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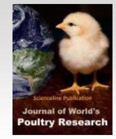

Comparison of Three Lines of Japanese Quails Revealed a Remarkable Role of Plumage Color in the Productivity Performance Determination

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ABSTRACT

The study was conducted to compare body weight, egg, and carcass characteristics, as well as several biochemical parameters amongst three lines of plumage color of quails, including, black, white, and brown (n= 200 each). Body weight was analyzed on a weekly basis throughout the study period (third– 13th week of age). Eggs were collected for seven consecutive weeks of sexual maturity (seventh – 13th week of age). In addition to egg quality measurements, 16 serum biochemical parameters were also determined. The brown line had exerted significantly higher values of body weight in most analyzed weeks of sexual maturity. It had given higher values of albumen height and shell thickness, as well as carcass dressing than other lines. Simultaneously, a significantly high number of eggs in the white line were observed in the most analyzed weeks. Besides, it had given higher values in terms of shell and yolk weights, as well as several carcass characteristics, such as the heart, thigh, breast, and back. The biochemical analyses had shown no significant differences amongst the analyzed populations with exception of a higher concentration of amylase in the brown line. In conclusion, our study revealed the presence of a clear superiority of the brown and white lines in terms of the meat and egg productivity, respectively. Therefore, we recommend breeders to raise brown and white lines for a better production of meat and eggs, respectively, whereas the black line has shown the least productive characteristics than other two lines throughout the study period.

Keywords: Eggs, Japanese quails, Line, Meat, Production, Serum

INTRODUCTION

Japanese quails (*Coturnix japonica*), are the smallest avian species raised for producing both meats and eggs. Several aspects account for the utility of this important bird, it provides an economic alternative to chickens. These birds attained a remarkable economic importance as an agricultural species that provide a special meat enjoyed for a unique flavor with a high nutritional value (Kayang et al., 2004). There are many reasons to encourage farmers to raise Japanese quails. Quails characterize with their low cost of maintenance, thus, poor people around the world are interested in rear quails on a commercial basis due to the lower initial investment (Jeke et al., 2018). They have a remarkable low risk rather than commercial broiler farming (Prabakaran, 2003). Furthermore, the early puberty, short generation interval (3-4 generation per year), and fewer feed requirements make these birds the most suitable and effective poultry which may boost farmers to go on in its production (Vali, 2008). In addition, there are several factors contribute for the utility of these birds in the scientific experiments, such as their resistance to diseases that associated with a high egg production which render these birds ideally suited for the scientific experimentations (Scholtz et al., 2009). In order to establish a breeding program, it is essential to estimate genetic parameters for improving the traits (Vali et al., 2005). A selection program not only affects the egg production traits but also the plumage color which depends upon various candidate genes and there has been a strong likelihood of linkage of various plumage color with quantitative traits that need to be explored (Delmore et al., 2016). Nevertheless, it is observed that most farmers confronted a problem to get a good quality commercial quail chicks (Nasar et al., 2016). Plumage color has been reported to significantly associate with body weight and abdominal fat, and egg characteristics (Minvielle et al., 1999). Add to that, information about growth performance and plumage color mutations are insufficient to assess their use in commercial production. The approach of the desired improvement strategy could be performed by making a direct comparative study among several lines of quails (Inci et al., 2015). Noteworthy, the plumage color phenotype draws the attention of recent genotyping studies as it is the main reactive manifestation of the complicated genetic composition of Japanese quails (Badyaev et al., 2017). However, the plumage color mutants in Japanese quail have received little attention. This is due to the limited number of stock available in different countries. The performance of the blood biochemical features with bird performance is needed to select the best characteristics to improve the production and health traits (Baylan, 2017). Therefore, the present study was conducted to assess the main productive traits amongst three different plumage color lines in terms of egg and meat which are the main focus of the current study. As well, the blood biochemical analysis is also highlighted too, which may collectively build a beneficial view for breeders to select the most appropriate line for their productivity ambitions.

MATERIALS AND METHODS

Experimental design

Initially, a total of 600 Japanese quails (*Coturnix japonica*) of two weeks of age were included in the study. The included birds belong to three morphologically different lines, in terms of plumage color, namely black, or dark brown (n=200), white (n=200), and brown or wild-type, (n=200) lines (Figure 1). All three lines were purchased at two weeks of age from the directorate of agricultural research/ministry of agriculture, Baghdad, Iraq. Birds were kept under the same management conditions throughout the study at the poultry research farm of Al-Qasim green university, Iraq. Quails were housed in battery cages according to their line (Manafi, 2018). The birds were raised under the same living conditions and received the same feed. According to the National research council (1994), a standard diet containing 240g crude protein/kg and 12.1 MJ (Megajoules) of ME (Metabolized Energy)/kg as well as water was provided *ad libitum* during the rearing period. The temperature of the quails' house was around 20ºC. A lighting schedule of 16 hours light and 8 hours of darkness was applied with an intensity of five lux throughout. Farm bio-security and standard hygienic precautions were maintained strictly to prevent the outbreak of any potential infection. Sex determination was performed by observing the cloaca and breast plumage color in the sixth week (Alkan et al., 2008). On this week, all males were excluded from the study (n=377), and all females were housed individually in laying cages. Then, a total of 223 of sexually mature females were screened in the study, including black (n 54), white (n 84), and brown (n 85).

Figure 1. The investigated three quails, including black, white, and brown populations (left to right, respectively) in the present study of both sexes that photographed at the second week of age at December-2017, Babil, Iraq

Productive data recording

Due to the low level of quail's domestication (Jone et al., 1994), all data of egg production were recorded only in the period third – 13th weeks of age. Regarding live body weight, the recording of this feature was performed on weekly basis on both sexes in the period third – sixth weeks of age. Subsequently, the recording of live body weight at the sexual maturity was restricted only on the separated females (n 223). Then, both egg weight and number for each line were identified by quails' number on weekly intervals (seventh– 13th weeks). Albumen weight, albumen height, yolk weight, yolk height, shell weight, and shell thickness characteristics were measured at the 13th week of age. Subsequently, all quails were slaughtered at the end of the 13th week of age. After slaughtering, evisceration, and defeathering, carcass traits including carcass weight and other body organs, including gizzard, liver, heart, thigh, breast, neck, back, wings were measured in carcasses.

Biochemical data recording

After slaughtering birds at the 13th week of age, blood samples were collected by cervical dislocation and were then decapitated. Subsequently, blood sera were initially prepared according to the procedure mentioned by Scholtz et al. (2009). The main serum biochemical parameters, including albumen, total protein, Globulin (GLOP), Albumen/Globulin (A/G), Total Bilirubin

(TBIL), Aspartate Aminotransferase (AST), Alanine Transaminase (ALT), Alkaline Phosphatase (ALP), Amylase (AMYL), Creatinine (CREA), Creatine Kinase (CK), Total Cholesterol (TC), Triglyceride (TG), High Density Lipoprotein (HDL) and Low Density Lipoprotein (LDL), were recorded according to the manufacturer's instructions (Chengdu Pulitai Biological techn. Co., Hi-tech, China). All biochemical experiments were performed in a fully automated hematological analyzer (Methic 18 Vet, Orphee, France).

Statistical analysis

The collected data were analyzed by general linear model procedure of SAS statistical package software (Statistical Analysis System, 2012). Least significant differences for a parameter were used to calculate the significant difference amongst three lines of quail. The following general linear statistical model was used to analyze the different parameters:

$Y_{ij} = \mu + t_i + e_{ij}$,

Where

Y_{ij} is the dependent variable of the experiment;

μ is the overall mean;

t_i is the effect of *ith* type (i = 1-3);

e_{ij} is the error term specific to each record.

The differences between the means were statistically estimated by ANOVA – Duncan's test. All values were expressed in mean standard error (SE) using a significant level of $P < 0.05$ and $P < 0.01$.

Ethics approval

All procedures involving animals were approved by the animal care and use committee at the respective university where the experiments were conducted (dated 11-22-2017, Decision No. 134).

RESULTS

Body weight

Regarding the first four weeks of raising (third week – sixth week), in which both sexes were recorded, our results had revealed no superiority for any one of the three lines. Subsequently, a remarkable difference was observed regarding the overall superiority of brown lines after separating both sexes from each other. With exception to the sixth week, in which the black line had higher body weight values, our results had shown significantly higher values ($P< 0.01$) for brown line females in most of the analyzed weeks than other two studied lines, black and white, respectively (Table 1).

Egg number and weight

The present study found significantly higher values for egg number and weight ($P<0.01$) in the white line in almost all studied weeks (Table 2). The only one exception for this observation is the higher values that were seen in the eighth week in which the brown line had significantly ($P< 0.01$) superseded the other two lines in both egg weight and number. However, a total clear superiority of white line was observed in terms of egg weight and number.

Egg external characteristics

Upon examining the effect of line differences on other recorded parameters, such as albumen weight and height, yolk weight and height, shell weight and thickness, an obvious competition was observed between both white and brown lines. This competition was presented by the observation of higher values for albumen height ($P< 0.01$) and shell thickness ($P< 0.05$) in the brown line, while the white line had exhibited higher values for yolk weight and shell weight ($P< 0.01$ each) (Table 3). Simultaneously, no significant differences were observed in the other analyzed traits, such as egg weight, and yolk height. The proportion of yolk weight in white line eggs is significantly higher than those found in the other two lines ($P< 0.01$). This observation was accompanied by a parallel high shell weight found in the same line.

Carcass traits

It was observed from the result of this study that color variation had a significant effect on several carcass traits. This observation was exhibited in the white line as it had shown highly significant values ($P<0.01$) in the thigh, breast, and back than other two lines (Table 4), while the brown line had given higher values in carcass dressing traits.

Biochemical criteria

The results of biochemical analyses are presented in table 5. With one exception observed in the amylase levels, in which highly significant values ($P< 0.01$) of this enzyme was recorded in the brown line, other serum biochemical parameters had shown no significant differences ($P\geq 0.01$) amongst other serum parameters, including albumen, total protein, GLOB, A/G, TBIL, AST, ALT, ALP, AMYL, CREA, Urea, CK, TC, TG, HDL, and LDL.

Table 1. Mean live body weight in grams recorded for different production weeks in three lines of quails. This experiment is extended from December-2017 to March-2018, Babil, Iraq

Variables / Sex	Line	Mean ± SE										
		third week M+F	**fourth week** M+F	**fifth week** M+F	**sixth week** M+F	**Seventh week** F	**eighth week** F	**ninth week** F	**tenth week** F	**11th week** F	**12th week** F	**13th week** F
BW	Black	$84.09^{b}\pm14.1$	$124.12^{b}\pm14.1$	$168.88^{ab}\pm14.1$	$226.41^{a}\pm14.1$	$194.71^{b}\pm14.1$	$218.492^{ab}\pm14.1$	$245.680^{a}\pm14.1$	$252.9^{a}\pm14.1$	$261.86^{ab}\pm14.1$	$272.60^{ab}\pm14.1$	$283.11^{ab}\pm14.1$
	White	$86.04^{a}\pm14.1$	$124.02^{b}\pm14.1$	$163.4^{b}\pm14.1$	$193.4^{b}\pm14.1$	$195.4^{b}\pm14.1$	$202.5^{b}\pm14.1$	$235.7^{b}\pm14.1$	$248.5^{b}\pm14.1$	$256.2^{ab}\pm14.1$	$263.9^{b}\pm14.1$	$267.6^{b}\pm14.1$
	Brown	$87.1^{a}\pm14.1$	$128.9^{a}\pm14.1$	$170.2^{a}\pm14.1$	$199.1^{b}\pm14.1$	$215.9^{a}\pm14.1$	$229.6^{a}\pm14.1$	$246.04^{a}\pm14.1$	$248.1^{b}\pm14.1$	$274.1^{a}\pm14.1$	$287.7^{a}\pm14.1$	$294.0^{a}\pm14.1$
Level of significance		NS	NS	NS	**	**	**	**	NS	**	**	**

Significant differences in means represented by different letters in the same column. BW; Body Weight, SE; Standard Error, *; (P<0.05), **; (P<0.01), NS; Non-Significant, M; male, F; female

Table 2. Mean egg numbers and weights in grams, for different production weeks in three lines of quails. The experiment is extended from January to March 2018, Babil, Iraq

Phenotypes / Traits	Line	Mean ± SE						
		Seventh week	**Eighth week**	**Ninth week**	**Tenth week**	**11th week**	**12th week**	**13th week**
EN	Black (54)	39.685a±1.961	35.963b±1.915	25.481b±3.321	31.056b±2.401	36.148ab±2.030	28.685b±1.500	19.130b±0.984
	White (84)	38.548a±1.573	38.548ab±1.536	59.250a±2.663	55.798a±1.925	52.429a±1.627	38.048a±1.203	31.560a±0.789
	Brown (85)	36.800a±1.563	53.800a±1.527	32.400ab±2.647	38.400ab±1.914	32.800b±1.618	32.200ab±1.196	22.600ab±0.785
Level of significance		NS	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**
EW	Black (54)	94.348b±8.036	341.389ab±16.573	240.463b±34.003	340.093b±24.351	361.574ab±23.203	282.500b±15.897	216.111b±10.339
	White (84)	262.536a±6.444	262.536b±13.288	611.190a±27.263	567.952a±19.524	577.107a±18.604	383.631a±12.746	342.679a±8.290
	Brown (85)	229.000ab±6.406	521.400a ±13.209	321.000ab±27.102	403.000ab±19.409	342.000b±18.494	323.400ab±12.671	259.000ab±8.241
Level of significance		**	**	**	**	**	**	**

EN; eggs number, EW; eggs weight, SE; Standard Error, *; (P<0.05), **; (P<0.01), NS; Non-Significant, significant differences in means represented by different letters in the same column

Table 3. External and internal egg quality traits of 13-week-old in quail lines, the studied traits include albumin weight, albumin height, yolk weight, yolk weight, shell weight and shell thickness. The experiment is performed at March-2018, Babil, Iraq

Lines / Traits	Mean ± SE					
	AW (g)	**AH (mm)**	**YW (g)**	**YH (mm)**	**SW (g)**	**ST (mm)**
Black (54)	11.405±0.163	31.235±0.146b	3.718±0.135b	21.824±0.167	1.177±0.040b	0.156±0.055b
White (84)	11.434±0.131	32.677±0.117ab	4.372±0.108a	21.966±0.134	1.348±0.032a	0.168±0.044ab
Brown (85)	11.420±0.130	33.320±0.116a	3.909±0.107ab	21.762±0.133	1.236±0.032ab	0.288±0.044a
Level of significance	NS	**	**	NS	**	*

AW; albumin weight, AH; albumin height, YW; yolk weight, YH; yolk height, SW; shell weight, ST; shell thickness, SE; Standard Error, * ;(P<0.05), **; (P<0.01), NS; Non-Significant, significant differences in means represented by different letters in the same column. AW; albumin weight, AH; albumin height, YW; yolk weight, YH; yolk height, SW; shell weight, ST; shell thickness

Table 4. Comparison of the average carcass characteristics of 13-week-old in quail lines. The experiment is performed at March-2018, Babil, Iraq

Carcass traits / Lines	Quail lines (Mean ± SE)			Level of significance
	Black (n=54)	**White (n= 84)**	**Brown (n= 85)**	
Carcass weight (g)	114.982 ± 5.188 a	130.570 ± 5.188 a	116.122 ± 5.188 a	NS
Gizzard % of carcass	5.046 ± 0.609 a	5.262 ± 0.609 a	4.656 ± 0.609 a	NS
Liver % of carcass	7.620 ± 0.264 a	8.018 ± 0.264 a	6.234 ± 0.641 a	NS
Heart % of carcass	1.718 ± 0.641b	2.084 ± 0.641ab	1.504 ± 0.264 b	**
Thigh % of carcass	34.256 ± 1.593 b	40.274 ± 1.593a	35.842 ± 1.593 ab	**
Breast % of carcass	49.698 ± 2.345 b	57.942 ± 2.345 a	51.576 ± 2.345 ab	**
Neck % of carcass	6.344 ± 0.549 a	6.410 ± 0.549 a	5.302 ± 0.549 a	NS
Back % of carcass	12.974 ± 1.477 ab	13.694 ± 1.477 a	8.276 ± 1.477 b	**
Wings % of carcass	9.226 ± 1.441 a	10.326 ± 1.441 a	12.836 ± 1.441 a	NS
Carcass dressing (%)	247.476 ± 15.198 ab	205.152 ± 15.198 b	256.116 ± 15.198 a	**

SE; Standard Error, *; (P<0.05), ** ;(P<0.01), NS; Non-Significant, significant differences in means represented by different letters in the same column

Table 5. Serum biochemical parameters (mean ± standard error) of 13-week-old in quail lines. The experiments are performed at March-2018, Babil, Iraq

Parameters / Lines	Quail lines (Mean ± SE)			Level of significance
	Black (n=54)	**White (n=84)**	**Brown (n=85)**	
Albumin (g/L)	12.133 ±1.475	9.000±1.475	11.533±1.475	NS
Total protein (g/L)	30.400 ± 2.246	28.000 ± 2.246	33.367 ± 2.246	NS
GLOB(g/L)	30.933 ± 0.038	30.100 ± 0.038	32.633 ± 0.038	NS
A/G	11.617 ± 1.232	15.000 ± 1.232	10.540 ± 1.232	NS
TBIL(μmol/L)	127.033 ± 6.111	112.867 ± 6.111	92.600 ± 6.111	NS
AST (U/L)	302.000 ± 49.879	257.333 ± 49.879	268.000 ± 49.879	NS
ALT (U/L)	7.000 ± 1.673	6.667 ± 1.673	9.667 ± 1.673	NS
ALP(U/L)	94.333 ± 40.159	99.000 ± 40.159	93.667 ± 40.159	NS
AMYL(U/L)	128.333 ± 12.597	94.000 ± 12.597	262.000 ± 12.597	**
CREA(μmol/L)	30.833 ± 3.340	32.867 ± 3.340	39.667 ± 3.340	NS
Urea(mmol/L)	1.240 ± 0.014	1.243 ± 0.014	1.003 ± 0.014	NS
CK(U/L)	1035.333 ± 38.679	926.333 ± 38.679	810.333 ± 38.679	NS
TC (mmol/L)	7.530 ± 0.770	7.910 ± 0.770	5.477 ± 0.770	NS
TG (mmol/L)	6.343 ± 0.036	6.047 ± 0.036	6.803 ± 0.036	NS
HDL (mmol/L)	1.947 ± 0.030	1.720 ± 0.030	1.423 ± 0.030	NS
LDL (mmol/L)	5.583 ± 0.479	6.190 ± 0.479	4.053 ± 0.479	NS

Significant differences in means represented by different letters in the same column, SE; Standard Error, *; (P<0.05), **; (P<0.01), NS; Non-Significant, GLOB; globulin, A/G; albumin: globulin, TBIL; total bilirubin, AST; aspartate aminotransferase, ALT; alanine transaminase, ALP; alkaline phosphatase, AMYL; amylase, CREA; creatinine, CK; creatine kinase, TC; total cholesterol, TG; triglyceride, HDL; high density lipoprotein, LDL; Low density lipoprotein

DISCUSSION

In the present study, a comparative evaluation of three lines of quails was performed to assess the best one in terms of egg and meat as well as biochemical characteristics. Accordingly, several measurements were observed, such as body weight, egg number, weight, external characteristics, carcass traits, as well as biochemical criteria. These cumulative measurements can potentially provide a concrete basis for choosing the appropriate egg/meat productive line that suits the desired breeders' demands.

Body weight

Several researchers were relatively agreed with present findings of body weights values as they indicated a relatively high body weight for the brown line than other analyzed lines (Petek et al., 2004; Minvielle et al., 2005; Yilmaz and Çağlayan, 2008; Sogut et al., 2015). These values are in agreement with the reports that stated the body weights were significantly influenced by different types of color mutants or varieties of quails (Rahman et al., 2010). On the other hand, the present study showed an obvious tendency of weight superiority toward the brown line that was clearly observed only after sexual maturity. This observation indicated that there is a potential interaction between gender type, plumage color, and body weight as the superiority of the brown line is highlighted only in females after two sex's separation. In agreement with our results, several reports were suggestive that the body weight was affected by the gender of the bird (Khaldari et al., 2010; Akbarnejad et al., 2015). However, the higher body weight values for brown line indicates a preferable tendency for the meat type quail production for the brown line of quail other than the two studied lines.

Egg number and weight

The present study revealed a remarkable role for plumage color in the egg number and weight characteristics. This observation came in line with a series of accumulated results that found significant differences in egg weight among different lines of quail (Ashok and Reddy, 2010). Another confirmation of this finding came from other reports that observed that egg production had significantly differed by the different lines of quails (Soliman et al., 2000; Rahman et al., 2010). However, the determination of the best plumage color line in terms of egg productivity is quite controversial among the published data. In contrast to our present results, in which we have observed a clear superiority of the white lines in both egg number and weight, Yilmaz and Çağlayan (2008), have revealed that the eggs of the white line had weighed significantly less than those of the other groups, while no significant differences between these lines and other studied lines were observed. Similarly, Ashok and Reddy (2010) have shown that the brown line has exhibited high values of egg weight, while the black lines have shown significant ($P<0.05$) superiority in terms of egg number. Conversely, Faruque et al. (2013) have reported that the egg weight of white line has higher percentage values than the other lines. Furthermore, any possible correlation between plumage color and egg characteristics was refuted by Farghly et al. (2015). No easy explanation for these differences is feasible, but the variation in the environmental conditions and sampling error due to limited sample size could not be excluded from such explanation (Prado-Gonzalez et al., 2003). Regarding live body weight and egg productivity, the present study indicated the presence of a prominent negative correlation between body weight and egg production. This correlation is obviously seen in the brown and white line as the brown line exhibited higher values of body weight and parallel lower values for egg productivity in comparison with the white counterpart that showed the opposite characteristics. This negative correlation has been widely confirmed in several quail variations (Silva et al., 2013; Baylan, 2017).

Egg external characteristics

Up to our knowledge, there was no published data revealed by other researches so as to compare our results with. However, the present study has clearly observed that the proportion of yolk in the white line eggs is larger ($P< 0.01$) than those in other lines, which may be correlated with their higher values of the egg weight (Ahn et al., 1997).

In the case of the shell thickness and albumen height, significantly higher values were exerted in the brown line. This observation was not revealed by Inci et al. (2015) who found that there were no significant differences among the several quail lines with regard to shell thickness. However, as well as the albumen height is an important trait and it is feasible to improve egg quality through, the eggs with higher albumen height tend to have better internal egg quality (Khawaja et al., 2013). This observation potentially indicates that the brown line has presented a better albumen quality than white and black lines, respectively. However, the present data were not in agreement with Yilmaz and Çağlayan (2008) who stated through recording the egg-shape index characteristics the absence of any significant differences among the studied lines of Japanese quails.

Carcass traits

Strain type is one of the factors affect carcass quantity and quality in Japanese quail (Kumari et al., 2008). Furthermore, the growth performances of carcass traits of Japanese quails raised under different conditions were compared (Inci et al., 2016). However, several variations were recorded in the studied lines in several carcass traits, which indicate an effective role for these variable lines in such characteristics. The observed variations of the present study appeared in the superiority of the white line in several internal organs values, including heart, thigh, breast, and back. Our results were in agreement with a recent study that reported an obvious superiority of white line in several productive features including carcass weight (Nasr et al., 2017). Simultaneously, our finding exhibits an obvious superiority for the brown line in terms of carcass dressing, then the other two studied lines. The recorded higher values of carcass dressing characteristics of the brown line that observed by Inci et al. (2015), came in line with our findings of this wild-type line. However, the clear superiority of the brown line in terms of carcass dressing may be correlated with its significantly higher values of body weight. Thus, this observation gives us another indication for the higher tendency of the brown line for meat production.

Biochemical criteria

The biochemical analyses are valuable tools for evaluating traits in breeding for high productivity and as indicators for the health of birds (Karesh et al., 1997). With few exceptions, the present study found no significant differences amongst the studied three lines in almost all biochemical criteria. Unfortunately, a few published data regarding biochemical records of this bird were available (Scholtz et al., 2009), which limit the comparison issue. This limitation may be due to the small size and the highly mobile nature of this bird that increase the technical difficulty of the sample collection (Sokół et al., 2015). Nevertheless, the present study has provided comparable concentration with regard to albumen, total protein, AST, urea, TC, and TG and similarly higher concentrations regarding ALT and CK than the concentrations observed by other related reports in quails (Saki et al., 2017). The reason behind these variations is unknown but it could be attributed to the type of the population, and the method of estimation that may deviate the observed data to some extent (Falconer and MacKay, 1996). However, the present results have come in line with Khawaja et al. (2013), who found a non-significant (P> 0.05) difference in blood glucose, triglyceride, cholesterol, calcium, protein, uric acid and ALP values among all chickens. The present study has suggested that the genotype of plumage color has intervened with the amylase level among the three analyzed lines of quail. This intervention was presented by the presence of significantly higher values of amylase level in the brown line. However, this observation may suggest a potential role for amylase concentration in the current comparative study among three genotypically different lines of quails. This suggestion may be aided by Brzęk et al. (2013), who have shown that the pancreatic enzymes in birds are regulated under a strict genetic control.

CONCLUSION

In the light of the obtained results, it can be stated that both white and brown lines had, in general, higher values of productivity compared with the black line. It can be determined from the present findings that the performance of white quails was superior in terms of egg production, and several carcass traits, while the brown line has been characterized with higher body weight and carcass dressing, as well as several biochemical parameters and increased egg-shell thickness. Since the white line was clearly shown highly significant values in terms of egg number and weight, the present study recommends it in terms of high egg production purposes. Similarly, this study recommends the brown line in the meat type production purposes. In contrast to brown and white, the black line was not currently recommended in terms of egg and meat production.

DECLARATIONS

Acknowledgments

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Competing interests

The authors declare that they have no competing interests.

Author's contributions

All the authors have made a substantive contribution to the study.

Consent to publish

All the authors gave their informed consent prior to their inclusion in the study.

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