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Carcass traits of broilers as affected by different stocking density and sex

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Abstract

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The aim of this study was to evaluate the carcass traits of male and female broiler chickens reared at three different densities. Evaluations were done using 216 one-day-old Ross 308 chicks kept in a battery system. Birds were randomly divided into three treatments: high stocking density (HSD) = 22, medium stocking density (MSD) = 18 and low stocking density (LSD) = 14 birds/m^2, with four replications for both sexes. The experiment lasted for 42 days. At the end of the experiment, five broilers per replicate were slaughtered to measure the following carcass characteristics: dressing weight, neck and front back, wings, whole breast, whole legs, heart, gizzard and liver. Dressing percentage was calculated as the ratio of hot carcass to live body weight. The effect of stocking density and sex on live weight was significant ($p < 0.05$). Heavier carcasses at slaughter were recorded for the MSD treatment (2149.70 g) and for the male broilers (2142.55 g) compared to the female ones (2022.82 g). The interaction of stocking density and sex did not significantly affect the live weight ($p > 0.05$). Breast weight was higher for the low density treatment ($p < 0.05$). The breast and whole legs weights of male broilers were significantly higher ($p < 0.05$) compared to those of the female broilers. Whole leg weights were significantly higher ($p < 0.05$) for the MSD treatment. No significant difference ($p > 0.05$) of stocking density and sex interaction was found in breast and whole legs weights. The carcass weights of MSD and LSD broilers were significantly higher ($p < 0.01$) compared to the HSD broilers. From the results obtained from this experiment, it can be concluded that 14 to 18 birds per square meter is acceptable and may ensure profitable broiler production up to six weeks of age.

Keywords: broilers; carcass parts; hybrid; sex; stocking density

Introduction

As a result of improved genetic and management practices, the contribution of broilers to meat production and supply for consumers has increased markedly in the last decade. Broiler meat is considered by consumers as a high-quality food because of its low fat and high protein content. Broiler chickens can grow almost anywhere and they are small therefore occupy less space compared with some other animals. Many factors can affect broiler carcass and meat quality, including stocking density and sex, which are the most important ones. National Chicken Council (USA) recommended that stocking density must allow all birds to access feeders and drinkers, and will depend on the target market weight, type of housing, ventilation system, feeder/drinker equipment, litter management and husbandry (NCC, 2017). Stocking density is one of the most important non-genetic factors in poultry breeding. A high density of birds per square meter reduces the cost of production, but excessive density may affect the performance of the broilers. This is supported by statements by Mehmood et al. (2014), who documented that the economical use of floor space is a common strategy for increasing the amount of meat produced per unit area. However, it is imperative that the growth space of birds does not affect the growth and production parameters, as well as the profitability. The stocking density should also be considered in terms of the welfare of chickens kept for meat production. This aspect is strictly defined by the Council Directive 2007/43/EC (2007), where welfare criteria to be met depending on the total load of yield per unit area are described. Following the research of Buijs et al. (2009), stocking density differs by country and husbandry system.

The maximum stocking density can be defined as the number of birds or weight per floor surface area (Berg and Yngvesson, 2012) and how well the birds meet their growth rate goals and weight per surface area just before slaughter. Depending on market demand, broiler chickens can be sold whole or cut into different parts, such as neck and front back, hind back, wings, gizzard, liver, whole breast and whole legs. The carcass yield is also a very important economic factor in the broiler industry. The final weight, body development and yield of the major carcass parts determine the slaughter carcass quality (Škrbić et al., 2011). The sex of the broilers also influences carcass yield (Nikolova and Pavlovski, 2009).

High stocking density can cause a reduction of growth and of the final body weight of 42-day-old broilers, and in some cases also a reduction in carcass quality (Türkyilmaz, 2008; Skomorucha et al., 2009; Sekeroglu et al., 2011; Hassanein, 2011). Stocking density affected the carcass performance of French guinea broilers (Nahashon et al., 2009). Gender also affects the live body weight and carcass composition of broiler chicken (Scheuermann et al., 2003; Hristakieva et al., 2014) owing to the different growth potential of male and female broilers. Results reported by Young et al. (2001) show different percentage and carcass yield between male and female chicken. Male broilers were found to be superior to females (Azahan et al., 2007) in terms of growth parameters such as body weight. Being aware of the importance of the number of birds kept in a specific area and owing to the fact that in Kosovo, broilers are typically bred without sexing, the aim of the present study was to evaluate the carcass traits of broiler chickens reared at three stocking densities for both sexes.

Materials and Methods

The effects of stocking density and sex were studied and discussed together. A total of 216 one-day-old Ross 308 broiler chickens were used in this study. The birds were purchased from the biggest commercial broiler company Kon-Soni in Gjilan. Broiler chickens were housed in four floor-wired cages with the dimensions of 100 × 100 cm and 50 cm height. Colony cages were equipped with drinkers and feeders. Birds were kept under controlled conditions, from one-day old until 42 days of age in the experimental facilities of the Faculty of Agriculture and Veterinary at Pristina University.

The birds had similar average body weights ($p > 0.05$) at the start of the experiment. The broiler chickens were feather sexed and divided into three experimental groups based on stocking density: high stocking density (HSD) = 22, medium stocking density (MSD) = 18 and low stocking density (LSD) = 14 birds/m^2. Each group was replicated four times. The birds were offered on an ad libitum basis 1 meter of feeding and watering space. The diets were formulated to meet the nutrient recommendations (NRC, 1994) and organised as starter, grower and finisher dietary treatments for all groups in the experiment. The body weight change of the birds was assessed weekly by individual measurements using a movable weighing scale.

At the end of 6 weeks, five birds from each replicate were weighed individually and sacrificed for measurement of the carcass parameters. Birds were slaughtered following the Halal method. After slaughtering and bleeding, the carcasses were defeathered and eviscerated by hand. Thereafter, the carcass was cut into parts. During this study, the carcass parameters measured were: neck and front back, wings, whole breast, whole legs, heart, gizzard, liver and dressed weight. All the carcass characteristics were expressed in grams except the dressed weight, which is expressed as a percentage of the final body weight.

Statistical analysis: The collected data on carcass parameters were subjected to analysis by statistical package JMP IN 7 (a business unit of SAS). One-way analysis of variance was used to compare the means of the data with an alfa level of 0.05 being used as the borderline of significance. The Tukey-Kramer test was used to compare the means and define the importance of the difference.

Results and Discussion

Mean values (± standard error of the mean, SEM) of carcass traits measured in the three different stocking densities over the experimental period are summarised in Table 1. It is evident from this table that the final live body weight was significantly affected ($p < 0.0001$) by stocking density. The final live weight decreased with increasing number of birds per m^2. This indicates that HSD may lead to restriction of movement, which will reduce the consumption of feed, which is followed by lower body weight at the end of the growth phase (42 days). Birds reared with the lower and MSD (14 and 18 birds/m^2) had higher final live weights. These results could be related to the greater feeder space combined with increased floor surface. Another factor that significantly affected ($P = 0.0036$) the final

Table 1. Results of body weight and carcass parameters of broiler chickens affected by stocking density at 42 day of age

Carcass parameters	Stocking density			P value
	HSD (Mean ± SEM)	MSD (Mean ± SEM)	LSD (Mean ± SEM)	
FLW, g	1958.73[b] ± 32.69	2149.70[a] ± 33.72	2139.63[a] ± 33.97	<.0001
CW, g	1504.06[b] ± 25.88	1656.73[a] ± 28.22	1658.17[a] ± 30.39	<.0001
Dressing, %	76.78 ± 0.25	77.01 ± 0.21	77.39 ± 0.31	0.2542
NFBW, g	173.12[b] ± 5.46	188.58[ab] ± 5.88	192.90[a] ± 6.52	0.0557
BRW, g	502.50[b] ± 10.98	570.02[a] ± 11.42	572.66[a] ± 13.54	<.0001
WLW, g	403.81[b] ± 7.29	440.14[a] ± 7.66	418.46[ab] ± 12.76	0.0209
WW, g	155.09[b] ± 3.04	170.64[a] ± 5.96	164.41[ab] ± 3.24	0.0353
BW, g	177.62[b] ± 4.69	184.99[ab] ± 4.99	196.74[a] ± 4.30	0.0176

Values in each row are a mean value of 4 replicates of each treatment.
Means within a column with different superscripts are significantly different (P < 0.05).
SEM – standard error of the means; HSD – high stocking density; MSD – medium stocking density; LSD – low stocking density; FLW – final live weight; CW – carcass weight; NFBW – neck and front back weight; BRW – breast weight; WLW – whole legs weight; WW – wings weight; BW – back weight

live weight was the sex of the broiler chickens (Table 2). Male birds had significantly higher final live weights than female and mixed-sex birds. Carcass weight was also notably affected (Tables 1 and 2) by the stocking density and sex of the birds (P < 0.0001 and P = 0.0089). The HSD typically decreases carcass weight. No significant interactions between stocking density and sex were found (P > 0.05) for final live weight and carcass weight (Table 3).

The stocking density as independent variable has not significant (P > 0.05) effect on dressing percentage and neck and front back weight (Table 1). Results for the percentage of dressing and weight of neck and front back, were slightly higher in male than in female chickens and mixed sexes, but differences are not statistically significant (P > 0.05). Dressing percentage and NFBW were not affected by interaction between stocking density and sex (P > 0.05).

Breast weight was markedly influenced (P < 0.0001) by stocking density and sex (P = 0.0016). The best breast weight (BRW) was found at LSD and in male birds. In the present study (Table 3), no significant difference (P > 0.05) in breast weight was found from the interaction between stocking density and sex. Table 1 shows that the stocking density also affected (P > 0.05) whole leg weight, wing weight and back weight. For the monitored group, the whole leg and wing weight was found to be higher with MSD, while the back weight was higher with LSD.

Significantly higher (P = 0.0008) whole leg weight was found in male compared to female chickens and for both sexed broiler chickens (Table 2). However, no significant differences of sex were found (P > 0.05) for wing and back weight. In the present study, we did not find any significant differences (P > 0.05) of interaction between stocking density and sex in terms of the whole carcass compositions (Table 3).

Results of the mean weights of useable and non-useable internal organs are presented in Table 4. Heart and liver weights were significantly (P < 0.05) affected by different stocking densities. The highest value for heart and liver weight was recorded in the group of birds at MSD.

Table 2. Results of the effect of sex on live body weight and carcass parameters of broiler chickens at 42-day old

Carcass parameters	Sex			P value
	Female (Mean ± SEM)	Male (Mean ± SEM)	Female and male (Mean ± SEM)	
FLW, g	2022.81[b] ± 30.23	2142.55[a] ± 26.57	2082.68 ± 20.78	0.0036
CW, g	1561.01[b] ± 25.26	1651.63[a] ± 22.86	1606.32 ± 17.46	0.0089
Dressing, %	77.10 ± 0.21	77.02 ± 0.21	77.06 ± 0.15	0.7730
NFBW, g	185.69 ± 6.00	184.04 ± 3.67	184.86 ± 3.50	0.8157
BRW, g	525.06[b] ± 10.84	571.73[a] ± 9.55	548.40 ± 7.50	0.0016
WLW, g	402.17[b] ± 9.16	439.44[a] ± 5.73	420.80 ± 5.64	0.0008
WW, g	158.71 ± 4.34	168.05 ± 2.49	163.38 ± 2.53	0.0641
BW, g	184.01 ± 3.96	188.90 ± 3.87	186.45 ± 2.77	0.3793

Values in each row are a mean value of 4 replicates of each treatment.
Means within a column with different superscripts are significantly different (P < 0.05)
SEM – standard error of the means; FLW – final live weight; CW – carcass weight; NFBW – neck and front back weight; BRW – breast weight; WLW – whole legs weight; WW – wings weight; BW – back weight

The gizzard weights of the three stocking densities were not significantly different (P > 0.05) from each other but chickens in the MSD group recorded slightly higher weight compared to other two groups. Stocking densities also affected the weight of digestive tract with slightly significant differences between treatments. The highest digestive tract weight

Table 3. Effect of interaction between stocking density and sex on live body weight and carcass parameters of broiler chickens at 42-day old

Carcass parameters	Sex	Stocking density * Sex			P value
		HSD (Mean ± SEM)	MSD (Mean ± SEM)	LSD (Mean ± SEM)	
FLW, g	F	1868.70 ± 43.57	2102.00 ± 50.79	2097.75 ± 46.48	0.5177
	M	2048.75 ± 40.44	2197.40 ± 43.00	2181.50 ± 48.91	
CW, g	F	1434.39 ± 33.34	1620.98 ± 42.37	1627.65 ± 42.07	0.5515
	M	1573.73 ± 33.56	1692.47 ± 36.59	1688.68 ± 43.85	
Dressing, %	F	76.78 ± 0.39	77.05 ± 0.28	77.48 ± 0.43	0.9712
	M	76.78 ± 0.32	76.97 ± 0.32	77.30 ± 0.45	
NFBW, g	F	172.56 ± 9.77	190.34 ± 10.33	194.16 ± 10.95	0.9602
	M	173.67 ± 5.17	186.82 ± 5.90	191.64 ± 7.39	
BRW, g	F	472.50 ± 13.35	554.01 ± 17.45	548.68 ± 19.83	0.6923
	M	532.50 ± 14.90	586.04 ± 14.29	596.65 ± 17.29	
WLW, g	F	383.65 ± 9.59	430.85 ± 11.98	392.00 ± 21.89	0.4076
	M	423.98 ± 9.13	449.42 ± 9.39	444.92 ± 10.74	
WW, g	F	145.60 ± 3.98	172.24 ± 11.11	158.28 ± 4.16	0.1666
	M	164.59 ± 3.56	169.04 ± 4.71	170.53 ± 4.66	
BW, g	F	175.25 ± 7.07	182.13 ± 6.77	194.64 ± 6.36	0.9934
	M	180.00 ± 6.32	187.85 ± 7.46	198.84 ± 5.91	

Values in each row are a mean value of 4 replicates of each treatment.
Means within a column with different superscripts are significantly different (P < 0.05).
SEM – standard error of the means; HSD – high stocking density; MSD – medium stocking density; LSD – low stocking density; FLW – final live weight; CW – carcass weight; NFBW – neck and front back weight; BRW – breast weight; WLW – whole legs weight; WW – wings weight; BW – back weight; F – female; M – male

Table 4. Effect of different stocking density on edible and nonedible internal organs of broiler chickens at 42-day old

Internal organs	Stocking density			P value
	HSD (Mean ± SEM)	MSD (Mean ± SEM)	LSD (Mean ± SEM)	
HW, g	$10.95^{b} \pm 0.28$	$12.70^{a} \pm 0.37$	$12.16^{a} \pm 0.47$	0.0046
LW, g	$35.98^{b} \pm 0.94$	$41.16^{a} \pm 0.92$	$40.23^{a} \pm 0.93$	0.0003
GW, g	33.43 ± 1.44	35.42 ± 0.92	34.38 ± 0.69	0.4196
DTW, g	$103.39^{b} \pm 2.61$	$110.45^{ab} \pm 2.65$	$113.51^{a} \pm 2.73$	0.0229

Values in each row are a mean value of 4 replicates of each treatment.
Means within a column with different superscripts are significantly different (P < 0.05).
SEM – standard error of the means; HW – heart weight; LW – liver weight; GW – gizzard weight; DTW – digestive tract weight; HSD – high stocking density; MSD – medium stocking density; LSD – low stocking density

Table 5. Effect of different sex on edible and nonedible internal organs of broiler chickens at 42-day old

Internal organs	Sex			P value
	Female (Mean ± SEM)	Male (Mean ± SEM)	Female and male (Mean ± SEM)	
HW, g	$11.44^{b} \pm 0.30$	$12.43^{a} \pm 0.33$	11.94 ± 0.23	0.0293
LW, g	38.42 ± 0.80	39.82 ± 0.80	39.12 ± 0.57	0.1946
GW, g	33.30 ± 0.59	35.52 ± 1.05	34.41 ± 0.61	0.0694
DTW, g	106.00 ± 2.25	112.23 ± 2.14	109.12 ± 1.57	0.0477

Values in each row are a mean value of 4 replicates of each treatment.
Means within a column with different superscripts are significantly different (P < 0.05).
SEM – standard error of the means; HW – heart weight; LW – liver weight; GW – gizzard weight; DTW – digestive tract weight

Table 6. Effect of interaction between stocking density and sex on edible and nonedible internal organs of broiler chickens at 42-day old

Internal organs	Sex	Stocking density * Sex			P value
		HSD (Mean ± SEM)	MSD (Mean ± SEM)	LSD (Mean ± SEM)	
HW, g	F	10.36 ± 0.38	12.41 ± 0.56	11.57 ± 0.55	0.8065
	M	11.56 ± 0.38	13.00 ± 0.50	12.75 ± 0.75	
LW, g	F	34.55 ± 1.29	40.44 ± 1.47	40.28 ± 1.04	0.5334
	M	37.41 ± 1.32	41.87 ± 1.14	40.19 ± 1.56	
GW, g	F	31.41 ± 1.02	33.86 ± 1.13	34.63 ± 0.80	0.2730
	M	35.46 ± 2.64	36.98 ± 1.40	34.13 ± 1.13	
DTW, g	F	97.75 ± 3.07	107.41 ± 3.86	112.87 ± 4.08	0.4079
	M	109.03 ± 3.89	113.49 ± 3.60	114.16 ± 3.73	

Values in each row are a mean value of 4 replicates of each treatment.
Means within a column with different superscripts are significantly different (P < 0.05).
SEM – standard error of the means; HW – heart weight; LW – liver weight; GW – gizzard weight; DTW – digestive tract weight; HSD – high stocking density; MSD – medium stocking density; LSD – medium stocking density; F – female; M – male

was observed in birds at LSD. As can be seen in Table 5, the best average heart weight was observed in male chickens.

Based on the study data, it was observed that the sex had a significant effect on the heart and digestive tract weight (P < 0.05). No differences in liver and gizzard weight were recorded (P > 0.05) between male and female chickens.

The effects of the interaction between stocking density and sex on the weights of useable and non-useable internal organs are shown in Table 6. These parameters were not influenced by the interaction between stocking density and sex (P > 0.05).

Results and Discussion

The number of birds kept in a specific area is one of the most important management tools in determining the profitability of broiler production, but it is also an important welfare issue. Stocking density significantly influenced the final live weight of broiler chickens. MSD chickens were significantly (P < 0.05) heavier than HSD chickens (2149.70 vs. 1958.73 g). Despite the better final live weight of MSD chickens compared to those in the LSD group, the differences were not significant. This lower body weight from the high and low stocking densities may be due to the effects of overcrowding on limiting the space for growth and limited access to feed, which may cause nutritional deficits, or may result in higher energy expenditure and finally increased stress. Some researchers reported that birds in the highest stocking density group (Hassanein, 2011; Simitzis et al., 2012; Petek et al., 2014) had the lowest final body weight compared to those at other densities. Similar to the present study, in investigations by Sørensen et al. (2000) and Das and Lacin (2014), the stocking density significantly affected the final body weight of broilers. The chickens in the LSD treatment group had a 10.07 g lighter final body weight compared to those in the MSD group, but they were 180.90 g heavier compared with chickens in the HSD group. Results obtained from our study are also in agreement with those of Hassanein (2011) and Petek et al. (2014), who reported a significant effect of stocking density on final live weight. Even though broilers are widely grown without sexing there are several reasons that separating the sexes should be considered. In this study, male broilers had 119.74 g and 59.87 g higher mean live final weights than females and the average of both sexes respectively. This difference in the final live weight between the three stocking densities and sex could be attributed to several mechanisms, e.g., different body composition, the metabolism of the broiler chickens or the biological value of the nutrients or feed. Differences in average body weight for the male and female chickens observed in this study are in agreement with those reported by Sekeroglu et al. (2011), Olawumi and Fagbuaro (2011), Shafey et al. (2013), Namakparvar et al. (2014) and Cengiz et al. (2015), who all reported that the sex significantly influenced final live weight.

Stocking density also significantly affected carcass, breast, whole legs, wings and back weight, but not the dressing percentage and neck front back weight. Similar results have been found by Hassanein, (2011) and Simitzis et al. (2012), who reported that the carcass weight significantly decreased with increasing stocking density. However, Uzum and Toplu (2013) found that carcass weight was not affected by stocking density. In their study, chickens at LSD had a higher dressing percentage, but no significant difference was found. These results are in accordance with previous reports (Hassanein, 2011; Sekeroglu et al., 2011; Das and Lacin, 2014) stating that stocking density had no effect on dressing percentage. Gender, as well as stocking density, did not affect dressing percentage, but it affected carcass weight, which is similar to the results of Shafey et al. (2013), who reported a significant effect of gender on the weight of carcasses. The impact of sex is also observed on the weights of the breast and whole legs. Similarly, Scheuermann et al. (2003) observed a significant effect of sex on breast weight. These results are contradictory to the results obtained by Shafey et al. (2013), who reported non-significant differences in breast weight and a significant effect on the wing weight of broilers of different sexes.

On the other hand, significant differences from the interaction of stocking density and sex were observed in all carcass parameters and internal organs (Table 3 and 6). In this case, heavier hearts and livers were observed in the group of chicken reared at MSD, while heavier weight of the digestive tract is observed in the LSD chickens, so the stocking density statistically affected the weights of these organs. On the contrary, no difference in the gizzard weight was found. The findings on heart and liver weight were not consistent with those reported by Sekeroglu et al. (2011), who indicated that the stocking density had no effect on the weights of the heart and liver. The heart weight of male birds was significantly higher than that in female birds. The present results show a significant effect of sex on digestive tract weight between male and female chickens. There was no significant difference in liver and gizzard weight between male and female chickens. This finding is comparable with that reported by Beg et al. (2016) for gizzard weight but different in terms of liver weight.

Conclusions

Considering these results, it can be concluded that the weights of the final body, carcass, breast, whole leg, back, liver and digestive tract were affected by stocking density. The results also showed no negative effects of stocking density on dressing percentage, neck and front back weight, and gizzard weight. In our case, broilers grown at high density had lower carcass weight compared with those grown at medium and low stocking densities. Based on these findings and starting from the fact that the breast meat and whole leg meat made up the majority of the carcass weight, we can finally conclude that the best carcass parameters will be achieved with medium and lower stocking densities. On the other hand, the sex had a significant effect on the final live weight and in some other carcass traits. However, at slaughter, males gave better results than females and some of the parts were significantly different between the two sexes. The carcass, breast meat, whole legs, wings and back weights were significantly higher in males than in females. This study once again confirms that a high density could retard the growth rate owing to lower nutrient availability so it is therefore suggested that broiler chickens be reared with lower stocking densities, which also ensures better welfare conditions.

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