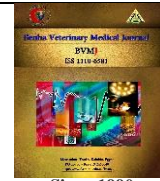




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Comparative study on the hygienic, production and economic indices of Japanese quails reared on floor and cage systems

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ABSTRACT

The study was done on 120 newly hatched day-old chicks of brown Japanese quail obtained from local Egyptian hatcheries, randomly divided into two groups. The 1st group was reared on cage system (CS), and the 2nd group was reared on floor system (FS) (60 chicks per group/3replicates, 20 chick/replicate), to investigate the effect of housing on the hygiene, performance, survivability, and economic efficiency of quails. The results showed that the total aerobic bacteria (TAB) of cloacal swabs had non-significant differences between CS, and FS. The higher TAB, *E. coli*, and total fungal count (TFC) were recorded in FS in feed, water, litter, and floor swabs samples, CS was more hygienic rearing system for quails. Moreover, the higher TAB, *E.coli*, and *lactobacillus* were recorded in intestinal samples collected from quails on FS (Log₁₀ CFU/g5.34, 4.47, and 3.96, respectively). There were no significant difference in immunoglobulin G, interleukin 2 &6, Malondialdehyde, Superoxide Dismutase, and catalase activity between both rearing systems. Regarding performance parameters, the higher body weight, and feed consumption were achieved in Japanese quails reared on FS. Moreover, the rearing system had no significant influence on the performance, and carcass traits. From the economic point of view, FS had higher feed cost, total variable cost, total cost, and cost of each kg body weight gain from feed than those reared on CS. While, the net profit, gross margin, benefit cost ratio, return on investment, and net profit for each kg body weight gain were non-significantly higher in CS than FS.

1. INTRODUCTION

Housing system is one of the most crucial factors affecting poultry welfare, health, and production efficiency. In Egypt, as in most developing country, it is often difficult to reach the optimum performance, owing to several factors such as suboptimal housing. Environmental extremes, and stress conditions can be managed if the design of the poultry house is appropriate, and help in maximizing profitability (El-kholy et al., 2017).

The short generation interval, high biological meat value, and the particular taste, give the quail farming great importance in a densely populated country, besides minimum floor space, early market age, and the gainful quick business return (Nwogor and Ifeyinwa, 2017).

In the Floor system, the birds showed a state of freedom; express more of natural behavior through scratching in litter with safe rate of the living biota (FAO, 2013).

The problems of litter were vanished in cage system, competing with FS in quail farming. It dispenses with the litter, increases the production per unit area, reduces the labor cost/m², and less effort for clean, and disinfection (Willis et al., 2001).

Nevertheless, obstacles of CS centered in the high costs of initial investment, the welfare deprivation, the relative increase in mortality rates due to wing, and leg disorders, and the lack of exercise (Moravej, 2012).

The present study was conducted to investigate the effect of housing system on the bird hygiene, performance, livability of quails, and economic indices and to recommend the suitable management system.

2. MATERIAL AND METHODS

The experiment was conducted at the Center of Experimental Animal Research, Faculty of Veterinary

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Medicine, Benha University, Egypt, and was approved by the Institutional Animals Care, and Use committee Research Ethics Board, Faculty of Veterinary medicine, Benha University, under ethical number BUFVTM 03-2-21.

One hundred, and twenty newly hatched day-old chicks of brown Japanese quail obtained from local Egyptian hatcheries and incubated for 14 days. The chicks were randomly selected, divided into two groups (60 chicks per group/ 3 replicates, 20 chick/replicate). The first group was raised on a CS provided with wire floor over galvanized trays with two feeders, and one drinker hanged separately outside the compartment. The second group of chicks was raised in three deep litter pens (FS) covered with sawdust sprinkled with slaked lime. The floor space in CS, and FS was recommended by (NRC, 2011) lists minimum space recommendations for quail as 7.6cm² floor area/bird.

All birds were allowed for 24 hours of artificial lighting, using one electric lamp (100 Watt), water, and feed ad libitum on balanced ration satisfying (NRC, 1994) recommendations. The birds were vaccinated against ND disease at 2nd week of the study duration.

2.1. Samples collection for microbiological examination:

Six samples (2 sample/ replicate/ group) from water, feed, litter, cloaca, and nasal swabs) were collected weekly. 100 ml of water, and 100 g of feed samples were collected, and prepared according to (Chowdhuri et al., 2011). The litter samples were prepared according to (Mahmoud et al., 2014). Cloaca, and nasal cotton swab samples were collected, and prepared according to (Jones et al., 2015), and processed according to (García et al., 2020). Samples from cecum were immediately collected, and processed at the end of experimental period according to (Sugiharto, 2016).

The appropriate dilutions were cultured and incubated overnight at 37°C for TAB (plate count agar-Lab M Limited), *E. coli* (chromogenic coliform agar-Oxoid Limited), and *Lactobacillus* (MRS agar-Lab M Limited), while incubated 2-5 days at 25°C for TFC (Sabouraud dextrose agar-Oxoid Limited). *Clostridium* (Tryptose sulfite cycloserine agar-Lab M Limited) spp were anaerobically incubated.

2.2. Biochemical analyses:

At the end of the rearing period at 42 days, six blood samples from each treatment were taken in sterile tubes without anticoagulant for serum separation. The interleukins levels were measured by ELISA kit used according to the manufacturer's instructions. The levels of serum immunoglobulins (IgG and IgM) were measured according to (Mancini et al., 1965), Superoxide Dismutase activity (SOD) was done according to Chanarin (1989), Malondialdehyde (MDA) was done according to Kei (1978), catalase activity according to Sinha (1972).

2.3. Growth performance and carcass traits:

Quails were weighed weekly from the beginning (at 14 days old) till the end of the rearing period (42 days old). The average bodyweight gain (BWG) was calculated weekly by subtract the previous week's weight from the average body weight. The difference between the offered feed weight, and the remainder part was used to compute feed consumption. The feed conversion ratio was calculated as total amount of feed divided by average body weight gain.

2.4. Mortality percentage:

Daily losses for each replicate were documented until the end of the rearing period (Faitarone et al., 2005).

Carcass traits:

At the end of the rearing period, the birds being fasted from feed, and given free access to water for around 12 hours, five birds were randomly selected from each group, weighed, slaughtered, dressed, and eviscerated. As a percentage of live weight, the dressing percentage was computed. The relative weights of internal organs to their live body weight were recorded separately (Badawi, 2017).

2.5. Economic analysis:

Collective economic efficiency measures that include:

2.5.1. Costs measures:

Total cost which calculated as summation of total variable cost (TVC), and total fixed cost .TVC include costs of chick price, feed cost (Surai and Fisinin, 2014), water, electricity, litter, and total veterinary management (TVM). The total fixed cost was calculated as depreciation value for building, and equipment's.

The total return (TR) was calculated by summation return from quails (bird weight per gram X meat price per gram), and litter (Shehata et al., 2018).

Net profit (Santhosh and Singh, 2007) = TR-TC.

Gross margin (GM) = TR- TVC (EMOKARO and Eweka, 2015).

Benefit cost ratio (BCR) = total return ÷ total cost

Return on investment (ROI) = net profit ÷ total cost

2.5.2. Partial economic efficiency measures which include:

Cost of each kg body weight and body weight gain from feed (feed cost ÷ BW, and feed cost ÷ BWG).

Net profit from each kg body weight and body weight gain (NP ÷ BW, and NP ÷ BWG).

2.6. Statistical analysis:

The data was analyzed using an independent sample *t* test using SPSS software, V.16 (SPSS, 2007). Livability and mortality % were analyzed by cross tabulation.

3. RESULTS

The cloacal and nasal swabs showed non-significant differences in TAB between CS, and FS. Nasal swabs showed non-significant difference in *E. coli*, while the TFC showed significant differences between CS and FS along experimental period (Table 1). However, the results cleared that there were significant increase in TAB, *E. coli*, and TFC in FS than CS in feed, water, litter, and floor swab samples at 2nd week, till end of the study duration.

Regarding the intestinal samples, higher TAB, *E. coli* and *Lactobacillus* (Log₁₀ CFU/g 5.34, 4.47, and 3.96, respectively) counts were recorded in birds raised on the FS, while higher *Clostridia* were recorded in those reared on the CS than FS (Log₁₀ CFU/g 4.90) (Fig. 1).

The biochemical parameters (Fig. 2) showed non-significant differences in IgG, IL2, IL6, MDA, SOD, and catalase enzyme between both rearing systems, while IgM showed significant increase in CS compared to FS.

Regarding, growth performance traits (Table 2) for Japanese quails reared on CS, and FS. The weekly live body weight (LBW) was significantly (P ≤ 0.05) higher in birds housed in FS at 3rd, and 5th week of age (g 86.88, and 193.17, respectively) than those reared on CS. While it was not significantly differ between quails reared on different systems at 6th week age.

In addition, the total feed consumption was significantly higher in quails reared on FS (g 779.65) than those reared on CS (g 692.74). However, the weekly body weight gain (BWG), and feed conversion rate were not significantly differing between groups along rearing period, except BWG in the period of 2nd week to 3rd week of age, and the FCR in the period of 3rd to 4th week of age were significantly higher in FS than CS group. Also, total FCR (2nd week to 6th week of age) was not significantly differ between the two groups.

Concerning carcass traits (dressing, liver, heart, and kidney percentages) (table 3) there were no significant differences between quails reared in the two different systems.

The results displayed in Table (4) showed a significant increase in feed cost (5.77 and 5.13 LE), total variable cost (11.07 and 9.83 LE), and total cost (12.10 and 11.09 LE) for Japanese quails reared on FS than those reared on CS, respectively. On the other hand, TR was not significantly higher in FS than CS, while, NP, GM, BCR, and ROI, NP/BW, and NP/BWG were not significantly higher in CS than FS. Finally, the cost of each kg body weight gain from feed was significant higher in FS (25.67 LE) than CS (23.56 LE).

4. DISCUSSION

The type of the house has direct effect on hygienic status of quails, as the different housing facilities (feeders, drinkers,

litter/wire floor, equipment's) shedding different number of microorganisms. The higher feed, water, and litter bacterial contamination were recorded at the 4th week of the study duration in FS than CS, a result that agreed with (Trawińska et al., 2016) they reported that the highest bacterial count in the litter was detected at the late rearing period of birds.

The significant increases in bacterial load (TAB, E.coli, and TFC) in feed, water, litter, and nasal swabs were from living birds reared on FS might be due to open feed troughs, and drinkers that easily to be contaminated with litter, birds, dust, and fecal matter (Ezekiel et al., 2011). The contaminated feed is one of animals bacterial, and fungal sources, which has a health concerns socio-economic impact not only on the birds, but also on consumers (Rosemary et al., 2013).

The nasal swab samples showed significant differences between FS, and CS, those results agreed with Al-Bahouh et al. (2012), who found that using cage provide better hygienic condition that could lead to improving the health, and quality of birds.

From the results of cecum microbial count, it was found that there was a significant ($P \leq 0.05$) difference on intestinal TAB and E.coli counts, and no significance on intestinal clostridia, and lactobacillus count between quails reared on CS, and FS (Fig.1).

Table 1. Total aerobic bacteria, *E. coli* and Total fungal count in Japanese quails reared on cages system (C. S.) vs floor system (F. S.)

	Cloacal swabs		Nasal swabs		Litter\ floor swabs		Feed		Water	
	C.S.	F.S.	C.S.	F.S.	C.S.	F.S.	C.S.	F.S.	C.S.	F.S.
Total aerobic bacteria										
1 st week	3.35 ^a ±0.26	3.46 ^a ±0.24	2.00 ^a ±0.33	1.82 ^a ±0.41	1.67 ^a ±0.33	2.22 ^a ±0.08	3.53 ^a ±0.09	3.54 ^a ±0.15	1.20 ^a ±0.17	1.24 ^a ±0.10
2 nd week	3.76 ^a ±0.30	4.55 ^a ±0.40	3.09 ^a ±0.22	3.37 ^a ±0.06	3.35 ^a ±0.15	3.81 ^a ±0.06	4.33 ^b ±0.10	4.74 ^a ±0.07	3.19 ^b ±0.05	4.25 ^a ±0.08
3 rd week	4.60 ^a ±0.11	5.23 ^a ±0.42	3.64 ^a ±0.07	3.81 ^a ±0.11	3.61 ^b ±0.12	4.13 ^a ±0.09	4.72 ^b ±0.04	5.47 ^a ±0.19	4.39 ^b ±0.06	4.78 ^a ±0.05
4 th week	5.22 ^a ±0.10	5.68 ^a ±0.18	3.94 ^b ±0.07	4.40 ^a ±0.07	4.23 ^b ±0.09	4.63 ^a ±0.09	4.91 ^b ±0.03	5.59 ^a ±0.12	4.61 ^b ±0.06	5.20 ^a ±0.08
<i>E. coli</i>										
1 st week	2.92 ^a ±0.21	2.36 ^a ±0.63	0.00	0.00	0.00 ^b	1.32 ^a ±0.35	0.00	0.00	0.00	0.00
2 nd week	3.52 ^a ±0.20	3.84 ^a ±0.06	1.43 ^a ±0.72	2.75 ^a ±0.14	4.73 ^a ±0.05	4.83 ^a ±0.14	3.37 ^b ±0.19	5.52 ^a ±0.04	1.56 ^b ±0.55	5.53 ^a ±0.11
3 rd week	5.36 ^a ±0.17	5.33 ^a ±0.33	3.09 ^a ±0.35	3.74 ^a ±0.08	5.28 ^a ±0.03	5.79 ^a ±0.27	4.72 ^b ±0.12	5.95 ^a ±0.05	2.59 ^b ±0.15	5.91 ^a ±0.06
4 th week	5.47 ^a ±0.14	5.48 ^a ±0.29	3.72 ^a ±0.19	4.14 ^a ±0.09	5.71 ^a ±0.06	5.94 ^a ±0.31	5.50 ^b ±0.02	6.11 ^a ±0.10	3.18 ^b ±0.10	5.96 ^a ±0.06
Total fungal count										
1 st week	4.06 ^a ±0.52	4.07 ^a ±0.52	0.00	0.00	0.00 ^b	1.37 ^a ±0.05	1.44 ^a ±0.32	1.43 ^a ±0.35	0.00	0.00
2 nd week	4.67 ^a ±0.08	4.73 ^a ±0.08	0.00 ^b	3.59 ^a ±0.14	3.20 ^b ±0.14	4.67 ^a ±0.09	2.32 ^b ±0.31	4.39 ^a ±0.09	2.35 ^b ±0.42	4.16 ^a ±0.12
3 rd week	4.74 ^a ±0.33	5.15 ^a ±0.10	0.00 ^b	1.57 ^a ±0.34	3.38 ^b ±0.12	5.51 ^a ±0.08	2.76 ^b ±0.21	5.40 ^a ±0.19	3.54 ^b ±0.23	4.61 ^a ±0.09
4 th week	5.01 ^a ±0.20	5.33 ^a ±0.34	0.00 ^b	2.94 ^a ±0.10	3.81 ^b ±0.18	5.85 ^a ±0.04	3.27 ^b ±0.04	5.61 ^a ±0.10	3.77 ^b ±0.14	5.36 ^a ±0.09

Means carrying ^{a-b} significantly differ ($P \leq 0.05$) among different housing systems

Table 2 Growth performance traits in Japanese quails reared on cages system vs floor system

Variables	Cages system	Floor system
Body weight changes (g)		
2 nd week	52.00 ^a ±1.53	53.67 ^a ±1.86
3 rd week	77.92 ^b ±0.89	86.88 ^a ±2.72
4 th week	138.87 ^a ±3.49	148.85 ^a ±3.56
5 th week	185.04 ^b ±2.21	193.17 ^a ±1.34
6 th week	217.60 ^a ±2.17	224.85 ^a ±4.59
Body weight gain (g) (BWG)		
2-3 week	25.92 ^b ±0.72	33.21 ^a ±1.94
3-4 week	60.95 ^a ±2.68	61.98 ^a ±0.92
4-5 week	46.17 ^a ±4.09	44.32 ^a ±4.88
5-6 week	32.55 ^a ±3.56	31.68 ^a ±4.08
Total gain	165.60 ^a ±1.88	171.19 ^a ±5.05
Feed consumption (g) (FC)		
2-3 week	155.67 ^b ±2.33	167.33 ^a ±1.45
3-4 week	166.68 ^b ±7.02	222.84 ^a ±3.83
4-5 week	181.99 ^a ±4.45	193.70 ^a ±7.67
5-6 week	188.41 ^a ±5.89	195.77 ^a ±6.06
Total feed	692.74 ^a ±17.83	779.65 ^a ±13.10
Feed conversion rate (FCR)		
2-3 week	6.02 ^a ±0.26	5.04 ^a ±0.31
3-4 week	2.74 ^b ±0.01	3.60 ^a ±0.08
4-5 week	3.94 ^a ±0.37	4.37 ^a ±0.37
5-6 week	5.80 ^a ±0.72	6.18 ^a ±0.79
Total FCR	4.18 ^a ±0.12	4.56 ^a ±0.09
Livability %	96.70%	93.30%
Mortality %	3.30%	6.70%

Means carrying ^{a-b} significantly differ ($P \leq 0.05$) among different housing systems

Table 3 Carcass traits in Japanese quails reared on cages system vs floor system

Variables	Cage system	Floor system
Dressing %	70.44 ^a ±0.43	68.59 ^a ±0.83
Liver %	1.98 ^a ±0.07	2.06 ^a ±0.07
Heart %	1.09 ^a ±0.05	1.11 ^a ±0.07
Intestine %	4.51 ^a ±0.27	5.08 ^a ±0.79

Means carrying ^{a-b} significantly differ ($P \leq 0.05$) among different housing systems

Table 4 Economic indices in Japanese quails reared on cages system vs floor system

Variables	Cages system	Floor system
Feed cost	5.13 ^b ±0.13	5.77 ^a ±0.10
Chick price	3.30	3.30
Total fixed cost	1.26	1.03
Labor	0.85	0.85
Total veterinary management	0.40	0.40
Water	0.15	0.15
Litter cost	0.00	0.60
Total variable cost (TVC)	9.83 ^b ±0.13	11.07 ^a ±0.10
Total cost (TC)	11.09 ^b ±0.13	12.10 ^a ±0.10
Return from litter	0.00	0.35
Return from quail selling	13.06 ^a ±0.13	13.49 ^a ±0.28
Total return (TR)	13.06 ^a ±0.13	13.84 ^a ±0.28
Gross margin	3.23 ^a ±0.11	2.77 ^a ±0.24
Net profit (NP)	1.97 ^a ±0.11	1.74 ^a ±0.24
Benefit cost ratio	1.18 ^a ±0.01	1.14 ^a ±0.02
Return on investment	0.18 ^a ±0.01	0.14 ^a ±0.02
Feed cost / body weight Kg	23.56 ^b ±0.47	25.67 ^a ±0.46
Feed cost / body weight gain	30.96 ^a ±0.87	33.73 ^a ±0.64
NP / body weight gain kg	11.88 ^a ±0.51	10.13 ^a ±1.18
NP / body weight kg	9.05 ^a ±0.45	7.71 ^a ±0.91

Means carrying ^{a-b} significantly differ ($P \leq 0.05$) among different housing systems

These results agreed with (Yan et al., 2020) who said that that floor rearing usually leads to a richer gut microbiota than other systems.

The environmental conditions could alter the gut microbiota, as the FS usually leads to a richer, and more diverse gut microbiota than other systems (Cui et al., 2017). While our results disagreed with (Li et al., 2017).

Regarding biochemical parameters, there was a non-significant difference in IgG, IL2, IL 6, MDA, SOD, and catalase between both rearing systems, while IgM showed significant increase in CS compared to FS. Antioxidant activity had no significant difference between both systems, in agreement with (Şimşek et al., 2014) except the values of MDA. The results of immunoglobulins were in agreement with (Darwish et al., 2017)

In the current study, we found that LBW was not significantly different between quails reared on both systems at end of rearing period. The weekly body weight gain (3rd-4th, 4th-5th, and 5th-6th week), and total body weight gain were not significantly different between the two systems; a result that was in accordance with (Badawi, 2017). However, the results disagreed with (Razee et al., 2016), who discovered that quails raised in battery cages had much larger final body weight than those raised in a floor pen

The total feed consumption by quails reared on FS was significantly higher than those reared on CS. These results were nearly similar to Ayorinde, (1994). On country to our result Razee et al. (2016) reported that quails reared on floor had consumed less feed comparing with those reared on cage.

The total FCR (2nd to 6th week of age) was not significantly different between quails reared on both systems. Our result was agreed with, (Padmakumar et al., 2000) who found FCR variation was shown to be non-significant in cage and litter reared birds. Our result disagreement with (Razee et al., 2016) as they record that FCR at 2nd, 3rd, and 5th week of quails reared on floor pen was significantly greater than those reared in cage rearing system.

There was no significant difference between quails reared on two different rearing systems in carcass traits (dressing, liver, heart, and kidney percentage). Our findings indicated insignificant difference between FS and CS on livability, and mortality percentages. These results were in accordance with (Badawi, 2017).

Economic analysis revealed that, rearing quails on FS had higher Feed cost, TVC, and total cost than those reared on CS. This might be due to higher feed consumed for FS birds that was reflected on feed cost, total variable cost, and total cost. This could be attributed to increased feed consumption in FS than CS (Abo Ghanima et al., 2020). The TR and cost of each kg body weight from feed was significantly higher in FS than CS. While NP, GM, BCR, ROI, NP/BW, and NP/BWG were non-significantly higher in CS than FS, this could be due to the non-significance increase in BW in FS than CS, this result was in agreement with (Badawi, 2017), and increasing feed cost in FS than CS, a finding that was in agreement with (Abo Ghanima et al., 2020).

5. CONCLUSION

From the results of this study, it is concluded that the CS were more hygienic rearing system for quails than FS, while the higher body weight, and feed consumption were achieved in Japanese quails reared on FS. Moreover, the rearing system had no significant influence on the performance, and carcass traits. From the economic point

of view, there were no significant difference in the total return, gross margin, net profit for both birds housed either on floor or cage systems.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest for current data

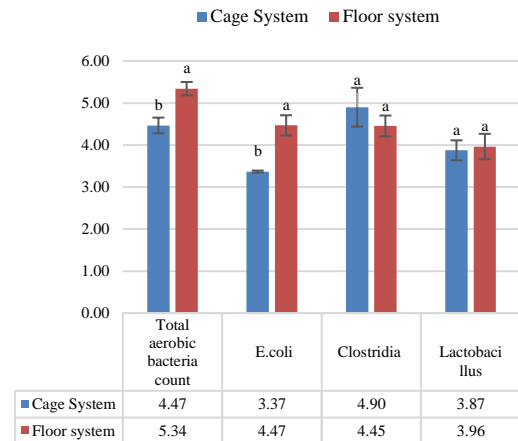


Fig 1 Total aerobic bacteria, *E. coli*, *clostridia*, and *lactobacillus* (Log₁₀ CFU/g) in Japanese quail reared on cage system and floor system. Means carrying ^{a-b} significantly differ (P≤0.05) among different housing systems

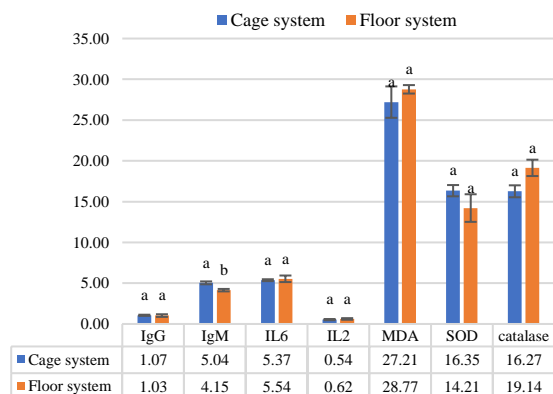


Fig 2 Biochemical parameters in Japanese quail reared on cages system vs. floor system. IgG (Immunoglobulin G), IgM (Immunoglobulin M), IL6 (Interleukin 6), IL2 (Interleukin 2), MDA (Malondialdehyde), SOD (Superoxide Dismutase activity). Means carrying same letter non-significant. Means carrying ^{a-b} significantly differ (P≤ 0.05) among different housing systems

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