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GROWTH PERFORMANCE, CARCASS TRAITS AND ECONOMIC VALUES OF PEKIN, MUSCOVY, AND MULARD DUCKS

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Abstract: This study aimed to reconnoiter breed variations in productivity, traits of carcass, economic rate, and IGF-1 gene regulation for meat production among Pekin, Muscovy, and Mulard ducks. A 10-week trial was conducted, using 120 ducklings (2-week old) that were divided into three groups based on breed. Each breed was kept in a separate group, divided into four replicates of 10 birds each. Muscovy ducks exhibited superior body weight, weight gain, feed conversion ratio, dressing and breast percentage compared to the other breeds (P<0.001). The highest percentage of crude protein was observed in the meat of Mulard ducks leg (23.17) and breast (50.55), and in Muscovy breast meat (51.04). Pekin ducks yielded a significantly higher (P<0.001) leg and breast fat content (6.27, 6.40 respectively) than Muscovy (4.58, 4.26 respectively) or Mulard ducks (4.13, 3.88 respectively). Notably, Muscovy ducks in comparison to the other breeds yielded the highest gross margin ($1.12) and lowest budget to produce 1kg of live body weight ($2.08) ($P$= 0.004). Furthermore, hepatic IGF-1 and IGF1R expression was higher in the Muscovy breed than in the other breeds. These genes increase the growth and development of muscles. Therefore, the Muscovy ducks are generally superior in terms of performance, carcass traits, and economic values.

Key words: duck breeds; performance; carcass merits; costs; IGF-1; IGF-1R

Introduction

Ducks have been consumed sporadically in the past, but are now reared both intensively and commercially. They are primarily reared for meat and eggs, although their feathers also have economic value. Duck meat is comparable to that of chicken and is an alternative source of protein, minerals, and other nutrients for humans. In comparison to chickens, ducks are better adapted to varying environmental conditions, require less care, and are more resistant to a number of diseases (1). These characteristics likely form the basis for the increasing importance and popularity of the duck industry. Some of the popular duck breeds raised for meat production under Egyptian conditions include the Pekin, Muscovy, and Mulard.

The Pekin duck is commonly bred for meat production in Egypt. Improvements in White Pekin strains take advantage of the duck's natural ability to grow rapidly and its resistance to infections to which other poultry are susceptible. Thus, producers are able to reduce input costs while improving carcass quality and

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feathering. Genetic improvements have now caused the modern domestic White Pekin to surpass the broiler breeds of chicken in feed efficiency and weight gain at a similar living market weight (2). On the other hand, Muscovy ducks are very popular because they adapt well to various rearing conditions and they have high breast meat with unique taste and least calorie content (3) in comparison to Pekin ducks. The Mulard (hybrid of Muscovy and Pekin ducks) has been used for production of fattened liver as well as for meat production (4,5). Their carcasses are characterized by a high proportion of breast and leg muscle and low proportion of subcutaneous fat.

Economic traits such as carcass traits and growth performance are very significant in duck production. These traits are controlled by sets of candidate genes which play an important role in ducks growth and development as the insulin-like growth factors genes (IGF-1 and IGF-2). The IGF-1 has the potential to be a key regulator of growth, body composition and skeletal traits during postnatal development (6), whereas IGF-2 reportedly functions primarily during embryonic growth and development (7). Therefore, this study was carried out to evaluate performance, carcass merits, economic values, and IGF-1 and IGF1R gene regulation in Pekin, Muscovy, and Mulard ducks reared under Egyptian subtropical conditions

Material and methods

Experimental design, diets, and husbandry of duck flock:

A total of 120 male, two weeks old Muscovy, Pekin, and Mulard ducklings (40 each) of uniform body weight were used in this study. Each breed was reared until the age of 12 weeks and maintained as separate groups, divided into four replicates with 10 ducklings each. A wing band was used to label each duck. During the experiment, water and feed were supplied *ad libitum*. Starter diets with 20% crude protein (from 2 to 7 weeks) and

Table 1: Ingredients and chemical composition of experimental diets fed to ducks

Items	Starter (2–7 weeks)	Grower/Finisher (8–12 weeks)
Ingredients (g/kg)		
Yellow corn	570.0	600.0
Soybean meal, 44%	315.0	295.0
Corn gluten, 60%	65.0	30.0
Soybean oil	6.0	30.0
Calcium carbonate	8.0	13.0
Dibasic calcium phosphate	26.0	20.0
Sodium chloride	5.0	5.0
Premix[1]	3.0	3.0
DL- Methionine, 98%	1.0	2.0
L-lysine, 78%	1.0	2.0
Calculated chemical composition[2]		
ME, MJ	12.12	12.56
CP, %	20.34	17.84
EE, %	4.39	6.80
CF, %	3.50	3.37
Ca, %	0.92	0.95
Available Ph, %	0.58	0.45
Lysine, %	1.13	1.18
Methionine, %	0.41	0.50

[1]Supplied per kg of diet: Vitamin A (12000 IU); Vitamin D_3 (2200 IU); Vitamin E (10 mg); Vitamin K_3 (3 mg); Vitamin B_1 (1mg); Vitamin B_2 (5 mg); Vitamin B_6 (1.5 g); Pantothenic acid (10 mg); Vitamin B_{12} (10mg); Niacin (30 mg); Folic acid (1mg); Biotin (50 mg); Fe (30 mg); Mn (60 mg); Cu (4 mg); I (1mg); Co (1mg); Se (1 mg); and Zn (50 mg); Choline chloride (300 mg).
[2] Calculated according to NRC (1994) tables.
ME = Metabolizable energy; CP = Crude protein; EE = Ether extract; CF = Crude fiber.

grower/finisher diets with 18% crude protein (from 8 to 12 weeks) were fed to the ducklings in the form of dry mash. All experimental diets were formulated to ensure an adequate supply of all nutrients according to the National Research Council (8) recommendations for duck breeds (Table 1).

Ducks of all groups were kept under similar management conditions and housed in pens with similar floors (5 birds/m^2) covered with a 5-cm thickness of wood shavings as bedding. The temperature of the houses was maintained at 25°C, and continuous light was provided from the 2nd week until the end of the study. All ducklings were vaccinated by live attenuated vaccines against duck cholera (1 ml/duckling, subcutaneous), duck plague (0.5 ml/duck, intramuscular), and duck virus hepatitis (1 ml/duck, intramuscular) at the age of 28, 46 and 50 days, respectively. The animal experiment protocol was approved by the Institutional Animal care and Use committee at Zagazig University. The experiment was conducted at the research farm of Poultry and Rabbit, Faculty of Veterinary Medicine, Zagazig University, Egypt.

Growth performance

Final live body weight (LBW) was recorded and body weight gain (BWG), average feed intake (AFI), and feed conversion ratios (FCR) were calculated at the end of experiment. The feed was withdrawn before birds weighing for 2h. Feed conversion was calculated as g feed/g gain. LBW and BWG were evaluated based on individual bird data, whereas AFI and FCR were assessed based on the replicate unit.

Sample collection, carcass traits, and meat analysis

Eight ducks from each studied breeds (two from each replicate) were selected according to an average body weight for the respective breed and fasted for 12h before slaughtering. The birds were marked with individual numbers, weighed, and euthanized by cervical dislocation before being manually defeathered and eviscerated. The giblets (liver, gizzard, and heart), eviscerated carcass, breast and thigh muscles were weighed and their percentages relative to live body weight were calculated.

After slaughter, the liver was weighed and two 1-cm sections were immediately resected, gently flushed with PBS, and stored at -80°C until mRNA extraction. Samples of breast and thigh meat of selected individuals were also resected, dried, ground, and subjected to proximate analysis to determine crude protein, moisture, total ash, and fat content. Samples were investigated using standard procedures (9).

IGF-1 and IGF1R gene expression in liver by Real-Time PCR

RNA from the liver samples was extracted using a QIAamp RNeasy Mini kit (Qiagen, Germany) according to the manufacturers' instructions. A GeneQuant spectrophotometer (Pharmacia Biotech, Freiburg, Germany) was used to estimate purity and concentration of RNA. Complementary DNA (cDNA) was obtained by reverse transcriptase of RNA using a RevertAid Reverse Transcription kit (Thermo Fisher). Real-time PCR analysis was performed using QuantiTect® SYBR® Green PCR kit (Qiagen, Germany), with β-actin as the internal control gene. Gene-specific primer sequences F1:CAACGAGCGGTTCAGGTGT, R1:TGGAGTTGAAGGTGGTCTCG, F2: ATCCAGCAGTAGACGCTTACACC, R2: CGTGCAGACTTAGGTGGCTTTA and F3: GGTATTCCACCTCACTCTCCT, R3: AACTTCCTTCACAACTCCATCT were used to amplify 92 bp of Duck β-actin, 117 bp of IGF-1, and160 bp of IGF1R (10).

The qRT-PCR was carried out in 25µl volume of 12.5 µl of 2× QuantiTect SYBR Green PCR Master Mix; 0.5 µl of each primer, 0.25 µl of RevertAid Reverse Transcriptase (200 U/µL); 3 µl of the template and 8.25 µl of nuclease free water. The cycling was programmed as follows: 95°C for 5 min; followed by 40 cycles of 15s at 95°C, 15s at 60°C, and 15s at 72°C. Melt-curve analysis was performed between 65°C to 95°C, using increments in temperature of 0.5°C.

Ct values for the SYBR green RT-PCR were measured using Stratagene MX3005P software

(Stratagene Technical Services, USA). To calculate the variation in gene expression in the RNA of various samples, the Ct of each sample was compared with that of the Pekin breed as a reference (the lowest growth breed) according to the "ΔΔCt" method outlined by Yuan et al. (11).

Economic values of duck breeds

The economic value of the breeds under investigation was evaluated using cost-benefit analysis, by estimating the total variable costs (TVC), gross income for live weight, gross margin, and benefit–cost ratio (BCR). Total variable costs were estimated by considering the cost incurred in obtaining the ducklings, as well as the expenses of feed, litter, labor, veterinary services, electricity, and other miscellaneous expenditure. Fixed costs were not included in the analysis, because they were equal across all breeds. Gross margin analysis was used to determine profitability of the breeds, as described by Olukosi and Erhabor (12). The unit of measurement was USD/kg live weight. The following equation was used to derive gross margin: GM= GI – TVC, where GM= gross margin; GI= gross income/kg live weight; and TVC= total variable cost that represents the total cost of production/kg live weight. The benefit–cost ratio (BCR) was derived by the following formula: GM/TVC.

Statistical analysis

All statistical analyses were performed using SPSS V.16 software (SPSS, IL, USA). Data were analyzed using one-way ANOVA, after normality was verifying using the Kolmogorov–Smirnov test. The Tukey's (HSD) multiple comparison test was used to determine significant differences between mean values. Variability in the data was expressed as the pooled SEM, and the alpha level for determination of significance was set at 0.05.

Results

Growth performance

As shown in Table (2), the Muscovy breed showed the greatest final BW (3903.75) and BWG (3659.65) followed by the Mulard (3518.52 and 3267.42, respectively) and Pekin (3355.00 and 3117.20, respectively). In addition, AFI and FCR were significantly declined in Muscovy breed compared to the other breeds. However, no significant change was detected between the Pekin and the Mulard.

Table 2: Growth performance of Muscovy, Pekin, and Mulard ducks

Parameter	Breed			SEM	*P*-value
	Muscovy	Pekin	Mulard		
Initial BW (g)	244.10	237.80	251.10	2.53	0.098
Final BW (g)	3903.75^{a}	3355.00^{c}	3518.52^{b}	27.05	< 0.001
BWG (g)	3659.65^{a}	3117.20^{c}	3267.42^{b}	28.36	< 0.001
AFI (g)	10744.90^{b}	11336.00^{a}	11240.61^{a}	84.16	< 0.001
FCR (g feed: g gain)	2.94^{b}	3.64^{a}	3.44^{a}	0.09	< 0.001

BW: Body weight, BWG: Body weight gain, AFI: Average feed intake, FCR: Feed conversion ratio
$^{a–c}$Means bearing different superscript letters within the same row are significantly different (P<0.05).
SEM: Standard error of means.

Carcass traits and meat composition

Carcass traits of the various breeds are summarized in table 3. The results revealed that the dressing percentage of Muscovy ducks (75.20) was highly significant (P< 0.001) than that of Mulard or Pekin ducks (73.73, 72.41 respectively). Both Muscovy and Mulard ducks possess a higher relative breast weight (51.04, 50.55 respectively) compared to Pekin ducks (49.39). The relative thigh weight differed significantly among the breeds, with the Muscovy breed yielding the highest values (P = 0.001). Differences in the percentages observed

Table 3: Carcass traits and meat composition of Muscovy, Pekin, and Mulard ducks

Parameter	Breed			SEM	*P*-value
	Muscovy	Pekin	Mulard		
Carcass characteristics					
Dressing %	75.20[a]	72.41[c]	73.73[b]	0.30	< 0.001
Breast %	51.04[a]	49.39[b]	50.55[a]	0.20	< 0.001
Thigh %	24.16[a]	23.02[b]	23.17[b]	0.16	0.001
Heart %	0.66	0.65	0.68	0.01	0.163
Liver %	2.36[b]	2.26[b]	3.34[a]	0.15	< 0.001
Gizzard %	2.35	2.39	2.07	0.08	0.179
Breast meat composition					
Moisture %	74.32[a]	71.53[b]	74.73[a]	0.38	< 0.001
Protein %	19.21[a]	17.41[b]	19.64[a]	0.26	< 0.001
Fat %	4.26[b]	6.40[a]	3.88[b]	0.29	< 0.001
Ash %	1.31	1.26	1.21	0.02	0.125
Thigh meat composition					
Moisture %	73.46	72.04	73.14	0.33	0.188
Protein %	17.52[b]	17.26[b]	19.08[a]	0.22	< 0.001
Fat %	4.58[b]	6.27[a]	4.13[b]	0.22	< 0.001
Ash %	1.12	1.04	1.09	0.02	0.253

[a–c]Means bearing different superscripts within the same row are significantly different (*P*<0.05). SEM: Standard error of means.

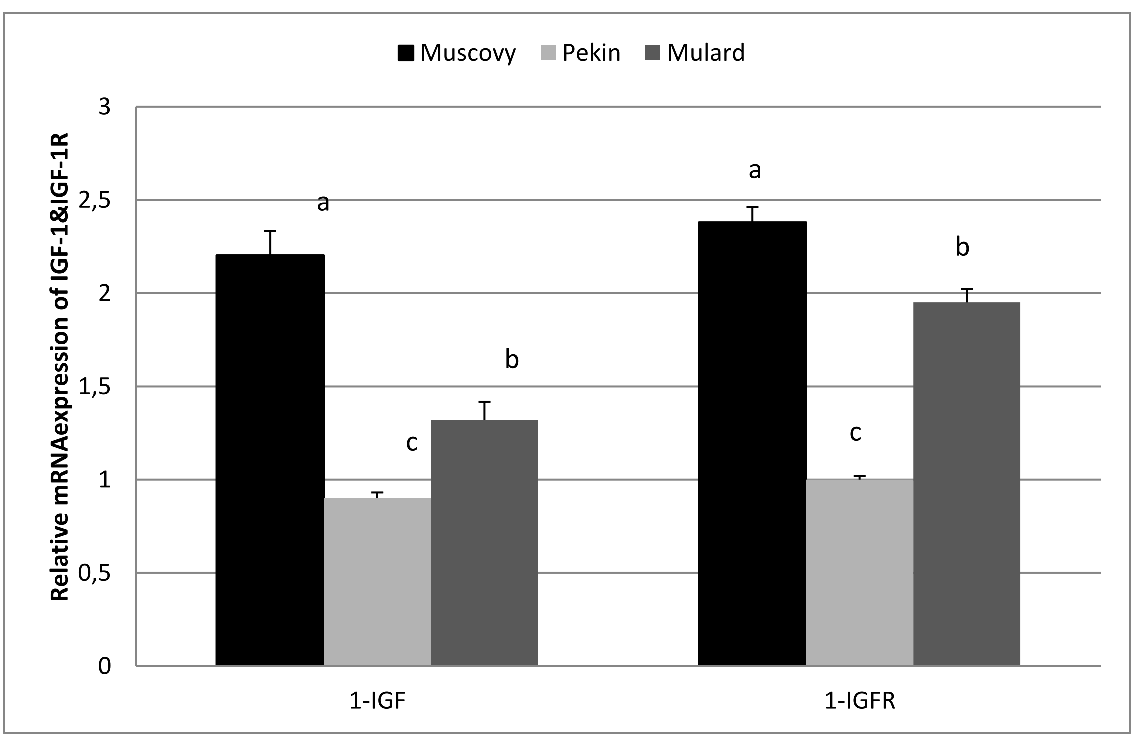

Figure 1: Quantitative expression of IGF-1 and IGF1R extracted from the liver of various duck breeds (mean ± SEM) after 10 weeks. Groups with different letters are significantly different (*P*< 0.05, one-way ANOVA)

Table 4: Economic values for Muscovy, Pekin, and Mulard ducks

	Breed				
Parameter	**Muscovy**	**Pekin**	**Mulard**	**SEM**	***P*-value**
Feed cost / duck ($)	4.59[b]	4.85[a]	4.83[a]	0.04	0.005
Feed cost / kg weight gain ($)	1.26[b]	1.67[a]	1.58[a]	0.04	< 0.001
TVC / kg live weight ($)	2.08[b]	2.15[b]	2.30[a]	0.03	0.004
Gross income / duck ($)	12.49[a]	8.15[c]	10.34[b]	0.21	< 0.001
GM / kg live weight ($)	1.12[a]	0.28[c]	0.64[b]	0.11	< 0.001
Benefit–cost ratio (BCR)	0.54[a]	0.13[c]	0.28[b]	0.05	< 0.001

Costs per kg feed=$0.45 and $0.41 for starter and grower ration, respectively.
Purchasing price per duck= $2.56, $1.41, $2.30 for Muscovy, Pekin, and Mulard, respectively.
Selling price (Gross income)/kg live weight= $3.20, $2.43, $2.94 for Muscovy, Pekin and Mulard, respectively.
TVC = Total variable costs; GM = Gross margin.
[a-c] Means bearing different superscripts within the same row are significantly different ($P< 0.05$).
SEM: Standard error of means.

for heart and gizzard were not significant ($P>0.05$) among the breeds; however, the liver percentage of Mulard ducks (3.34%) was considerably higher than that of Muscovy and Pekin ducks (2.36 and 2.26%, respectively).

As shown in Table 3, the breast and thigh meat composition differed significantly among the various breeds. The moisture content was highly significant ($P< 0.001$) in the breast meat of Mulard and Muscovy ducks compared to that of Pekin ducks. The highest percentage of crude protein was observed in the leg and breast meat of Mulard ones, and in Muscovy breast meat. Pekin ducks yielded a significantly higher ($P<0.001$) content of fat in both leg and breast meat than Muscovy and Mulard ducks, whereas the carcass fatness of Muscovy and Mulard ducks was similar. No significant differences ($P>0.05$) were detected in the ash content of breast and thigh muscles among the various breeds.

IGF-1 and IGF1Rgenes expression

The relative changes in IGF-1 mRNA transcript levels are presented in Figure (1). These results clearly demonstrate that the Muscovy ducks showed higher significant IGF-1 gene expression, followed by Mulard and Pekin ducks in that order.

Economic values of duck breeds

Economic calculations revealed that Muscovy breed had a significantly lower ($P<0.001$) feed cost and feed cost/kg gain compared to the other breeds, whereas there is no significant difference between Pekin and Mulard breeds (Table 4). However, the total variable costs of Muscovy and Pekin were significantly lesser than those of Mulard ducks ($P = 0.004$). Muscovy ducks showed the highest values for gross income ($12.49), gross margin ($1.12), and benefit–cost ratio (0.54), followed by Mulard and Pekin ducks in that order.

Discussion

It is important to note that the three breeds under investigation (Muscovy, Pekin, and Mulard) differ considerably in terms of growth rate and the characteristics of valuable body parts, but all have the ability to grow continuously until the 12th week of life (13). As shown in our results, Muscovy ducks yielded superior values for body weight, weight gain, average feed intake, and feed conversion ratio (3903.75, 3659.65, 10744.90 and 2.94, respectively), which is consistent with previous studies (14-16). However, Bhuiyan et al. (17) claimed that the Pekin breed is superior to both Muscovy and Deshi white ducks. The highest weight in Mulard hybrid ducks during the 12th week of life, in comparison to Muscovy and Pekin ducks (13).

Numerous studies have shown that the carcass's composition and the meat yield of ducks varied by breed. In the present study, Muscovy ducks yielded a significantly higher dressing percentage of 75.20 compared to Pekin (72.41%) and Mulard ducks (73.73%). More-over, the highest breast and thigh percentages were observed in Muscovy ducks. The high dressing percentage observed in the Muscovy could be attributed to its heaviness. In addition, two possible reasons for the higher dressing percentage of Muscovy ducks are reduced plumage and smaller internal organs in comparison to other breeds (14). Similarly, El-Soukkary et al. (18) reported that the Muscovy duck had a significantly higher commercial cut yield (including the breast and drumstick) than Pekin and Sudani ducks. Also, Wawro et al. (19) reported that the highest values for breast and leg muscle weight were observed in the carcasses of Muscovy males. However, Bhuiyan et al. (17) reported that the highest dressing yield was observed in Pekin ducks (70%) as compared to Muscovy and Deshi White ducks.

The present study clarified that the moisture content in the breast meat of Mulard and Muscovy was highly significant than that of Pekin breed. The highest percentage of crude protein was observed in the meat of leg and breast of Mulard ducks, and in Muscovy breast meat. Pekin ducks yielded a significantly higher in both leg and breast meat fat content than either Muscovy or Mulard ducks. No significant variances ($P > 0.05$) were detected in ash content of breast and thigh muscles among the various breeds. These results are consistent with those of another study conducted by Wawro et al. (19), who reported the highest crude protein values ($\bar{X}$ = 19.5%) in Muscovy and Mulard breast muscles, and low significant value in the Pekin breast muscle ($\bar{X}$ = 19.0%). According to Isguzar et al. (20), the fat content of the Pekin leg and breast meat is significantly higher than that of local Turkish breeds. The moisture percentage in the Muscovy leg and breast meat was higher than Sudani ducks (21). In contrast, Bons et al. (22) noted greater content of breast protein (21.5%) and muscles of leg (22.5%) of Pekin breed. The thigh and breast muscle water content were significantly higher, and the ash content was significantly lower in the Pekin than in the Muscovy (15).

The IGF system has been considered as an essential regulatory system for controlling development and growth in mammals and chickens. IGF-1, as a member of the IGF family, is a growth, metabolism, body composition, skeletal characteristics, fat deposition and growth of adipose tissue candidate gene in chickens (23). Moreover, IGFIR is a membrane glycoprotein mediating the biological actions of IGF-1 and IGF-2, which have a great effect on chicken growth and quality traits of meat and carcass (24). IGF1R played important roles on the developmental and adult stages such as the cell cycle, transplantation, subsistence, metabolism, propagation and differentiation (25) In previous studies, higher significant of hepatic IGF-1 expression has shown breed specificity in ducks (26), and chickens (27). Similarly, the present results showed significant differences in IGF-1 expression among the various breeds. The highest expression was observed in the Muscovy, a finding that might be responsible for its superior muscle growth and carcass merit.

Assessment of the three breeds indicated that the Muscovy was the most economical (followed by the Mulard and Pekin), both in terms of the cost to produce 1kg live weight and the feed cost per unit gain. In addition, the highest profit margin was realized from the Muscovy. The main contributing factors to the comparatively higher profit margin of Muscovy ducks include the higher market price of the meat, and to a lesser extent, the superior biological efficiency of Muscovy ducks in comparison to Mulard and Pekin ducks (28). In comparison to other breeds, the Muscovy yields the best values for net income, net income margin, and gross return attributed to the total variable costs per 100 parent ducks (29).

Conclusion

In conclusion, Muscovy ducks showed higher performance, dressing percentage, and IGF-1 expression than Mulard or Pekin ducks. The Muscovy and Mulard breeds yielded better quality than the Pekin, owing to higher protein content and lower body fat.

Conflict of interest

The authors declare that they have no conflict of interest.

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