

Exterior egg quality as affected by enrichment resources layout in furnished laying-hen cages

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Objective: This study aimed to investigate the effects of enrichment resources (a perch, dustbath, and nest) layout in furnished laying-hen cages (FC) on exterior quality of eggs.

Methods: One hundred and sixty-eight (168) Hy-Line Brown laying hens at 16 weeks of age were randomly distributed to four treatments: small furnished cages (SFC), medium furnished cages type I (MFC-I), medium furnished cages type II (MFC-II), and medium furnished cages type III (MFC-III). Each treatment had 4 replicates or cages with 6 hens for SFC (24 birds for each SFC) and 12 hen/cage for MFC-I, -II, and -III (48 birds for each MFC-I, -II and -III). Following a 2-week acclimation, data collection started at 18 weeks of age and continued till 52 weeks of age. Dirtiness of egg surface or cracked shell as indicators of the exterior egg quality were recorded each week.

Results: The results showed that the proportion of cracked or dirty eggs was significantly affected by the FC type ($p < 0.01$) in that the highest proportion of cracked or dirty eggs was found in MFC-I and the lowest proportion of dirty eggs in SFC. The results of this showed that furnished cage types affected both dirty eggs and cracked eggs ($p < 0.01$). The results also indicated that not nest but dustbath lead to more dirty eggs. Only MFC-I had higher dirty eggs at nest than other FC ($p < 0.01$). The results of dirty eggs in MFC-I and MFC-II compared with SFC and MFC-III seemed suggest that a low position of dustbath led to more dirty eggs.

Conclusion: SFC design affected exterior egg quality and the low position of dustbath in FC resulted in higher proportion of dirty eggs.

Keywords: Furnished Cage; Cage Design; Exterior Egg Quality; Laying Hen

INTRODUCTION

Furnished cages (FC) are designed to improve welfare of hens by providing enrichment resources in cages such as perch, dustbath and nest [1]. Previous research has shown that design of FC can impact laying behavior and egg quality, such as eggs laid outside the nests and higher proportion of dirty eggs due to less bottom lining of the nest [2,3]. Sosnowka-Czajka et al [4] reported that more dirty eggs were found in alternative production systems compared with conventional cage systems [4]. Also higher percentage of broken eggs was found in FC than in standard cages [5]. The higher incidences of broken eggs found in FC could result from more frequent collisions between eggs laid in nest or outside the nest [6,7]. Wall found that exterior egg quality was superior in 8-hen FC than in 20- or 40-hen FC, and these differences in egg quality probably reflected differences mainly in the cage design rather than the group size [8]. Mallet et al [6] also suggested that properly designed FC should encourage more hens to lay eggs in nest, and achieve better egg hygiene than in conventional cages [6]. Therefore, this study aimed to investigate how FC design, especially, layout of cage resources (perch, dustbath, and nest) affect exterior egg quality in order to better understand the importance of FC design on egg quality.

MATERIALS AND METHODS

Design of FC

Small furnished cage: The small furnished cage (SFC) (Figure 1a) was designed according to the European Union criteria that allowed six hens in a cage [9]. It had the dimensions of 1,200 mm wide, 500 mm deep, and 450 mm high at the rear, with a wire mesh floor of $<8^\circ$ slope. The SFC was furnished with a perch, a nest, and a dustbath area. A wooden perch with a cross-sectional dimension of 36 mm \times 30 mm was placed across the cage. The bottom of the perch was approximately 150 mm above the wire floor and 190 mm away from the rear side. A sheet metal nest (240 mm wide, 500 mm deep, and 270 mm high) was positioned at one side of the cage. A piece of 15-mm thick artificial turf (240 mm W \times 500 mm D) was placed on the nest floor. The dustbath (240 mm W \times 500 mm D \times 50 mm H) was placed on the top of the nest, containing approximately 20 mm deep sand substrate that was refilled periodically to maintain the depth. The floor allowance was 600 cm² per hen, equivalent to a stocking density of 10 hens/m².

Medium furnished cage type I: The medium furnished cage type I (MFC-I) (Figure 1b) had the dimensions of 1,920 mm wide, 625 mm deep, and 450 mm high. Two wooden perches were placed in parallel 150 mm above the floor across the cage. The back and front perches were 200 mm and 400 mm, respectively, away from the rear side of the cage (i.e., 200 mm horizontal distance between

the two perches). A nest was located at one side of the cage, and a dustbath was placed on the other side. The floor allowance and the resultant stocking density were same as in SFC.

Medium furnished cage type II: The medium furnished cage type II (MFC-II) (Figure 1c) had the dimensions of 1,600 mm wide, 750 mm deep, and 700 mm high, and it was divided into two tiers for greater floor space allowance. Each cage was furnished with two perches, a nest and a dustbath. One perch (the back or lower perch) was located 200 mm above the bottom floor and 200 mm away from the rear side of the cage. The other (the front or higher perch) was located 300 mm above the bottom floor and 400 mm away from the rear side of the cage. A nest was placed in the top tier on one side of the cage. The dustbath was located underneath the nest. The floor allowance was 1,000 cm² per hen, equivalent to a stocking density of 10 hens/m².

Medium furnished cage type III: The medium furnished cage type III (MFC-III) (Figure 1d) was same as MFC-II in size. Two wooden perches were across the cage and arranged same as in MFC-II. Two nests were placed in the top tier floor, one on each side. A dustbath was placed between the two nests. The floor allowance and the resultant stocking density were same as in MFC-II.

Animal housing and experimental treatments

In this study, 168 Hy-Line Brown laying hens at 16 weeks of age reared in conventional cages were randomly assigned to four treat-

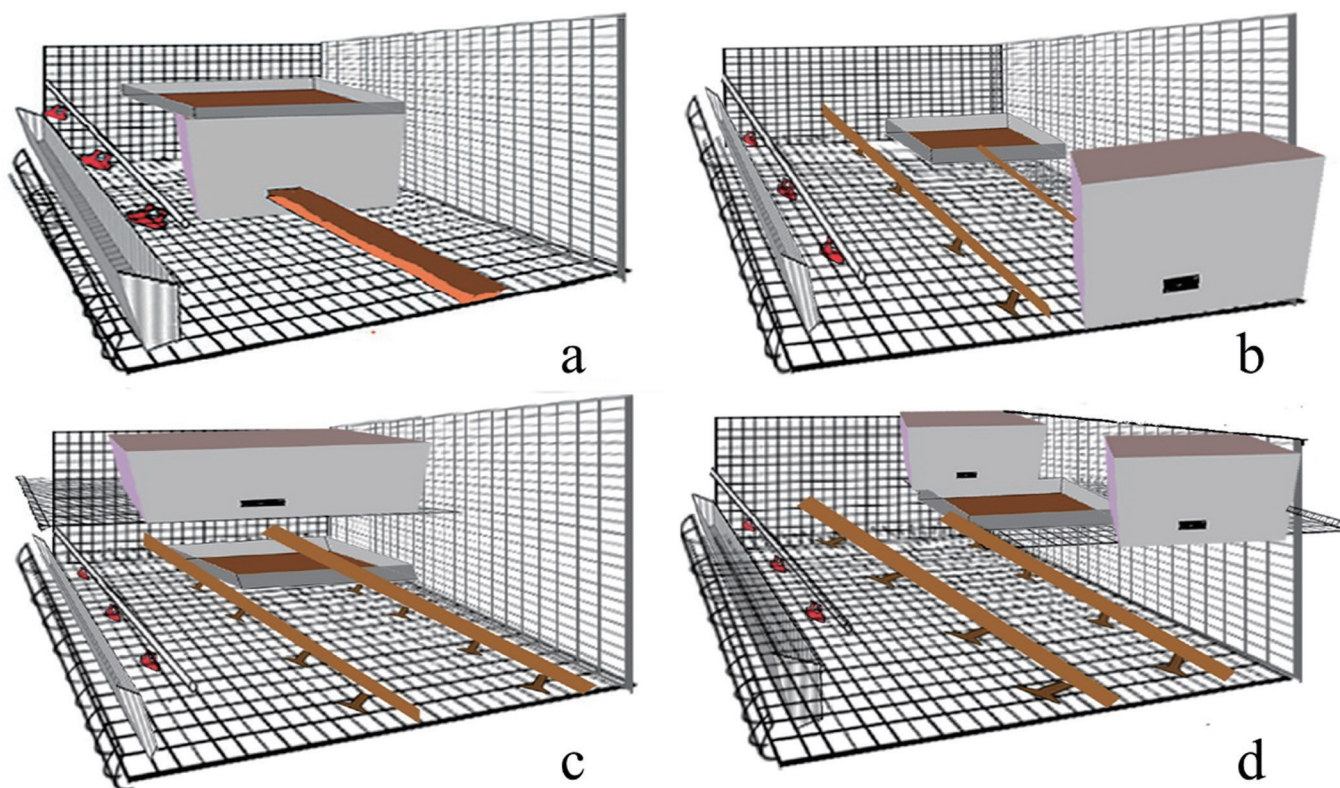


Figure 1. Furnished cage design. (a) Small furnished cage (SFC), (b) medium furnished cage I (MFC-I), (c) medium furnished cage II (MFC-II), (d) medium furnished cage III (MFC-III).

ments (FC types) with 6 hens for each SFC cage and 12 hens for each MFC-I, -II, or -III type. Each FC type had 4 replicates. The experimental birds were randomly chosen by an experienced technician, and no birds from the same original group were allowed to be allocated to the same cage as a replacement. All birds were acclimatized for 2 weeks (from 16 to 17 weeks) before data collection commenced. The cages were arranged in two parallel rows in the room. Two cages of each FC type were located in each row. The data collection started at 18 weeks of age and continued till 52 weeks of age. During the experimental period, the hens received a commercial diet (metabolizable energy of 11.10 MJ/kg, crude protein of 16.50%) and were fed *ad libitum* each day. Mechanical ventilation was used to control room temperature and relative humidity. Indoor air temperature was maintained at 22°C±2°C and relative humidity was kept at 62%±6% (Listed in Table 1) during the experiment. A photoperiod of 16h L:8h D was provided with florescent light. Water was available *ad libitum* in

all cages. The research protocol met the guidelines approved by the institutional animal care and use committee (IACUC). In order to keep a constant stocking density for all cages throughout the experiment, the extra birds were reared in conventional cages as replacements and they were managed as same as the experimental birds.

Measurements

Eggs in each cage were manually collected daily, and recorded according to their laying positions (cradle, dustbath, and nest). Furthermore, the eggs were recorded and classified as dirty and/or cracked eggs. The daily egg production per hen and the proportions of dirty and cracked eggs were calculated on the basis of the total eggs collected for each cage. Egg collection was conducted on daily base over the experimental period. The dirty and cracked eggs were recorded each week for the locations and numbers. Dead hens were removed promptly and replaced with backup hens that were kept in conventional cages.

Statistical analyses

Data were analyzed using the one-factor analysis of variance procedure of the SAS package (SAS 8.2). Duncan test was used for multiple mean comparisons. Data were presented as mean± standard deviation. Probability values less than 0.05 were considered statistically significant.

RESULTS

The cage type was shown to significantly affect the proportion of cracked and dirty eggs ($p < 0.01$, Table 2). MFC-I was found to have more cracked eggs ($10.5\% \pm 14.7\%$, $p < 0.01$) than SFC ($1.8\% \pm 6.3\%$), MFC-II ($3.2\% \pm 6.0\%$), and MFC-III ($1.7\% \pm 4.1\%$). Similarly, the proportion of dirty eggs ($37.9\% \pm 38.5\%$) in MFC-I was significantly higher than that in other FC types (MFC-II: $26.1\% \pm 17.6\%$, MFC-III: $17.3\% \pm 15.3\%$, and SFC: $10.4\% \pm 12.9\%$; $p < 0.01$). The dirty eggs in MFC-II was significantly higher than in MFC-III and SFC ($p < 0.01$). Although the dirty eggs in MFC-III was higher than in SFC, the difference was not significantly different.

The FC type did not affect the occurrence rate of cracked and dirty eggs in the cradle (Table 2, $p = 0.423$ and $p = 0.117$). The highest proportion of the cracked eggs was found in MFC-I ($2.0\% \pm 6.1\%$), while the lowest cracked egg proportion was found in MFC-III ($0.5\% \pm 2.3\%$). The highest proportion of dirty eggs was found in MFC-I, and no dirty eggs were found in SFC. There tended to be more cracked eggs in the nests of MFC-I, MFC-II, and MFC-III than in SFC, though not significant ($p = 0.083$); but there were significantly more dirty nest eggs in MFC-I than in other FC ($p < 0.01$). More cracked eggs in the dustbath were observed in MFC-I than in other cages ($p < 0.01$); and more dirty eggs in MFC-I and MFC-II dustbaths were observed than in SFC and MFC-III ($p < 0.01$).

Table 1. The indoor temperature and humidity changes per week

Weeks	Indoor temperature (°C)	Indoor humidity (%)
18	20	65
19	20	65
20	22	55
21	22	60
22	24	60
23	23	58
24	22	58
25	25	54
26	23	55
27	20	60
28	22	59
29	21	54
30	21	60
31	24	62
32	20	65
33	22	60
34	24	55
35	24	55
36	22	54
37	24	54
38	20	65
39	23	68
40	20	72
41	20	70
42	20	70
43	23	69
44	23	65
45	24	58
46	22	60
47	21	70
48	21	67
49	20	69
50	22	65
51	20	64
52	23	55

Table 2. Proportion of cracked and dirty eggs at different positions in different cages¹⁾ (%)

Positions	Egg quality	SFC	MFC-I	MFC-II	MFC-III	F value	p value
Cradle	Cracked	1.68 ± 6.3	2.04 ± 6.13	0.84 ± 2.88	1.12 ± 3.60	0.971	0.423
	Dirty	0.00 ± 0.00	0.54 ± 2.43	0.14 ± 1.22	0.13 ± 1.21	1.859	0.117
Nest	Cracked	0.10 ± 1.09	1.05 ± 5.04	0.89 ± 3.26	1.11 ± 4.48	2.074	0.083
	Dirty	0.19 ^B ± 1.81	5.05 ^A ± 4.04	3.26 ^B ± 0.22	4.49 ^B ± 0.98	8.317	<0.01
Dustbath	Cracked	0.00 ^B ± 0.00	7.42 ^A ± 13.07	1.17 ^B ± 5.23	0.93 ^B ± 3.08	19.67	<0.01
	Dirty	10.25 ^B ± 12.69	33.3 ^A ± 38.20	33.64 ^A ± 24.7	24.96 ^A ± 14.13	39.306	<0.01
Total	Cracked	1.80 ^B ± 6.30	10.53 ^A ± 14.72	3.17 ^B ± 5.99	1.66 ^B ± 4.05	17.19	<0.01
	Dirty	10.45 ^C ± 12.9	37.89 ^A ± 38.47	26.09 ^B ± 17.6	17.26 ^C ± 15.27	40.44	<0.01

¹⁾ SFC, small furnished cage; MFC-I, medium furnished cage I; MFC-II, medium furnished cage II; MFC-III, medium furnished cage III.

^{A,B,C} Different superscripts in a row indicate significant differences at $p < 0.01$.

The number of hen mortalities during the experiment was 2 for SFC, 4 for MFC-I, 3 for MFC-II, and 3 for MFC-III. No significant difference in mortality was found among the FC types.

DISCUSSION

Numerous studies showed that the proportion of cracked eggs in conventional cages was lower than in modified conventional cages, aviary systems, and furnished cage systems [3,10-13]. The reason for less cracked eggs in conventional cages than FC may be that the absence of nest or dustbath allows eggs to roll out from the cages in a timely manner [11]. The absence of perches may be another reason [14]. However, Holt et al found no significant difference in cracked eggs between conventional cages and FC if only considering the eggs laid in nests [15]. Guesdon and Faure argued that if the nests in FC were well designed, the proportion of cracked eggs would be much lower [3]. In our study the overall results showed that the more dirty eggs found in MFC-I and MFC-II than SFC and MFC-III indicated that the low position of dustbath was likely to be the factor leading to more dirty eggs. At dustbath, the proportion of the dirty eggs in SFC was less than MFC-I, -II, and -III, this may indicate that group size may be another factor affecting dirty egg rate since the stocking density of SFC was same as that of MFC-I (12.5 hens/m²), but group size was different (6 hens per cage was for SFC treatment and 12 hens per cage for MFC-I). Since the hens in MFC-I had relatively higher competition for nest space compared with SFC, it might lead to a larger number of eggs laid in dustbath in MFC-I, which caused more dirty eggs. In this study the nest seemed not to be the factor affecting dirty eggs although more dirty egg was found for MFC-I than other cages. However, the results of this study also suggested that not the nest but dustbath was the main factor contributing to more cracked eggs. Thus, dustbath was main contributor to more dirty and cracked eggs. We would like suggest that based on the results of this study [3] a “so-called” better design of furnished cages for reducing cracked eggs should not just consider the nest design but also a better dustbath design as well. We also found that if the eggs laid in dustbath were not collected in a timely manner, they would be pecked on by the hens, which would in-

crease the proportion of cracked eggs. Therefore, plans to reduce the eggs laid in the dustbath should be considered when designing FC. Wall and Tauson suggested that an egg cradle and longer nest flap could decrease the proportion of cracked eggs [2]. On the other hand, conventional cages had fewer cracked eggs since they contained no nest or dustbath that blocked eggs from rolling out of the cages to the egg cradle in a timely manner. Guesdon and Faure suggested the proportion of dirty eggs would be decreased if nests were well designed [3]. Utilization of the nest by hens was related to the number of nests [11,16]. Producers often increased the hen usage of nests by increasing the number of nests. In this study, the number of nest was relatively low for MFC-I and MFC-II compared with MFC-III.

In this study although we did not consider the effect of social hierarchy on dirty or cracked eggs since the different stocking density among FC treatments might cause different competition for resources. However, this factor should be not ignored for considering design of a large furnished cage. Thus more investigation is recommended.

In this study the new hens replacing the occasional mortality in the cages might involve in initial hierarchical fight which could have impacted the incidence of cracked or dirty eggs. However, the long-term trial and very rare occurrence of mortality made such “artifact” impact negligible in terms of assessing the effect of the FC types.

In conclusion, the results of this study indicated that FC design affects the exterior quality of eggs, and the FC types of MFC-II and MFC-III with low positions of dustbath would lead to more cracked or dirty eggs than the SFC and MFC-I with high positions of dustbath.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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