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Effectiveness of limited feeding times in enhancing feed conversion ratio, carcass characteristics and blood biochemicals in growing Japanese quail raised under different densities

Diaa E. Abou-Kassem[1], Salah Abol-Ela[2], Rahma M. Amin[2] and Khalid M. Mahrose[1*]

[1]Animal and Poultry Production Department, Faculty of Technology and Development, Zagazig University, Zagazig, **Egypt**

[2]Poultry Department, Faculty of Agriculture, Zagazig University, Zagazig 44511, **Egypt**

***Correspondence:** ostrichkhalid@zu.edu.eg **Received 10-03-2021, Revised:16-05-2021, Accepted:05-06-2021 e-Published:10-06-2021**

This work examined the influences of stocking density (SD) and feed restriction time (FRT) on growth performance indices, carcass characteristics and blood biochemicals of growing Japanese quail. A cohort of 540 Japanese quail (1-week-old) was randomly divided into 6 groups in a 2×3 factorial arrangement (including 2 levels of SD; 150 and 100 cm^2/chick and 3 FRT; 0, 8 and 16 h/day). Our findings showed that body weight (BW) at 3 and 6 weeks of age and body weight gain (BWG) and feed conversion ratio (FCR) at 1-3 and 3-6 weeks of age were boosted by providing more space. Body weight at 3 and 6 weeks of age and BWG and FCR during 1-3 and 1-6 weeks of age were augmented with reducing FRT. Quail exposed to FRT for 0 and 8 h/day showed the greater BW and BWG than those of 16h/day. Under each cage density, quails fed during 24 or 16 h/day displayed the lowest FCR during 1-3 and 1-6 w weeks of age. Carcass, giblets, dressing percentages, total protein, albumin, AST and cholesterol levels were enhanced with lessening SD. Giblets, dressing percentages, total protein, albumin, AST, ALT and cholesterol levels were increased with decreasing FRT. Quails raised in the low SD and exposed to FRT for 8 h/day exhibited the lowest cholesterol concentration. Decisively, reducing space per bird had an undesirable impact on growth performance. Feed restriction for 8h/day can achieve a better FCR.

Keywords: Feed restriction times, growing quail, growth performance, stocking density.

INTRODUCTION

Quail (*Coturnix coturnix Japonica*) has numerous benefits as supplier of meat and eggs for human consumption in different countries (El-Tarabany et al. 2015; Farghly et al. 2015; Mahrose et al. 2020). Quail agribusiness is increasing attractiveness since quails are simple to handle and small in size therefore they can be reared in small ground area (Attia et al. 2012; Abd El-Ghany, 2019). The improvement in quail farming is being restrained by some management and environmental issues, infectious and non-infectious diseases (Abd El-Ghany, 2019; Mahrose et al. 2019a; Mahrose et al. 2019b; Mahrose et al. 2020). To attain the complete genetic growth ability, birds must be kept beneath ideal environmental circumstances, and any variation may damage their performance, produce immunosuppression, and substitute their physiological reactions, increasing their susceptibility to diseases (Qaid et al. 2016; Abd El-Ghany, 2019).

Reasons affecting stress comprise environmental aspects and rearing concerns, such as cage density and feeding systems (Mahrose et al. 2020). Cage crowdedness and floor space have become very imperative financial issue owing to the extension of poultry industry, reduced profit per bird, well-being and welfare and too lesser revenue (El-Gogary et al. 2015; Gupta et al. 2017; Selvam et al. 2017; Mahrose et al. 2019a&b). Providing low floor space for growing Japanese quails guided to a decrease in body weight and body weight gain at 6 weeks of age and an increase in feed conversion ratio (Attia et al. 2012; Boontiam et al. 2019; Mahrose et al. 2020). Management of feeding practices aim to enhance animal welfare and production without rising cost (Mateos et al. 2012). Feed restriction schedule is one of the key practices in growth arch management for intensifying production efficacy in fattening of poultry species (Sahraei, 2012; Mahrose et al. 2020). Severity and length of restriction and marketing age are the essential elements to take into consideration in a feed restriction schedule (Sahraei, 2012). Restricting feeding times were found to boost feed conversion ratio in broilers (Ahmad et al. 2009; Boostani et al. 2010; Shamma et al. 2014; Alkhair et al. 2017). Numerous feeding schedules were used to enhance growth performance of broilers (Omosebi et al. 2014; Jahanpour et al. 2015; Adeyemo et al. 2017; Tůmová et al. 2019), but little are applied on quail and with cage density. Recently, Fondevila et al. (2020) concluded that restricting feeding times reduced feed consumption in broilers. The contemporary investigation was planned to examine the influences of stocking density and feed restriction time on growth performance indices, carcass characteristics and blood biochemicals of growing Japanese quail.

MATERIALS AND METHODS

Birds and experimental design

This work was carried out at Poultry Research Farm belonging to Poultry Department, Faculty of Agriculture, Zigzag University, Zigzag, and Egypt. All experimental procedures followed the guidelines of the Ethical committee of Faculty of Agriculture, Zagazig University, Egypt. A total number of 540 Japanese quail chicks at one week of age were randomly separated into 6 treatment groups (108 or 72 birds /each group; the first 3 groups contained 72 chicks/group, while the other 3 groups contained 108 chicks/group) and each group was sub-divided into 6 replicates, each of 36 and 24 chicks. Each replicate was housed in one pen, and the area of each pen equal 1800 cm². A factorial arrangement (2 × 3) was performed including two levels of stocking density (150 and 100cm²/chick) and three restricted feeding times (8h, 16h and 24h).

2.2. Diet and management

The basal experimental diet was formulated to cover the nutrient requirements of growing Japanese quails as recommended by NRC (1994) during 1 to 6 weeks of age as shown in Table 1. Quail chicks were reared during experimental periods under the same managerial, hygienic and environmental conditions. Birds were exposed to 24h of light per day during first week, while during the experimental period, chicks were provided 16h light/ day, fed *ad-libitum* and fresh water were available during the experimental periods, while drinkers and feeding troughs were daily cleaned. A temperature of 34˚C was maintained during the first 3 days and decreased to 33˚C for four days after that it was reduced 3˚C/week until a constant temperature of 25˚C was achieved.

Table 1: Composition and calculated analysis of experimental die.

Ingredients	(%)
Yellow corn	52.70
Soy bean meal	38.20
Corn-gluten 60%	4.30
Cotton seed oil	1.60
Di-calcium phosphate	1.60
Limestone	0.90
Nacl	0.30
Premix *	0.30
L-lysine	0.03
D- L methionine	0.07
Calculated analysis **	
CP %	24.12
ME kcal/kg	2910.11
Ca %	0.85
P% Avail, P.	0.46
Lysine %	1.31
Methionine %	0.50
Met.+ Cys. %	0.82

*Growth vitamin and mineral premix each 3 kg consists of: Vit A 12000, 000 IU; Vit D_3, 2000, 000 IU; Vit. E. 10g; Vit k_3 2 g; Vit B_1, 1000 mg ; Vit B_2, 49g ; Vit B_6, 105 g; Vit B_{12}, 10 mg; Pantothenic acid, 10 g; Niacin, 20 g , Folic acid , 1000 mg ; Biotin, 50 g; Choline Chloride, 500 mg, Fe, 30 g; Mn, 40 g; Cu, 3 g; Co, 200 mg; Si, 100 mg and Zn , 45 g.

** Calculated according to NRC (1994).

2.3. Measurements

The body weight (BW) and feed consumption (FC) on a repeat foundation were weighed to the closest gram at 1, 3 and 6 weeks of age, and then the mean body weight gain (BWG) and feed conversion ratio (FCR; g feed/g gain) were computed during 1-3, 3-6 and 1-6 weeks of age. Dead quails were documented on a daily basis and stated as a percentage (mortality rate, %) during 1-6 weeks of age.

At 6 weeks of age, 6 birds from each group were haphazardly chosen, having average body weight around the quail group mean, fasted overnight, weighed, and slaughtered. The abdominal cavity was opened, and the edible organs contain (gizzard, liver, and heart) were removed and weighed in gram to the nearest three decimal points, and proportionate to the live body weight. Whole eviscerated carcasses were individually weighed, and the dressing percentage or carcass yield was recorded.

2.4. Blood biochemicals

At 6 weeks of age, 36 males had randomly chosen (6 in each group) to measure blood biochemicals. Blood samples were collected at day of slaughter. Plasma total protein, albumin, creatinine and cholesterol were measured colorimetrically using commercial kits (bought from Bio-diagnostic, Giza, Egypt) according to the manufacturers' guidelines. Plasma transaminase enzymes (ALT and AST), Superoxide dismutase (SOD) and plasma malondialdehyde (MDA) activities were determined by colorimetric manners according to Diamond Bio-diagnostic, Giza, Egypt. Total albumin, protein, alanine transaminase (ALT) and aspartate transaminase (AST) were assessed using biodiagnostic commercial kits provided from Biodiagnostic Company (Giza, Egypt) Batch No: ALT (cat#AL1032), AST (cat#AS1062) according to the manufacturers' guidelines.

2.5. Statistical analysis

Data were statistically analyzed on a 2x3 factorial arrangement basis according to (Snedecor & Cochran 1982) using the following model: $Y_{ijk} = \mu + S_i + F_j + SF_{ij} + e_{ijk}$, Where: Y_{ijk} = an observation, μ = the overall Mean, S_i = effect of SD (i = 1 to 2), F_j = effect of FRT (j = 1 to 3), SF_{ij} = the interaction between SD and FRT (ij = 1 to 6) and e_{ijk}= random error. Differences among means within the same factor were tested using Duncan's new multiple rang test (Duncan, 1955).

RESULTS

Findings presented in Table 2 showed that BW at 3 and 6 weeks of age was significantly (p < 0.01) increased by providing more space for growing quails. In the same trend, BWG was significantly (p < 0.01) increased during 1-3 and 1-6 weeks of age with the low SD. Body weight at 3 and 6 weeks of age and BWG during 1-3 and 1-6 weeks of age were significantly (p < 0.01) linearly augmented with reducing restricted feeding times (Table 2). Groups of quail exposed to feed restriction for 0 and 8 h/day showed the greater BW and BWG than quails exposed to feed restriction for 16h/day. The interaction between to SD and FRT did not affect BW or BWG at all periods studied. Mortality rate was insignificantly differed due to the main factors studied and their interaction (Table 2).

Table 3 indicates that FCR was significantly (p < 0.01) improved through 1-3 and 1-6 weeks of age with the low SD (150 cm²/bird) as compared with the high one (100 cm²/bird), while FC was changed numerically. Regarding FRT effects, there was a significant (p < 0.01) increase in FC during 1-3 and 1-6 weeks of age with reducing FRT. Feed conversion ratio through 1-3 and 1-6 weeks of age exhibited the same trend as FC. The variations in FC and FCR between birds exposed to 0 and 8 h/day of FRT were not significant (Table 3). There were no significantly differences in FC owing to the interaction between SD and FRT during all experimental periods. Under each cage density, quails fed during 24 or 16 h/day displayed the lowest (p < 0.05 and 0.01) FCR during 1-3 and 1-6 w weeks of age as shown in Table 3.

Results of carcass characteristics are found in Table 4. Carcass, giblets and dressing percentages were significantly (p < 0.01) increased with lessening SD. Also, each of giblets and dressing percentages were significantly (p < 0.01) increased with decreasing FRT. All of carcass characteristics studied were not altered by the interactions between SD and FRT.

Total protein, albumin, AST and Cholesterol levels were significantly (p < 0.05 and 0.01) increased as decreasing SD (Table 5). On the other hand, total protein, albumin, AST, ALT and Cholesterol levels significantly (p < 0.05 and 0.01) were linearly increased with reducing FRT. Quails raised in the low SD and exposed to FRT for 8 h/day exhibited the lowest (p < 0.05) cholesterol concentration when compared with their counterparts as revealed in Table 5.

Table 2: Live body weight and weight gain of Japanese quail chicks as affected by stocking density, feed restriction time and their interactions

Treatment groups	Body weight (g)			Weight gain (g)			Mortality rate
	1w	3w	6w	1-3 w	3-6 w	1-6 w	1-6 w
Stocking density (cm/bird)							
150	20.40	110.57	171.76	90.17	62.28	151.36	0.00
100	20.18	100.89	162.03	80.70	61.14	141.85	2.08
SEM	0.29	1.58	1.57	1.44	2.61	1.64	0.03
P value	0.623	0.002	0.001	0.003	0.923	0.009	0.537
Feeding restriction time (h/D)							
0	20.14	111.84[a]	173.25[a]	91.69[a]	61.41	153.11[a]	0.00
8	20.23	109.80[a]	171.75[a]	89.61[a]	61.91	151.52[a]	0.00
16	20.50	95.51[b]	155.68[b]	75.01[b]	60.17	135.18[b]	1.73
SEM	0.33	1.87	2.04	1.93	3.11	2.01	0.05
P value	0.788	<0.001	<0.001	<0.001	0.833	<0.001	0.734
Interactions							
Stocking density (150 cm/bird)							
0	20.19	117.32	178.21	97.12	60.89	158.02	0.00
8	20.25	114.77	176.77	94.52	62.00	156.52	0.00
16	20.76	99.63	160.29	78.87	60.66	139.53	0.00
Stocking density (100 cm/bird)							
0	20.09	106.36	168.30	86.23	61.94	148.20	0.00
8	20.21	104.91	166.73	84.70	61.82	146.52	0.00
16	20.24	91.39	151.07	71.15	59.68	130.83	1.90
SEM	0.71	2.16	3.09	3.09	2.80	3.05	0.03
P value	0.888	0.908	0.987	0.876	0.978	0.974	0.581

Means in the same column within each classification bearing different letters are significantly ($p < 0.05$ and 0.01) different.

Table 3: Feed intake and feed conversion times of Japanese quail chicks as affected by stocking density, feed restriction time and their interactions

Treatment groups	Feed intake (g)			Feed conversion ratio		
	1-3w	**3-6w**	**1-6w**	**1-3 w**	**3-6 w**	**1-6 w**
Stocking density (cm/bird)						
150	244.36	251.41	493.80	2.71	4.07	3.26
100	241.30	249.51	492.90	2.99	4.13	3.47
SEM	2.15	3.20	4.55	0.13	0.21	0.17
P value	0.637	0.479	0.671	0.001	0.079	0.031
Feeding restriction time (h/D)						
0	255.80[a]	257.31	513.10[a]	2.79[a]	4.19	3.35[b]
8	245.53[a]	254.45	499.90[a]	2.74[a]	4.11	3.30[b]
16	226.53[b]	256.92	483.41[b]	3.02[b]	4.27	3.58[a]
SEM	2.99	3.84	4.05	0.19	0.17	0.15
P value	0.001	0.395	0.017	0.002	0.094	0.010
Interactions						
Stocking density (150 cm²/bird)						
0	248.71	253.67	504.13	2.75[c]	4.13	3.31[c]
8	244.46	251.39	501.22	2.73[c]	4.09	3.28[c]
19	235.95	250.44	489.06	2.86[b]	4.17	3.43[b]
Stocking density (100 cm²/bird)						
0	248.10	254.25	503.11	2.89[b]	4.16	3.41[b]
8	243.75	253.09	496.42	2.86[b]	4.12	3.38[b]
16	240.03	254.20	488.15	3.00[a]	4.20	3.52[a]
SEM	2.36	3.54	4.13	0.12	0.09	0.17
P value	0.617	0.310	0.215	0.011	0.128	0.009

Means in the same column within each classification bearing different letters are significantly ($p < 0.05$ and 0.01) different.

Table 4: Carcass characteristics of growing Japanese quail as affected by stocking density, feed restriction time and their interactions

Treatment groups	Pre-slaughter weight	Carcass %	Giblets %	Dressing %
Stocking density (cm²/bird)				
150	159.72	81.21	5.41	86.62
100	153.06	80.19	4.71	84.91
SEM	2.11	0.19	0.10	0.17
P value	0.071	0.003	<0.001	<0.001
Feed restriction time (h/D)				
0	155.44	80.79	4.63[c]	85.42[b]
8	161.59	80.32	4.99[b]	85.32[b]
16	152.13	80.98	5.57[a]	86.55[a]
SEM	2.14	0.22	0.09	0.19
P value	0.106	0.181	<0.001	0.001
Interactions				
Stocking density (150 cm²/bird)				
0	152.66	80.41	4.17	84.58
8	159.45	79.72	4.58	84.30
16	147.06	80.44	5.39	85.84
Stocking density (100 cm²/bird)				
0	158.22	81.17	5.09	86.27
8	163.74	80.93	5.40	86.33
16	157.20	81.52	5.74	87.26
SEM	4.23	0.47	0.21	0.44
P value	0.761	0.797	0.128	0.563

Means in the same column within each classification bearing different letters are significantly ($p < 0.05$) different.

Table 5 :Blood biochemicals of growing Japanese quail as affected by stocking density, feed restriction time and their interactions

Treatment groups	Total protein g/dl	Total albumin g/dl	Total globulin g/dl	AST g/dl	ALT g/dl	MDA mmol/ml	SOD U/L	Creatinine Mg / dl	Cholesterol
Stocking density (cm²/bird)									
150	4.62	2.91	1.71	46.22	33.42	0.22	0.19	0.19	281
100	4.30	2.63	1.67	55.19	35.11	0.23	0.21	0.20	259
SEM	0.09	0.07	0.05	0.88	0.75	0.01	0.02	0.02	7.92
P value	0.001	0.010	0.098	0.021	0.158	0.627	0.110	0.828	0.031
Feed restriction time (h/D)									
0	5.03[a]	3.31[a]	1.72	47.84[b]	31.88[b]	0.25	0.19	0.17	243[a]
8	4.63[b]	2.98[b]	1.65	52.96[b]	33.15[b]	0.21	0.20	0.21	201[b]
16	4.41[c]	2.72[c]	1.69	63.13[a]	39.49[a]	0.23	0.20	0.23	187[c]
SEM	0.12	0.10	0.07	1.05	0.64	0.03	0.02	0.01	9.18
P value	<0.001	0.019	0.412	0.03	0.029	0.650	0.719	0.328	<0.001
Interactions									
Stocking density (150 cm²/bird)									
0	4.83	3.09	1.74	58.23	32.22	0.21	0.26	0.21	216[b]
8	4.59	2.93	1.68	49.31	31.36	0.19	0.18	0.20	204[c]
16	4.51	2.81	1.70	61.42	29.87	0.20	0.23	0.22	242[a]
Stocking density (100 cm²/bird)									
0	4.63	2.95	1.68	55.18	32.89	0.23	0.18	0.19	184[d]
8	4.52	2.86	1.66	56.25	31.92	0.21	0.22	0.18	172[e]
16	4.37	2.69	1.68	57.83	33.65	0.22	0.19	0.20	199[c]
SEM	0.29	0.18	0.15	1.68	1.13	0.06	0.11	0.02	9.27
P value	0.343	0.428	0.051	0.063	0.297	0.095	0.051	0.605	0.027

Means in the same column within each classification bearing different letters are significantly ($p < 0.05$) different.

DISCUSSION

The chief objective of the current study is to examine the impacts of restricting feeding times for growing quails raised under different stocking densities. Growth delay of quails under high SD might diminish in gaseous and heat exchange inside the pen (Boontiam et al. 2019), occasioning in poorer BW. The latter researchers confirmed that a satisfactory SD for growing quails should not surpass 51.85 birds/ m^2. The obtainable results, regarding BW and BWG, are consistent with those of previous studies (Attia et al., 2012; El-Tarabany, 2016; Mahrose et al. 2019b) who showed reductions in the BW in quails at high stocking densities. The existing results are in agreement with those of Boontiam et al. (2019) who observed that marketing BW and BWG were reduced in the quails raised under density of 25 quails/m^2 as compared with birds kept under density of 13 or 17 quails/m^2. Furthermore, McKeith et al. (2020) found that there was a significant variation in BW between standard SD and low SD in broiler chicks during 4-6 weeks of age. Cengiz et al. (2015) stated that weight gain was higher in birds at low SD than those reared at high SD during periods of 0-21, 22-42, and 0-42 days of age. The latter investigators indicated that the reduction in BW and BWG due to high stocking density limit the movement of the birds to a confine area within the pen. Our explanation can be consisting of the competition on feeders and drinkers which occurred with high SD as compared to low one. On the other hand, Ayoola et al. (2014), David and Subalini (2015) and Mahrose et al. (2019a) showed that SD had no impact on BW and BWG in broiler chicks and growing ostriches, correspondingly.

Shamma et al. (2014) attributed the decrease in BW to the decline in FC of birds which were exposed to feed restriction 16 hours. Accordingly, these birds cannot create compensatory growth to accomplish those restricted for 0 or 8 hours. Adeyemo et al. (2017) indicated that feed restriction regimes had no influence on marketing BW and BWG of broilers.

In this study, SD was not affected mortality rate as agreed with Ayoola et al. (2014) who concluded that SD did not change mortality rate in growing quail. In this concern, McKeith et al. (2020) clarified that mortality rate was not determined to be significantly different between the two SD studied (0.23 and 0.27 m^2 per bird) in broilers. The present results agreed with those of Fondevila et al. (2020) who concluded that feed restriction times for 4, 6, and 8 h/day during 7-19 days of age did not change mortality rate in broiler chicks. On contrary, Attia et al. (2012) found that higher SD resulted in higher mortality rate in growing quail during 1-6 weeks of age, and the same researchers indicated that overcrowding and space per quail might cause stress on quail chicks and increased mortality rate. The obtained outcomes of mortality rate may be mentioned to the point that FRT lessened mortality as it reduces down quick growth (Shamma et al. 2014).

The contemporary findings disagree with those of Mahrose et al. (2019b) who found that increasing stocking density in Japanese quails resulted in an increase in FC and improved FCR. Our results were supported with those of previous studies (Attia et al. 2012; El-Tarabany, 2016) that showed reductions in FC in growing quails kept under high stocking densities. In this regard, Boontiam et al. (2019) observed a reduction in FC when increasing SD in quail chicks from 13 to 25 quails/ m^2. In the current investigation, it could be hard for growing quails kept under high SD to simpler approach to feeders and waterers than those raised under low one (Boontiam et al., 2019). In broiler chicks, Cengiz et al. (2015) stated that FC was decreased and FCR was enhanced during 0-21, 22-42, and 0-42 days of age in birds reared at high SD as compared to those at low SD. Feddes et al. (2002) demonstrated that high SD led to a reduction in gaseous and heat exchange within the microclimate of the birds may account for the lowered FC and body weight gain which leading to worst FCR. Results of the current study agreed with findings of Fondevila et al. (2020) who concluded that feed restriction times for 4, 6, and 8 h per day during 7-19 days of age decreased FC in broiler chicks, but did not change FCR. Rodrigues and Choct (2018) clarified that the consistent disruption in growth performance observed for the first days in broilers after the start of the restriction feeding period is often followed by a good improvement in FCR as compared to feed continuously available. Contradicting findings were achieved by Ayoola et al. (2014) and Adeyemo et al. (2017) who found that FCR was not impacted by SD.

Our findings may be owed to the point that feed restriction boosts feed efficiency which could be accredited to decreased total preservation necessities triggered by a temporary decline in basal metabolic rate. Particularly, when birds are exposed to early feed restriction they display sluggish growth tailed by a period of fast growth and weight gain as they approach market weight to reimburse for the postponed growth through early restriction period (Shamma et al. 2014) and this transforms into decreased preservation necessities and enhanced FCR. Furthermore, Novel et al. (2009) confirmed that feed restriction plans enhance FCR and permitting complete BW retrieval has been recognized to a total of influences such as decreased of preservation metabolizable energy necessities linked to poorer BW and metabolic and digestive acclimatization.

All carcass characteristics negatively affected by high SD. A decrease in relative carcass yield of broilers occurred with increasing SD may be linked with the reduction in FC of Pekin ducks (Abo Ghanima et al. 2020). Our clarification of this point showed that the improvement of carcass traits is linked with increasing BW and BWG at low SD. Mormede et al. (2007) showed that external stress such as SD possibly stimulates the hypothalamic pituitary-adrenal axis which due to releases hormonal stress and sub-sequent decreases the breast muscle percentage. Attia et al. (2012) Boontiam et al. (2019) and Mahrose et al. (2019b) on growing quail and Adeyemo et al. (2016) on broiler chicks illustrated that SD had no influence on carcass characteristics. Several researchers reported that there were insignificant differences in carcass yields of broilers at different stocking densities (Tong et al. 2012; Vargas-Rodriguez et al. 2013 and Cengiz et al. 2015).

Boostani et al. (2010) concluded that broilers kept under FRT for 8 h during 21-35 and 14-28 days of age had poorer breast weight and abdominal fat weight as linked to control birds, respectively. Results of David and Subalini (2015) and Alkhair et al. (2017) exhibited non-significant alterations in entire carcass weight among the experimental groups due to different FRT. Mohammadalipour et al. (2017) stated that FRT did not change dressing percentage in broilers. On contrast, Shamma et al. (2014) stated that FRT (4-6 h/daily) enhanced carcass weight, edible parts. Our findings might be attributed to that early feed restriction may decrease adipocyte hyperplasia (Hassanabadi and Moghaddam, 2006). Cherry, Swartworth, and Siegel (1984) concluded that although hyperplasia proceeds during periods of nutrient restriction, the adipocytes remain smaller. The lesser relative weights of the giblets of quails could be ascribed to their stress reactions (Shamma et al., 2014). The inconsistent results related to FRT might be linked to the feed restriction scheme and circumstances of the experiments.

Blood biochemicals provide evidence on the metabolism in birds (Tůmová et al. 2019). All blood biochemicals were inside the physiological scale (Scholtz et al. 2009). The contemporary results of total protein and albumin were increased in quails stocked at low density, indicating absence of crowding stress. Our outcomes were previously confirmed by El-Shafei et al. (2012) in laying quail. Gupta et al. (2017) found non-significant alterations in total protein, albumin and globulin concentrations in chickens due to SD. The present results were in agreement with findings of Cengiz et al. (2015) who stated that low and high SD in growing quail had no significant effects on blood MDA. Controverting outcomes were showed by Abo Ghanima et al. (200) on Pekin ducks, Selvam et al. (2017) on broilers and Mahrose et al. (2020) on growing quails, where MDA and SOD were significantly altered due to SD or quantitative feed restriction. AST is expended as an operative biomarker to recognize tissue harms, specifically in the liver (Mahrose et al. 2016). In this work, an increase in AST activity was observed in quails reared under high SD, indicating that high SD was damaging to the liver. Augmenting AST activity in quails housed in lesser area could possibly direct to hepatic or muscular imperfection and dangerous liver harm (Mahrose et al. 2020). Similar findings were observed by Abo Ghanima et al. (2020), while El-Shafei et al. (2012) indicated controversial results. Our results greed with those of El-Shafei et al. (2012) and Silas et al. (2014) who stated that blood cholesterol levels of broilers were higher in the birds raised under low SD than those kept under high SD. Qaid et al. (2016) showed that chicks raised at upper densities exhibited upper serum cholesterol concentrations (120=90>60=30 chicks/m^2, respectively).

Dissimilar findings were obtained by Boostani et al. (2010) and (Tůmová et al. 2019) who showed non-significant variations in total protein and albumin of broilers exposed to different FRT. Cholesterol is an imperative pointer that reveals the lipid metabolism of the animal (Mahrose et al. 2020). Boostani et al. (2010) observed that cholesterol levels of broilers reared under FRT for 8 h during 14-28 and 21-35 days of sage were lesser than those of control birds.

CONCLUSION

Growing Japanese quails raised below to the stress circumstances of low cage space exhibited deficiency in body weight and feed conversion ratio, as well as a change in some blood biochemicals, considering the economic hazards of housing growing quails at cage area lesser than 150 cm^2/bird. The contemporary results propose that increased stocking density with decreasing cage space per bird had an undesirable impact on growth performance. Also, feed restriction time for 8 hours daily as in the existing investigation be able to succeed a superior feed conversion ratio.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ANIMAL WELFARE STATEMENT

The authors confirm that the ethical policies of the journal, as observed on the journal's author directions page, have been monitored. All exercises were concerned coherent with the Resident Investigational Animal Care Board and acceptable by the ethics of the institutional board of Poultry Department, Faculty of Agriculture, Zagazig University, Zagazig, Egypt and join the European Union (EU) standards on the safety of animals used for scientific practices.

AUTHOR CONTRIBUTIONS

Add contribution of each author (with abbreviated name) here. For example DA, SA, RA and KM designed and performleed the experiments and also wrote the manuscript. KM, DA, and RA performed animal treatments, flow cytometry experiments, tissue collection, and data analysis. KM and DA designed experiments and reviewed the manuscript. All authors read and approved the final version.

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