes (Campbell et al., 2019). Benefits accrue especially to current/sophisticated commercial poultry's housing systems. Prospective issues may be connected to poultry required standard of living (Aljubory & ALTikrety, 2023 ; De Jong et al., 2012). The development of the poultry industry has also brought new challenges: One of these issues is the design of these houses or, in fact, the absence of design (Bergman et al., 2017). Newly hatched birds are stocked on the hard, flat floors covered with sawdust in most of commercial broiler farms (Adler et al., 2020), and these houses contain no structural facilities above the ground level except for feeders and drinkers (Gersberg et al., 2016).

Environmental enhancement entails creating a context that either provides stimuli, or conditions that will naturally incite certain activities; promoting birds' mental activity and general welfare. In the context of broiler production, enrichment interventions aim to create a more stimulating and fulfilling environment for the birds by offering opportunities for species-specific behaviors such as perching, foraging, and dust bathing (El Jeni et al.,2021). Environmental improvement strategies, including perches, pecking materials, or different housing arrangements, aim to promote the physical and mental health of broiler chickens. These changes may lead to better behavioral changes, including reduced aggression and increased participation in species-appropriate activities, including dust bathing and exploration (Zuidhof et al., 2014). In addition, an enriched environment can indirectly affect production performance through a partial reduction in stress levels and increased immune response, thus improving growth rate and feed conversion ratio (Kells et al., 2001).

Another aspect related to broiler housing is air quality, as toxic levels of dust, ammonia (NH_3) ,carbon dioxide (CO_2) have negative effects on health and production (Janczak & Riber, 2015).
This study aims to test the effects of different environmental improvement systems such as broiler housing in straw boxes, wicker baskets and dark plastic boxes to see if new housing designs are beneficial in improving poultry farming practices and improve broiler welfare, production standards, behavior and air quality inside broiler housing.

MATERIAL AND METHODS

Experimental design

A total of 180 Ross 308 broiler chicks were randomly assigned to 4 treatment groups, each containing Three replicates. Each replicate contained 15 birds, ensuring equal distribution across the groups. The experiment was conducted over a period of 35 days.
Group Assignment
The broilers were distributed into four treatment groups as follows (see Figure.1) :

- T1 (Control): Standard commercial rearing
- T2: Dark plastic boxes
- T3: Wicker baskets
- T4: Straw boxes

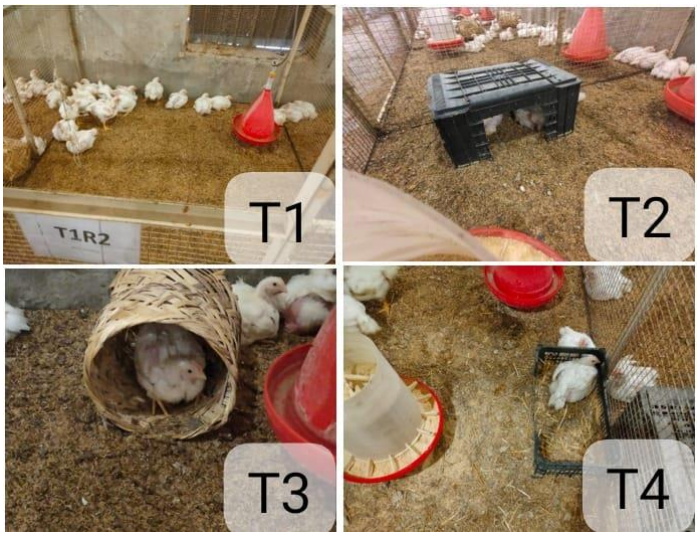

Figure.1 Illustration Depicting the Detailed Elements of the Image

Feeding: According to Rose Broiler Manual 308, the birds were fed three diets: starter, grower, and finisher. Feeding and drinking were free. (Al-Saada et al., 2024).

Productive performance

Body Weight (BW): The birds' body weight was measured using a digital scale with a precision of ±0.1 g.
Feed Intake (FI): The total feed consumed per group was recorded weekly by subtracting the leftover feed from the total feed offered.
Feed Conversion Ratio (FCR): FCR was calculated as the ratio of feed consumed to body weight gain (FCR = feed intake/weight gain).
Average Daily Gain (ADG): ADG was calculated as the weekly body weight gain divided by the number of days.
Monitoring Behaviors :Bird behaviors were monitored visually three times a day and observations were recorded for 5 min for each repetition according to Elsayed *et al* (2024).

Table 1. Ethogram of behavioral elements recorded.

Behaviour	Definition
Lying down	The bird lies with the head resting on its ground or erect. The eyes may be open or closed.
Sleeping	The bird's neck is fully recumbent, and its eyes are fully closed.
Standing	The bird is motionless with no activity and its abdomen is not in contact with the ground.
Walking	The bird is moving forward at a steady walking pace.
Jumping/flying	The flapping of the wings forces the bird to be lifted from the ground.
Eating	The bird's head is above the feeding trough or pecking at the feed within the feeder.
Drinking	The bird's beak is in contact with water in or above the drinker.
Preening	The bird uses its beak to arrange or trim feathers.
Dust-bathing	The bird is bathing in the litter with the use of its head, neck, legs, and wings.
Wing flapping	The bird extends both wings out from the body simultaneously and flapping wings.
Feather pecking	The bird is pecking the feathers of another bird.
Floor pecking/scratching	The bird pecks the litter in search of food or scratches the litter with its feet in a backward movement.

Air Quality: The air quality in the experiment was measured at 30 days by KKMOON air quality tester and AR8500 smart sensor (see figure.2) .

Figure.2 air quality tester and ammonia smart sensor

Statistical analysis:

The results of the experiment were statistically analyzed using the completely randomized design (CRD) and the general linear model within the ready statistical program (SAS,2005) to study the effect of different types of environmental enrichment on broiler chickens. The Duncan test (Duncan, 1955) was used to determine the significant differences between the averages of the factors affecting the traits, and the study was conducted at a significant level ($p < 0.05$).

RESULTS AND DISSCUSION

Table 4 shows the effects of different environmental enrichment methods (T2: The present study aimed at investigating the effects of using non-conventional housing systems (T1: dark plastic crates, T2: wicker baskets, T3, straw crates) compared to the standard commercial rearing (T1) on broiler growth performance in terms of body weight, feed intake and FCR. At the first week of age, the result of the T1 broilers reared under the standard commercial regime was significantly heavier ($P < 0.05$) than the T2, T3 and T4 enrichment groups. Nevertheless, there were no significant differences in the body weight in the treatments at 2, 3, 4, and 5 weeks of age ($P > 0.05$) (Table 1). This indicates that the effect of the standard rearing regime on body weight was reduced with time implying that the birds may adapt to the enriched environments as they grow older.

These findings are also in line with Dakkens et al. (2003) who observed that early disparity in body weight arising from environmental changes was transient and that birds in enriched environments had similar growth rates to those in standard environment. On the other hand, Ventura et al. (2010) observed that continued enhancement in broilers' growth performance could be attributed to the use of more advanced forms of stimulation, including perches and ramps that promote physical activity and muscle growth. The type of enrichments used in the present study was not very complex and this may be the reason why no long term effects were observed.

The mean daily feed intake of the birds was not significantly different between any of the groups during the entire rearing period ($P > 0.05$) as presented in table 2. Likewise, there were no differences in FCR between the control and enriched groups ($P > 0.05$). These outcomes indicate that the environmental enrichments offered had no or minimal impact on feed consumption and feed conversion rate. These findings are in agreement with Leishman, (2021) who found that while environmental enhancement enhances welfare, it has no impact on feed intake and feed conversion rate. However, Bizeray et al. (2000) pointed out that some types of enrichment, for example ramps or elevated structures, could promote activity that might enhance feed conversion rate. The enrichments used in the current study, the boxes and baskets, are static and thus may not provide the kind of physical stimulation that would enhance feed efficiency.

Table 2. Productive performance traits of broilers in different experimental groups.

	Treatments			
	T1	T2	T3	T4
Body weight				
Week 1	201.11 ± 2.47 a	198.33 ± 1.84 ab	193.22 ± 2.41 b	191.89 ± 1.66 b
Week 2	516.33 ± 15.99	511.22 ± 12.99	502.11 ± 7.55	504.00 ± 12.62
Week 3	996.67 ± 23.09	1001.11 ± 16.37	988.89 ± 21.11	952.22 ± 33.18
Week 4	1647.78 ± 42.57	1664.44 ± 31.99	1587.78 ± 50.34	1583.33 ± 37.56
Week 5	2143.33 ± 61.13	2153.33 ± 40.73	2118.89 ± 44.28	2054.44 ± 40.48
Feed intake				
Week 2	384.44 ± 9.27	388.22 ± 22.56	345.89 ± 12.46	385.44 ± 19.89
Week 3	707.78 ± 17.78	715.56 ± 60.69	660.00 ± 11.71	703.33 ± 20.00
Week 4	950.00 ± 16.78	976.67 ± 38.44	958.89 ± 12.81	995.56 ± 28.57
Week 5	1233.33 ± 40.32	1193.33 ± 37.17	1204.44 ± 27.91	1151.11 ± 28.89
Body weight gain				
Week 1-2	315.22 ± 14.08	312.89 ± 11.95	308.89 ± 5.19	312.11 ± 13.48
Week 2-3	480.33 ± 7.15	489.89 ± 7.66	486.78 ± 14.93	448.22 ± 21.46
Week 3-4	651.11 ± 19.75	663.33 ± 15.75	598.89 ± 29.83	631.11 ± 6.19
Week 4-5	495.56 ± 19.47	488.89 ± 11.60	531.11 ± 42.00	471.11 ± 4.84
Feed conversion				
Week 2	1.23 ± 0.07	1.25 ± 0.10	1.12 ± 0.02	1.24 ± 0.08
Week 3	1.47 ± 0.04	1.46 ± 0.12	1.36 ± 0.03	1.58 ± 0.13
Week 4	1.46 ± 0.03	1.47 ± 0.04	1.61 ± 0.10	1.58 ± 0.05
Week 5	2.49 ± 0.07	2.44 ± 0.05	2.29 ± 0.12	2.44 ± 0.06

T1 (Control): Standard commercial rearing, **T2**: dark plastic boxes, **T3**: wicker baskets**, T4**: straw boxes. Means within the same row having different superscripts are significantly different at $P<0.05$.

The results of this study indicate significant variations in bird behaviors across different housing conditions: control (T1), dark plastic boxes (T2), wicker baskets (T3), and straw boxes (T4). Several behavioral patterns were affected, which implies that the type of housing materials affects the welfare and activity of birds.

The proportion of time spent lying down and sleeping, two of the most important behaviors associated with rest, differed among treatments. The overall lying down position was significantly higher in T3 (wicker baskets) with 47.00% of the birds lying down. Nevertheless, T4 (straw boxes) had the highest sleeping rate of 31.00%. This may mean straw boxes with the softer more natural surfaces allow for more interrupted sleep, which is a essential for

growing chicks. Conversely, the least percent of time spent laying down, except sleeping, the percent of time sleeping were recorded by birds in T2 (dark plastic boxes) 43.00%, 28.50% respectively this could be interpreted to mean that this type of housing is uncomfortable or leads to frequent disruptions.

Active Behaviors (Standing, Walking, and Jumping/Flying):

The number of active behaviors, including standing and walking, was also higher in T2: 12.50% standing and 7.00% walking, which means that birds in dark plastic boxes were more active or involved in exploratory or vigilant activities. In contrast, the lowest values of standing (8.50%) and walking (5.80%) were observed in T4 (straw boxes), indicating that birds in straw boxes were more comfortable and less willing to move.

It was also noted, jumping/flying incidence was also higher in T2 (2.50%) which could be due to stress or trying to fly away from the housing types. Comparing T4, we can observe that jumping/flying occurred at relatively low extent of 1.20%, which indicates that the birds seemed more comfortable in this housing condition.

The eating behavior revealed slight variation between the treatments; the highest eating rate was observed in T4 (71.00%), while the lowest was in T2 (67.50%). These insignificant differences suggest that the straw boxes afford a better opportunity for continuing feeding, perhaps because of a less tense condition. Drinking behavior on the other hand was significantly higher in T2 (22.00 %) which may be attributed to compensatory drinking arising from increased activity or stress. Comfort and Grooming Behaviors (Preening, Dustbathing, Wing Flapping): Preening and dustbathing are basic activities for self- grooming and cleaning. while T2 had the least, 3.50%. This means that the birds in the straw boxes would turn over more often to maintain hygiene, probably because they were more relaxed. Comfort behavior dustbathing was also highest in T3 (wicker baskets, 11.00%), which suggests that the wicker baskets provide a better environment that triggers this behaviour in the birds.

Feather pecking regarded as a behavior sign of stress or poor welfare. Feather pecking was also highest in T2 at 2.00% and lowest in T4 at 0.80% thus supporting the notion that dark plastic boxes may elicit stress-related behaviors. This was in contrast to the more natural straw environment which seemed to have a stress lowering effect. Likewise, floor pecking/scratching which is an exploratory or stress behavior was also highest in T2 (4.50%).

Table 3. The effect of different types of environmental enrichment on the behavior of broiler chickens

Behavior %	T1	T2	T3	T4
Lying down	45.00 ± 2.00 ab	43.00 ± 1.80 b	47.00 ± 1.50 a	44.00 ± 1.80 ab
Sleeping	30.00 ± 1.50 ab	28.50 ± 2.10 b	29.00 ± 1.20 ab	31.00 ± 1.90 a
Standing	10.00 ± 1.00 ab	12.50 ± 1.70 a	9.00 ± 0.80 b	8.50 ± 1.00 b
Walking	5.50 ± 0.90 ab	7.00 ± 1.20 a	6.00 ± 0.50 ab	5.80 ± 0.70 b
Jumping/Flying	1.00 ± 0.50 b	2.50 ± 0.60 a	1.50 ± 0.40 ab	1.20 ± 0.30 b
Eating	70.00 ± 3.00 ab	67.50 ± 2.50 b	69.00 ± 3.50 ab	71.00 ± 3.00 a
Drinking	20.00 ± 1.20 ab	22.00 ± 1.50 a	18.00 ± 1.00 b	19.50 ± 1.30 ab
Preening	4.00 ± 0.60 ab	3.50 ± 0.80 b	4.20 ± 0.70 a	4.50 ± 0.90 a
Dustbathing	10.00 ± 0.80 ab	8.00 ± 0.70 b	11.00 ± 1.00 a	9.50 ± 1.00 ab
Wing flapping	2.50 ± 0.40 ab	3.00 ± 0.50 a	2.20 ± 0.30 b	2.00 ± 0.30 b
Feather pecking	1.00 ± 0.10 b	2.00 ± 0.20 a	1.50 ± 0.30 ab	0.80 ± 0.10 b
Floor pecking/scratching	3.00 ± 0.50 b	4.50 ± 0.60 a	3.50 ± 0.40 ab	4.00 ± 0.50 ab

T1 (Control): Standard commercial rearing, **T2**: dark plastic boxes, **T3**: wicker baskets**, T4**: straw boxes. Means within the same row having different superscripts are significantly different at P value less than or equal to 0.05.

It is found that straw boxes (T4) and wicker baskets (T3) encourage more natural expressions like dustbathing and preening and less stress related activity like feather pecking. T2, on the other hand, dark plastic boxes elicited higher stress related behaviors and restlessness such as standing, walking, jumping and feather pecking. These studies stress the need to adopt proper housing that will enhance the well-being of the birds and will resemble the natural environment as much as possible. More research could be done to understand the impact of these housing conditions

of the birds and their dwellings on the germline, soma, and psychological state in the long run to give more input on the best housing to provide for diverse species. As presented in the data, the behavioral observations of birds in different housing environments, show significant differences in welfare results. study's results reveal that different housing materials (dark plastic boxes, wicker baskets, straw boxes) have a significant but small effect on behaviors such as lying down, sleeping, and feather pecking. For example, lying down occurred at a somewhat more in wicker baskets (47.00%) than other conditions, implying which might imply preferential comfort or stress reduction in this kind of housing. This is in concordance with current research that has pointed out that soft natural substrate is conducive to stress-free rest in birds (Hartcher and Jones,2010 ; Dixon et al.,2010). Birds were more active in dark plastic boxes while standing and walking More standing and walking behaviors were found in dark plastic groups which concluded that birds in cages without heights may have more agitation or discomfort, as birds in cages with heights have lower standing and movement. Likewise, enhanced feather pecking and dust bathing in particular housing conditions, such as straw boxes, suggest that material significantly reduces aggression (Jones 2001). Studies have revealed that housing materials significantly influence welfare especially in conditions where abnormal behaviors such as feather pecking. it is possible to improve the environment with the right textures and layout and reduce some of these difficulties. For example, one study showed that when layers are given with feed such as silage, aggression was minimized (Hartcher and Jones ,2017). To improve birds' quality of life, enrichment objects that reflect not only environmental conditions but also satisfy their behavioral needs, including scratching, pecking, and resting (Dixon et al., 2010), are suggested. These studies suggest, it can be inferred that housing materials may be given close attention in order to enhance animal welfare.

Table 4 below depicts the outcome of environmental enrichment strategies on the air quality parameters (CO2, TVOC, HCHO and NH2) in broiler houses. There were no significant differences between treatments as the enrichments used (dark plastic boxes, wicker baskets, and straw boxes) did not affect the housing environment in terms of air quality. These findings align with other studies showing that environmental enhancement can be integrated into broiler houses without affecting key air quality factors provided proper husbandry techniques are employed.

The CO2 levels were 1045 ± 39.51 ppm (T1) and 1139.67 ± 5.90 ppm (T3) and were not significantly different. CO2 concentrations in broiler houses depend on bird respiration rates and ventilation (Xin et al., 2011). The lack of difference in CO2 levels between treatments indicates that enrichments did not affect ventilation or increase bird activity to a level that would increase CO2. Other research has also indicated that good housing systems keep the CO2 levels constant regardless of the prevailing environmental conditions (Wathes, 1998). TVOC concentrations were 2.04 ± 0.13 (T1) and 2.36 ± 0.03 (T3). even though materials like wicker and straw have theoretically higher potential to emit more of the TVOC(Casey et al., 2006), the result shows no significant variation, suggesting that these materials emitted negligible levels that were perhaps counteracted by ventilation. Comparable findings have been made in other researches where the bedding materials like straw or sawdust did not influence the VOC levels if the air flow was good (Donham., 2013). The concentration of formaldehyde was slightly higher in T3 (0.32 ± 0.01 ppm) and T4 (0.31 ± 0.004 ppm) than in the control group T1 (0.28 ± 0.01 ppm) but the difference was not significant. It is known that formaldehyde can be produced from decomposition of organic matter (Alberdi et al., 2016), however, the levels detected in the current study are within the range characteristic of poultry housing environments and are not influenced by bedding materials. However, all treatments were kept below the level reported to be toxic to broiler health (Donham et al., 2002). The ammonia concentration was also similar in all the treatments and fluctuated slightly between 3.25 and 3.30 ppm. Al-Jumaily and Hassan (2022) reported that ammonia production in broiler houses is influenced by litter moisture and nitrogen content, which are not affected by the fertilization materials. These results align with prior studies indicating that environmental enrichment do not lead to higher ammonia emissions if proper litter management (da Silva and de Jong, 2019).

The lack of variation in the air quality parameters in the different treatments is a positive sign for using of environmental fertilization in broiler production. Perches like wicker baskets and straw boxes are considered enrichments that help improve bird welfare by optimising their instincts (Brantsæter et al., 2016). The findings indicate that these enrichment can be carried out without affecting housing conditions as long as proper ventilation and litter management are observed. This is significant since high concentration of pollutants causes respiratory diseases, low production rates and welfare problems in broiler chickens (Al-Nasseri et al., 2021; David et al., 2015). The study

provides evidence for the use of enrichment strategies part of welfare-oriented farming practices without compromising the environmental conditions.

Table 4. The effect of different types of environmental enrichment on Air Quality Parameters.

Treatments	CO_2 (ppm)	TVOC	HCHO	NH_3 (ppm)
T1	1045± 39.51	2.04 ± 0.13	0.28 ± 0.01	3.30 ± 0.03
T2	1051.33 ± 51.68	2.07 ± 0.18	0.27 ± 0.02	3.28 ± 0.03
T3	1139.67 ± 5.90	2.36 ± 0.03	0.32 ± 0.01	3.25 ± 0.02
T4	1089.00 ± 4.04	2.23 ± 0.03	0.30 ± 0.004	3.27 ± 0.02

T1 (Control): Standard commercial rearing, **T2**: dark plastic boxes, **T3**: wicker baskets**, T4**: straw boxes. Means within the same row having different superscripts are significantly different at P value less than or equal to 0.05. **TVOC** : Total Volatile Organic Compounds , **HCHO**: Formaldehyde**.**

CONCLUSION

The results of this study indicate that environmental enrichment patterns had no significant impact on production performance and air quality. In contrast, significant effects on bird behavior were observed, with straw boxes and wicker baskets encouraging more natural expressions such as dust bathing and feather grooming and less stress-related activities such as feather pecking. On the other hand, dark plastic boxes elicited stress- and anxiety-related behaviors such as standing, walking, jumping and feather pecking. This study underscores the need to adopt appropriate housing types that promote bird welfare and resemble the natural environment as closely as possible.

CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

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