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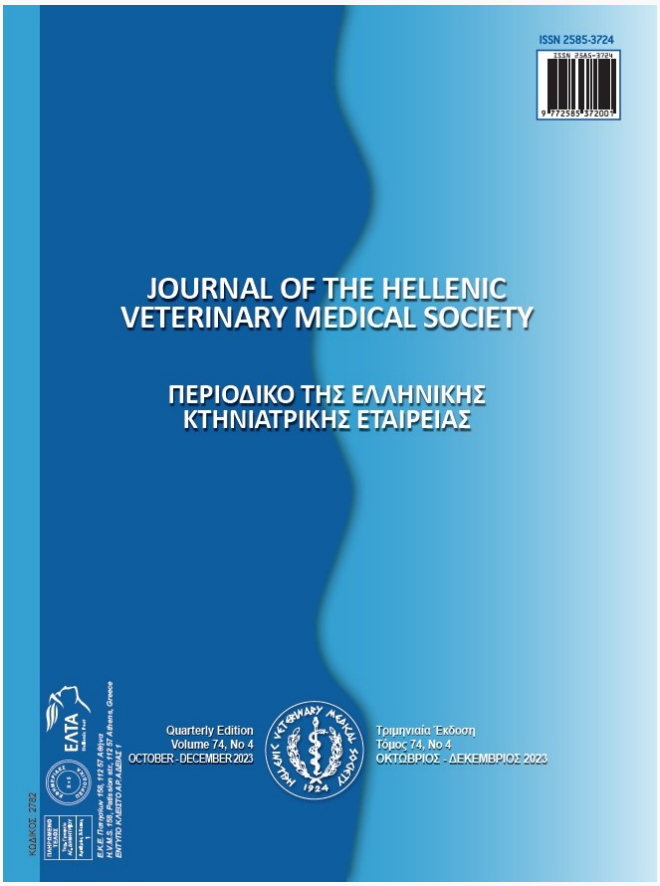

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Research article
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Comparison of productive performance, gene expression, metabolic biochemical profile and economic evaluation between some layer and broiler breeds

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ABSTRACT: The objective of this study was to explore comparative features of productive performance, gene expression, metabolic biochemical profile and economic evaluation between some layer (Fayoumi, Dokki 4, and Gimmizi) and broiler (Arbo, Avian, and Ross) breeds. Gimiza and Ross breeds elicited a higher productive performance than other ones in layer and broiler chickens respectively. mRNA levels of productive (*growth hormone*, *insulin-like growth factor-I*, *phosphoglycerate mutase 2* , and myostatin), bone (*osteocalcin*), reproductive (*estrogen receptor*) and intestinal health (*cathepsin*, *gastrotropin* and *mucin 2*) markers significantly differed among broiler and layer breeds. Serum levels of cholesterol, triglycerides (TG), high density lipoprotein (HDLP), low density lipoprotein (LDLP), triiodothyronine (T3) and thyroxine (T4) significantly varied within and between layer and broiler breeds. Regarding economic parameters Gimiza and Ross breeds had higher total and net returns and economic efficiency than other layer and broiler breeds. However, the latter two breeds elaborated an opposite trend for total variable and fixed costs. This study revealed that the breed factor has an impact on productive performance, gene expression, serum profile and economic parameters in layers and broiler breeds. Therefore, the aforementioned parameters could be utilized for selection of favorable breed within and between chicken breeds.

Keywords: Layers; broilers; productive performance; gene expression; economic evaluation

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INTRODUCTION

Poultry represent nearly one-fourth of all the meat produced globally. It is a source of protein that plays an important role in human nutrition. Modern intensive production strategies can produce market ready broiler chickens in less than 6 weeks. This achievement arises from improved productivity via genetic selection, improved feeding and health management practices (Apata, 2012).It has been estimated that 90% of the phenotypic changes in poultry have come from genetic progress (Havenstein, 1994). Therefore, the main objective of primary breeders was to select breed that deliver the best commercial performance (growth rate, feed conversion and meat yield) with high economic return for their customers (Seyedabadi, 2010). Genetic diversity in local or domestic breeds of animals not only allows breeders and researchers to develop new characteristics in response to changes in environment, diseases or market conditions and maintain genetic diversity but also improves productivity. The yields of animals are the result of the combined effects of genotype and environmental conditions. In order to increase the yield level, it is necessary to optimize the environmental conditions and to improve the genetic structure of the animal by selection and crossbreeding (Cilek and Tekin, 2005).

The pursuit of increased egg production in laying hens is a key area of emphasis for poultry breeding and management (Kang et al., 2009). According to Rodriguez-Hernandez et al. (2021), an animal's genetic make-up, the environment to which it is exposed, and how these three variables interact all have an impact on how the animal produces eggs. In the hen oviduct, alterations in gene transcription and protein synthesis throughout poultry production may affect both the interior and external quality of the eggs (Jung et al., 2011). According to Christians and Williams (1999), variations in the plasma levels of reproductive hormones like gonadotropins (LH, FSH), progesterone, and inhibins were thought to be responsible for the disparities in ovulation rate. In the last decade, the need for broilers meat is increased because the consumers consideration of a high-quality food with low fat and high protein. Therefore, consumers are aware of animal welfare and quality. Researchers are investigating ways to achieve the most significant amount of broiler meat from the smallest possible floor area to decrease production costs (Chmelnicna and Solcianska, 2007). Identifying the quantitative trait loci responsible for the economic important traits in chickens and understanding the genetic and metabolic control of growth will provide an opportunity for genetic improvement and facilitate poultry breeding programs. The application of genetic selection methods in the poultry industry has resulted in increased growth rate and carcass quality (Zhou et al., 2005).

Genetic differences among the chicken breeds of different growth rates have been extensively studied and a number of genes and quantitative trait loci have been reported in controlling the growth rate of chickens (Buzala et al., 2015). The genetic selection that has been carried out for almost a century by poultry breeders has led to significant progress in improving productive traits in poultry (Joseph and Moran, 2005). Modern molecular genetic techniques, coupled with classic qualitative genetic methods, have proved very successful in selecting broiler breeders and layer hens for egg and meat production (Buzala et al., 2014).

Genetic selection for different performance traits results in considerable differences in the mechanisms of growth and development and, thus, in avian metabolism (Tavaniello et al., 2014). In broiler breeders and layer hens, the effectiveness of intensive genetic selection is already seen during the first 48 h of embryonic development and after hatching (Emmerson, 1997). The improvement in layer hens in terms of intensive egg production and of broiler breeders in terms of high body weight and rapid rate of growth has led to considerable differences in their production efficiency (Sato et al., 2006). Intensive genetic selection for economically important production traits significantly shortened the time needed to achieve the desired traits but also significantly accelerated the occurrence of metabolic disorders, which are often detected at the embryo level (Emmerson, 1997). As a result of broiler breeder selection, bone and internal organ growth fails to keep pace with rapid muscle mass gain. Consequently, the birds have reduced cardiopulmonary capacity in relation to their muscle mass and cannot tolerate much physical exertion (Ho et al., 2011). Compared to layer hens, broiler breeders are more predisposed to developing pulmonary arterial hypertension, as a result of which the energy demands of muscle tissue exceed the capacity of the cardiovascular system to deliver adequate amounts of oxygen to the tissues. To compensate for muscle hypoxemia, the circulatory system of both juvenile and adult broiler breeders must perform at a higher capacity than that of layer hens to supply sufficient oxygen to relatively under perfused muscle tissue (Ho et al., 2011).

Previous studies investigated comparison of production performance in layers and broilers; however this this investigation was carried out within breed (Kebede, 2017; Nowier et al., 2018; Ghanem, 2014; Pauwels et al., 2015; Gonzales et al., 1998). In addition, there is little information on comparison between productive, reproductive, and intestinal health genes in broiler and layer breeds using real time PCR approach (Bhattacharya et al.,2015; Antar, et al., 2020). In the same respect, comparison between layers and broilers breeds from metabolic and economic aspects is scarcely reported (Alamgir and Haque, 2007).

Consequently, the aim of this research was to make a comparative study from the productive point of view, gene expression, the hormonal profile and economic evaluation between different breeds of layer and broiler chickens.

MATERIALS AND METHODS

Experimental design, birds and management

The experimental birds were obtained from the Poultry Production Unit, Agricultural Experiment and Research Unit, Faculty of Agriculture, Ain Shams University, Egypt. In total, three hundred 24 weeks old laying hen (1535 ± 3 g average body weight) (Fayoumi, Dokki 4, and Gimmizi) were randomly assigned to three groups represented layer breeds, 100 birds each, and three hundred one-day-old broiler chicks (45 ± 5 g average body weight) of three breeds (Arbo, Avian, and Ross) were randomly assigned to three groups represented broiler breeds, 100 birds each. Broiler chicks received commercial diet formulated according to National Research Council (NRC), 1994 begins by starter (1:10 days), grower (11: 22 days), finisher1 (23:42days) and then finisher 2 (43:60 days) rations, while layer hens received a concentrate diet formulated according to NRC, 1994 each according to its production state. Composition of diet fed to layers and broilers was depicted in Tables 1 and 2. All diets will be iso - caloric and iso-nitrogenous. The broiler chickens were maintained on lighting (16L: 8D) system per day and on standard conditions of temperature and ventilation while layerwere maintained on lighting 23 L: 1D system per day. The Broiler chicks were reared together in the brooding unit (deep litter system) under the same environmental conditions and

Table1. Composition of diet fed to layers.

Ingredients %	Diet
Yellow corn	61.6
Soybean meal	22.4
Corn gluten	4.6
Mixed oil	0.9
limestone	9
Dicalcium phosphate	0.5
Min.Vit. premix [1]*	0.23
Salt	0.3
Dl-methionine	0.15
threonine	0.3
Total	100
Calculated nutrient content [2]	
CP%	18.03
ME(kcal/kg)	2804.89
Ca%	3.52
P%	0.43
Methionine%	0.47
Lysine%	0.81

Vitamin-mineral premix provided per kilogram diet: IU: vit. A 8000, vit.$D^3$1300; mg: vit. E 5, vit. K 2, vit. B^1 0.7, vit. B^2 3, vit. B^6 1.5, vit. B^{12} 7,biotin 0.1, folic acid 1, pantothenic acid 6, niacin 20, Mn 60, Zn 50, Cu 6, I1,Se 0.5,Co1

[2]calculated according to NRC (1994).

Table 2. Composition of diet fed to broilers.

Ingredients	Starter (1-21 days)	Grower (22-42 days)
Yellow corn	56.9	63
Soybean meal	33.5	28.17
Corn gluten	2.9	1.77
Inert	0	0.4
Oyster shell	1.1	1.1
Dicalcium phosphate	2	1.7
Salt	0.3	0.3
Vitamin/mineral premix[1]	0.5	0.5
DL-methionine	0.1	0.03
L-lysine	0.0	0.03
Animal fat	2.65	3
Vitamin E	0.10	0.10
Total	100	100
Calculated nutrient content		
Crude fat	0.06	0.06
Dry matter	89.03	89
Moisture	10.97	11
ME (kcal kg^{-1})	3000	3050
Protein (%)	21.5	19.5
Calcium	0.81	0.83
Available phosphorus	0.40	0.41
Lysine	1.19	1.18
Methionine	0.48	0.49
Methionine+cystine	0.81	0.73

For each kg of the diets, Vitamin A: 9,000,000 IU, Vitamin D3: 2,000,000 IU, Vitamin B1: 1,800 mg, Vitamin B2: 6,600 mg, Vitamin B3: 10,000 mg, Vitamin B6: 3,000 mg, Vitamin B12: 15 mg, Vitamin E: 18,000 mg, Vitamin K3: 2,000 mg, Vitamin B9: 1,000 mg, Vitamin B5: 30,000 mg, Folic acid: 21 mg, Nicotinic acid: 65 mg, Biotin: 14 mg, Choline chloride: 500,000 mg, Mn: 100,000 mg, Zn: 85,000 mg, Fe: 50,000 mg, Cu: 10,000 mg, I: 1,000 mg and Se: 200 mg

layer chickens were reared on cages to make the process of laying and egg collection easy.

Hen production parameters, egg quality characteristics, and growth traits

For laying breeds, Egg production was recorded on individual hens and hen day egg production was calculated as total eggs divided by the total number of days and hens. Eggs were collected daily, weighted individually and recorded daily for 12 weeks. Fifteen eggs per replicate were selected weekly for egg quality analysis. Egg mass/hen/week calculated using the following formula: Egg Mass/hen = Egg weight × Egg number (Haugh, 1937)**.**

Eggs were individually weighed, then broken and the inner contents placed on a leveled glass surface to determine yolk and albumin grade. Egg shell, yolk and albumin separated and weighted on a fresh matter basis; Haugh unit (HU) determined according to equation described previously (Haugh, 1937).

HU = 100 log (H+7.57-1.7 W 0.37).

Yolk height will be measure in mm using a tripod µm, yolk width will be measure in mm using a vernier caliper and yolk index will be calculate from the equation: Yolk index = Yolk height /Yolk diameter

Egg shells were rinsed clean with distilled water and will dry in an oven before weighing and measurement of thickness twice on opposite sides of the midline with a digital micrometer. All egg quality measurements will be performed by the same person throughout the study to prevent any subjective influence.

On a weekly basis, the body weight, average daily feed intake (ADFI), and the feed efficiency were recorded for each group of the broiler one. The average body gain was calculated as differences between each two successive weights.

Experimental samples

At the end of the experiment blood samples were collected from wing vein in a clean tube, left to coagulate and collect serum that stored frozen until biochemical assay. Moreover, ten birds per each group were randomly selected, weigh and euthanized by cervical dislocation for sampling (Jacobs et al., 2019).

Random twenty females from each breed in both layers and broilers were used for gene expression analysis. Samples from liver, muscle, bone, ovary and intestinal tissues were sterile collected, washed in phosphate buffer saline (PBS), snap frozen in liquid nitrogen and stored at −80 °C for quantification of gene expression. After collecting the samples and completing the experiment the unused animal tissues were disposed of in double plastic bags where they were delivered to the concerned waste company.

Gene expression profile

Total RNA was extracted from liver, muscle, bone, ovary and intestinal tissues using Trizol reagent (easy-RED™, iNtRON Biotechnology) according to the manufacturer's procedure. The amount of extracted RNA will be quantified using NanoDrop® ND-1000 Spectrophotometer. The synthesis of first strand of c-DNA from the obtained RNA was achieved through the use of QuantiTect Reverse Transcription kit (Qiagen, Heidelberg, Germany) and procedures of the manufacture were applied.

Relative quantification of mRNA levels of productive (*GH*, *IGF-I*, *PGAM2*, and *MSTN*), bone (*osteocalcin*), reproductive (*ESR*) and intestinal health (*CathB*, *gastrotropin* and *MUC2*) genes was performed by real-time PCR using SYBR Green PCR Master Mix (2x SensiFastTM SYBR, Bioline, catalog No. Bio-98,002). The reaction mixture will be carried out in a total volume 20 µl consisted of 10 µl 2x Sensi Fast SYBR, 3 µl cDNA, 5.4 µl H2O, 0.8 µl of each primer. The primer sequences were designed according to the Pubmed published sequence of *Gallus gallus* as shown in table 3. The real time PCR procedures were carried out according to procedures described previously (Ateya et al., 2019).

The PCR cycling conditions were conducted as follows: 95 °C for 10 min followed by 45 cycles of 94 °C for 15 s, annealing temperatures as shown in Table 3 for 20 s, and 72 °C for 20 s. At the end of the amplification phase, a melting curve analysis was performed to confirm the specificity of the PCR product. The relative expression of each gene in each sample was normalized to a control housekeeping *GAPDH* gene and calculated according to the $2^{-\Delta\Delta Ct}$ method (Pfaffl, 2001).

Biochemical data

Stored serums were used for assaying of TG, TCand LDL-C levels. Serum total protein (TP) and albumin (Alb) were evaluated using Stanbio Laboratory USA kits (Dumas and Biggs, 1972). Cholesterol,

Table 3. Oligonucleotide primers sequence, accession number, annealing temperature and PCR product size of investigatedgenes used in real time PCR.

Gene	Isolation source	Primer	Product length (bp)	Annealing Temperature (°C)	Accession number	Reference
GH	Liver	F5′- GACATGGAGCTGCTTCGGTT -3′ R5′- AACACTCTGTCTGAGGTGCC - 3′	116	62	NM_204359.2	Current study
IGF-I	Liver	F5′- TACCTTGGCCTGTGTTTGCT -3′ R5′- CCCTTGTGGTGTAAGCGTCT - 3′	170	60	NM_001004384.3	Current study
PGAM2	Muscle	F5′- GGGGGATGCTCTCAAGCAAT -3′ R5′- GGACTGGGCACCCATCTTAG - 3′	169	60	NM_001031556.3	Current study
MSTN	Muscle	F5′- GGAATCCCGATGTTGTCGCT-3′ R5′- GGTGTACCAGGTGAGTGTGC-3′	155	62	AY448007.1	Current study
MUC2	Intestine	F5′- ACAGAAGGAACTTCTTCGTACA -3′ R5′- GGTGGTGACATACTGCCAGA - 3′	173	58	XM_040673077.2	Current study
Cath-B	Intestine	F5′- TGAAGAACCTGATGTGGGGC-3′ R5′- CAGGCCCTTCCCTAGGATCA - 3′	196	58	NM_205371.3	Current study
Gastrotropin	Intestine	F5′- TGAGGGTGATAGTGAGCTCGT-3′ R5′- AATCCCCACACGACACCAAG- 3′	205	60	NM_001277700.2	Current study
ESR	Ovary	F5′- ATGATCGGCTTAGTCTGGCG -3 R5′- GCAGCAGTAGCCAGTAGCAT -3′	137	60	NM_205183.2	Current study
Osteocalcin	Bone	F5′- CTTCATCTCCCACCGCCAG -3′ R5′- AGCTCACACACCTCTCGTTG - 3′	123	58	U10578.1	Current study
GAPDH		F5′- AGTCAACGGATTTGGCCGTA-3′ R5′- ACAGTGCCCTTGAAGTGTCC -3′	159	60	NM_204305.2	Current study

triglycerides and high density lipoprotein HDL were assessed according to Young and Friedman, 2001 using kits produced by Spinreact Spain. The concentration of the hormones thyroxine and triiodothyronine was calculated by the method of enzyme-linked immunosorbent assay (ELISA) using commercial kits supplied by Spinreact Spain according to methods directed previously (Wang et al., 2014).

Economic evaluation parameters

Total variable costs (TVC)

TVC included labor, feed, chicks, veterinary management, costs related to production and miscellaneous costs (Bano et al., 2011).

Total fixed costs (TFC)

TFC included land, building and equipment depreciation. The buildings depreciation rate was calculated on the basis of 25 years, whereas the equipment depreciation was calculated on the basis of 5 years (Muhammad, 2002).

Depreciation rate = value of asset / age of asset (year).

Total costs (TC)

TC included the sum of total variable costs and total fixed costs (Tom, 2000).

TC = TVC + TFC.

Total and net returns

The total return (TR) from total eggs sale in layer groups and live weight sale in broiler groups that calculated according to the market prices during the study, whereas the net return (NR) was calculated by the following equation as described by Atallah, 2004.

Net income = total return-total costs.

Economic efficiency

The economic efficiency was calculated for the different layer and broiler groups as the ratio between return from layer or broiler and total cost of feed consumption during the experiment period**.** According to the market price of feed ingredients the cost of each kg of diets for each group in layer and broiler, and according to market sale price of egg and broiler meat the returns from egg and weight gain were calculated. Economic efficiency was calculated by the following equation (Atallah, 2000).

$$\textbf{Economic efficiency \%} = \frac{\text{net return (EGP)}}{\text{total feed cost (EGP)}} \text{ X } 100$$

Where:

Net return = return of weight gain (EGP) - total feed cost (EGP)

Return of weight gain (EGP) = total weight gain × price of kg live BWt (EGP)

Return of egg sale (EGP) = total number of eggs × price of egg (EGP)

Total feed cost (EGP) = total feed intake (kg/ head) × price of kg feed (EGP)

Statistical analysis

Between groups (layer and broiler breeds), all the data were statistically analyzed using SPSS (version 16), hypothesis testing methods included independent sample T test. Within groups (layers and broilers individually) data were analyzed by analysis of variance. P values of less than 0.05 will indicate statistical significance.

Data were analyzed by the General Linear Model (GLM) procedure of the SPSS (version 16).

Yik =μ +Bi+ eik

Where: **Yijk** = any observed value, **μ** = overall mean, **Bi** = effect of breed (i = 1, 2 and 3 i.e. layers (Fayoumi, Dokki 4 and Gimmizi) broilers (Arbo, Avian and Ross), and **eik** = random deviation due to unexplained source.

Least Squares Means (LSM) ± standard errors were calculated and tested for significance using "T" test. **Yik =μ + eik**

Where: Y**ik**= Any observed value, **μ**= Overall mean, **eik**= Random deviation due to unexplained source.

RESULTS

Productive performance of broiler and layer breeds

Productive performance for Fayoumi, Gimmizi and Dokki 4 breeds are shown in Table 4. Gimiza breed recorded significant higher egg production traits compared to other two breeds (Fayoumi and Dokki 4). Egg weight and egg mass weight per breed were significantly higher in Gimmizi compared to other breeds. There were significant differences (P<0.05) in FE between all experimental groups; where Gimiza was higher than other layer breeds. Gimmizi breed showed significantly increased the eggshell thickness and egg yolk index (P<0.05) in all experimental groups compared to other two breeds.

Productive performance for Ross, Cobb and Avian breeds are shown in Table 5. Ross breed was significantly higher in body weight followed by Cobb breed, while Avian breed showed the lowest body weight. Ross breed showed the highest significant body gain compared to other two breeds. There were non-significant differences between breeds in feed intake. There

Table 4. Productive performance of layer breeds.

Traits	GROUP I				
	Fayoumi	Dokki 4	Gimmizi	P - value	SEM
Egg production %	86.45 ^{c}	94.36^{b}	95.53 ^{a}	0.01	0.45
Egg weight	54.33^{b}	55.54 ^{ab}	56.26 ^{a}	0.01	0.36
Egg mass	46.96 ^{c}	52.40 ^{b}	53.74 ^{a}	0.01	0.39
FI g/h/d	102.35	102.12	102.07	0.42	0.31
Fe	0.46 ^{c}	0.51^{b}	0.53 ^{a}	0.01	0.34
HU	78.30^{c}	87.61^{b}	88.96^{a}	0.01	0.43
Yolk index	0.40^{b}	0.44^{a}	0.44^{a}	0.05	0.38
Egg shell thickness	0.34^{b}	0.36^{a}	0.37^{a}	0.05	0.29

Table 5. Productive performance broiler breeds.

Traits	GROUP II				
	Cobb	Avian	Ross	P value	SEM
Weight	2.416 ^{ab}	2.250^{b}	2.450^{a}	<0.01	0.35
Gain	2.371^{b}	2.207^{c}	2.406^{a}	<0.05	0.53
Fi	3.552	3.532	3.511	<0.53	0.32
Fc	1.47^{b}	1.57^{c}	1.43^{a}	<0.01	0.05

were significant differences in FE between all experimental groups which was significantly higher in Ross breed compared to other breeds.

Expression profile of productive, reproductive and intestinal health genes

mRNA levels of productive (*GH*, *IGF-I*, *PGAM2*, and *MSTN*), bone (*osteocalcin*), reproductive (*ESR*) and intestinal health (*CathB*, *gastrotropin* and *MUC2*) markers were depicted in Figure (1). Levels of productive, reproductive and intestinal health markers significantly differed among broiler and layer breeds. The expression profile of *GH*, *IGF-I*, *PGAM2*, *MSTN*, *osteocalcin*, *CathB*, *gastrotropin* and *MUC2* was significantly up-regulated in Ross and Gimmizi broiler and layer breeds respectively. Comparison between expression profile of investigated genes between layers and broilers; *GH*, *IGF-I*, *osteocalcin*, *CathB*, *gastrotropin* and *MUC2* genes were significantly up-regulated in layer breeds. Meanwhile *PGAM2* and *MSTN* elicited an opposite trend.

Biochemical parameters

The serum profile of cholesterol, TG, HDLP, LDLP, T3 and T4 in layer and broiler breeds was depicted in Figure 2. Serum cholesterol levels in different breeds of broiler and layer showed a significant ($p < 0.001$) increase in Avian breed than other one. However, other breeds did not show significant variation. Results of serum TG levels in enrolled chicken breeds appeared significant increase in layers than broilers.

High density lipoprotein showed significant variability among broiler breeds .However, levels among layer breeds did not significantly varied. In broiler, Ross and Arbo were significantly increased when compared with Avian but not reach to the levels reported in layer breeds. Low density lipoprotein recorded a significant increase only in Avian breed in broiler breeds only however levels in the other studied breeds are slightly similar.

Serum T3 level was significantly increased in avian than Ross and Arbo breeds. However, layer breeds did not exhibit any significant variation. . The data of T4 did not showed any significant variation between layer and broiler breeds in this study

Economic evaluation of broiler and layer breeds

Layer breeds

The results depicted in Table 6 cleared that, there is non-significant difference among the different layer breeds in TVC and TC values. Whereas, there is a significant difference ($P < 0.01$) in TR and NR values

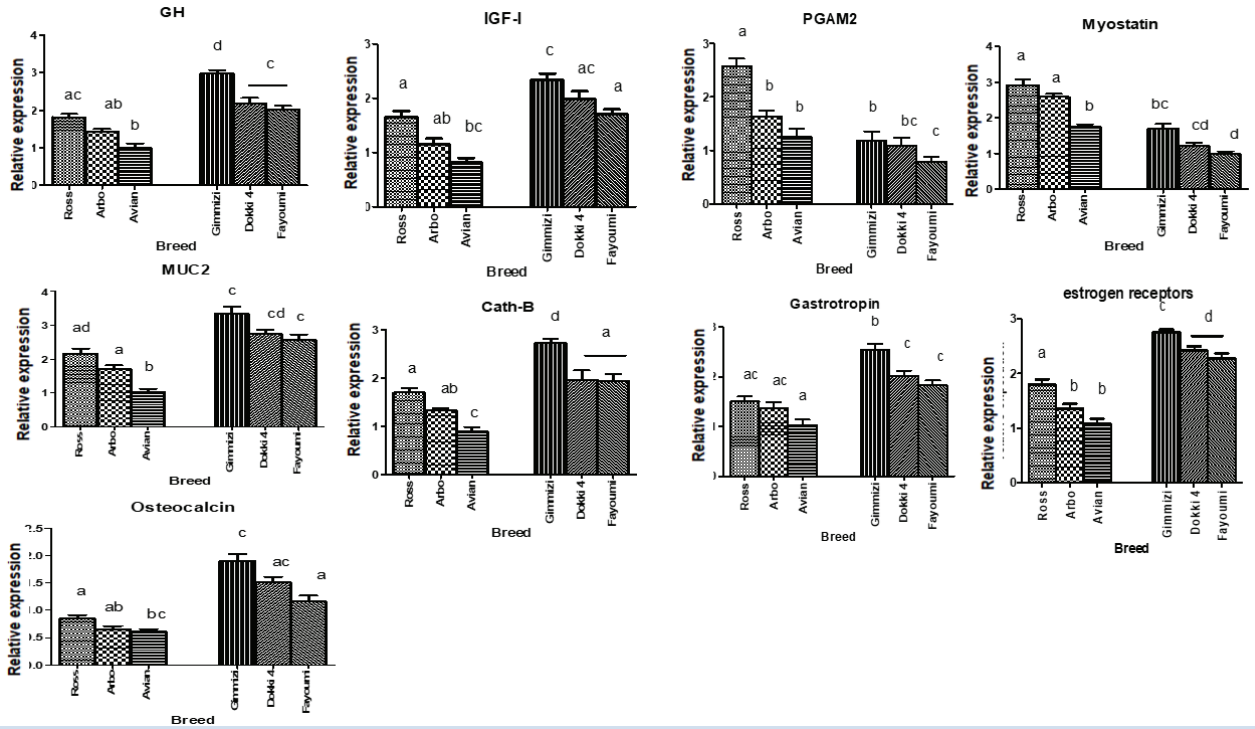

Figure 1. mRNA level of productive (*GH*, *IGF-I*, *PGAM2*, and *MSTN*), bone (*osteocalcin*), reproductive (*ESR*) and intestinal health (*CathB*, *gastrotropin* and *MUC2*) genes in broiler and layer breeds. Small alphabetical letters show significance when ($p < 0.05$).

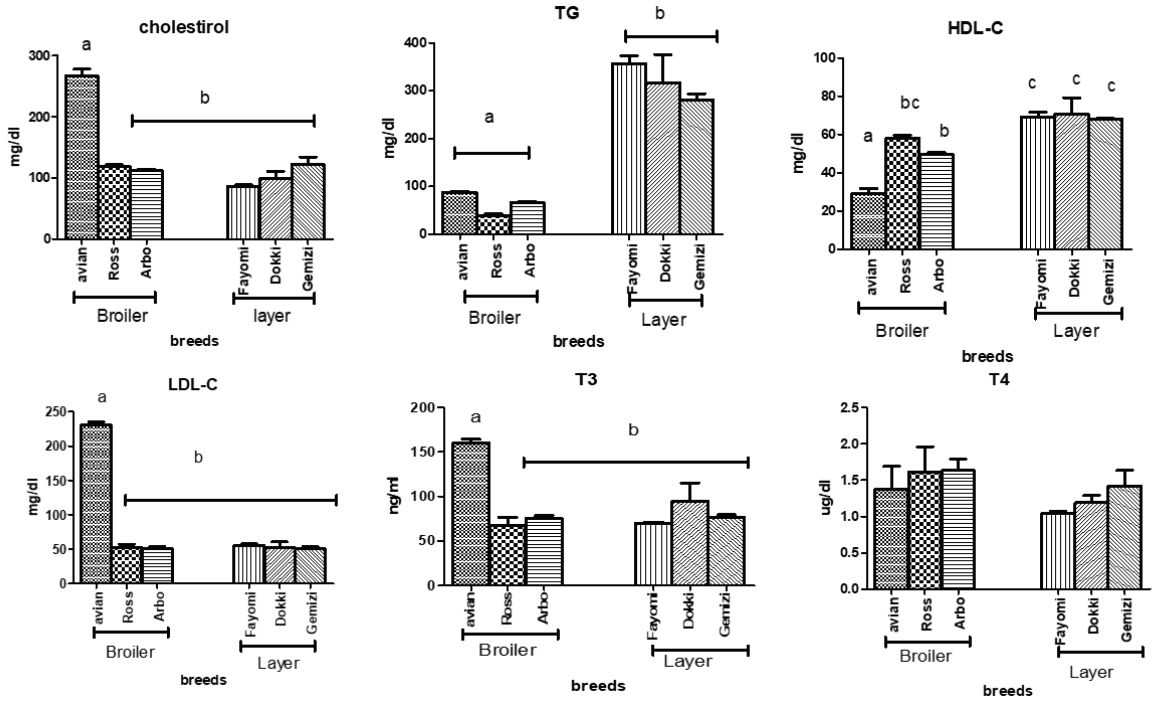

Figure 2. Serum level of Cholesterol, TG, HDLP, LDLP, T3 and T4 in broiler and layer breeds. Small alphabetical letters show significance when ($p < 0.05$).

Table 6. Total variable costs (TVC), total fixed costs (TFC), total costs (TC), total return (TR), net return (NR), and economic efficiency/bird/year among layer breeds.

Economic Parameters	Layer breed		
	Fayoumi	Dokki 4	Gimmizi
TVC (EGP)	394.68± 0.13	393.84± 0.28	393.66± 0.76
TFC (EGP)	7.5	7.5	7.5
TC (EGP)	402.18± 0.12	401.34 ± 0.27	401.16± 0.76
TR (EGP)	445.50± 0.20 [c]	488.25± 0.42 [b]	495 ± 0.54 [a]
NR (EGP)	43.32 ± 0.37 [c]	86.91 [b] ± 0.68	93.84 ± 0.15 [a]
Economic efficiency %	0.12	0.23	0.25

Table 7. Total variable costs (TVC), total fixed costs (TFC), Total costs (TC), total return (TR), net return (NR), and economic efficiency/100 birds among broiler breeds.

Economic Parameters	Broiler breed		
	Cobb	Avian	Ross
TVC (EGP)	5182.34± 0.56 [a]	5160.87 ± 0.70 [b]	5137.94 ± 0.89 [c]
TFC (EGP)	60	60	60
TC (EGP)	5242.34 ± 0.57 [a]	5220. 87 ± 0.71 [b]	5197.94 ± 0.89 [c]
TR (EGP)	7248 ± 0.25 [b]	6750 ± 0.43 [c]	7350 ± 0.84 [a]
NR (EGP)	2005.66 ± 0.95 [b]	1529.13 ± 0.62 [c]	2152.06 ± 0.75 [a]
Economic efficiency %	0.51	0.39	0.56

with the highest values in Gimmizi breed followed by Dokki4 breed and the lowest TR and NR were observed in Fayoumi breed. In regards to the economic efficiency%, from the economical point of view, Gimmizi breed gave the best efficiency value 25% followed by Dokki breed gave 23%, while the lowest efficiency value was in Fayoumi breed gave 12%.

Broiler breeds

The results presented in Table 7 showed a significant difference among the broiler breeds in TVC and TC values. The highest TVC and TC were in Cobb

breed, whereas, the lowest TVC and TC were in Ross breed. Results of TR and NR revealed a significant difference ($P < 0.01$) with the highest values were in Ross breed followed by Cobb breed and the lowest TR and NR were recorded in Avian breed. Referring to the economic efficiency%, economically, Ross breed gave the best economic efficiency value 56% followed by Cobb breed gave 51%, while the lowest efficiency value was in Avian breed gave 39%.

DISCUSSION

The aim of this study was to investigate the potential productive differences between broiler breeds (Avian, Ross and Cobb) and layer breeds (Dokki 4, Gimmiza and Fayoumi). Gimiza breed showed the highest FE, egg production, egg weight and egg mass compared to Fayoumi breed; while FI was not significantly affected between different breeds. Our results were similar to a study by Kebede, (2017)who reported that Fayoumi chicks tended to record light weights, this indicated slower growth rate in Fayoumi during the rearing period. In addition, Nowier et al., (2018) reported that Rhode Island Red recorded a significant heavier body weight compared to Fayoumi. Moreover, showed that the pullet and mature body weight of Rhode Island Red breed was significantly heavier compared to Fayoumi breed (Lemlem and Tesfay, 2010).

Regarding broiler breeds, our results were in-accordance with Ghanem et al., (2016)who showed that Ross breed has the highest measurements of live body weight, weight gain and feed efficiency than other breeds. Disagreements with our results, it was cited that Cobb-500 breed achieved higher body weight and weight gain than the other breeds (Ghanem, 2014; Pauwels et al., 2015; Gonzales et al., 1998).In contrary to our results, Avian broiler breed showed a sharp increase in feed intake from weeks 2 to 6, showed a decrease in FCR (i.e. highest efficiency), at each age measured (Jia et al., 2018). As a general comparative between broiler and layer breeds, layer breeds showed lower body weight, gain and feed efficiency compared to the broiler one which had a significantly higher body weight gain and this was in agreements with previous studies (Antar et al., 2020; Al-Marzooqi et al., 2019).Similarly, broiler chicken has a fast growth rate, higher breast muscle yield, and higher feeding efficiency (Halevy et al., 2000).

In this context, real time PCR was carried out to quantify mRNA level of productive (*GH*, *IGF-I*, *PGAM2*, and *MSTN*), reproductive (*ESR*), bone (*osteocalcin*) and intestinal health (*CathB*, *gastrotropin* and *MUC2*)markers in broiler and layers breeds. Our findings revealed that the expression pattern of investigated genes was higher in Ross and Gimmizi broiler and layer breeds respectively. Comparison between the genes expression in broiler and layer breeds; the investigated genes were significantly up-regulate in layer than broiler breeds except for *MSTN*. Our study is the first to compare between productive (*GH*, *IGF-I*, *PGAM2*, *MSTN* and *osteocalcin*) reproductive (*ESR*) and intestinal health (*CathB*, *gastrotropin* and *MUC2*) genes in broiler and layer breeds using real time PCR approach. Our study was designed to overcome the limitations of previous work by investigating polymorphism in gene using RFLP and SNP genetic markers (Anh et al., 2015; Niu et al., 2017).Consequently, *GH*, *IGF-I*, *PGAM2*, *MSTN* ,*osteocalcin*, *ESR*, *CathB*, *gastrotropin* and *MUC2*)genes regulation mechanisms are well understood in broiler and layer breeds. To the best of our knowledge, comparative features for the expression profile of productive genes in broiler and layer breeds is scarcely reported. Bhattacharya et al.,(2015) cited that the gene expression profile of *MSTN* in muscle was different between broiler and layer strains. The authors reported that the pattern of expression was similar between two broiler strains, while it was different between layer breeds. It was elicited that there was no difference in the expression levels of total *MSTN*(MSTN-A and -B forms) during embryonic development and at D33 between the two broiler and layer breeds (Kim et al., 2022). However, the ratios of MSTN-B to -A were significantly higher in the broiler compared to the layer at most ages. *MSTN* expression levels were not different between broiler and layer chickens at embryonic ages and post-hatch day 33 (Dou et al., 2018). However, *MSTN* expression was significantly higher at post-hatch day 5 in broiler chickens compared to layer chickens. Nakashima et al.,2009 found there was no difference in *CathB* gene expression in the skeletal muscles of layer and broiler chickens.

Unlike our study, previous studies elaborated gene expression profile of productive (*GH*, *IGF-I*, *PGAM2*, *MSTN*), bone (*osteocalcin*), reproductive (*ESR*) and intestinal health (*CathB*, *gastrotropin* and *MUC2*) and its association with productive performance traits either in broiler or layer breeds. For instance, Antar, et al., 2020 cited that *GH* and

IGF-I mRNA levels were higher in Cobb than Fayoumi breed; while *MSTN* elicited an opposite trend. It wasreported there is a difference in *GH* mRNA levels between genotypes in the growing chickens (Sinpru et al., 2021; El-Attrouny et al., 2021). However, IGF-I mRNA levels were not different among genotypes. Fouda et al., (2021) reported that expression patterns of IGF-I gene revealed a significant up-regulation in Avian than Cobb and Ross breeds. Giachetto et al., (2004) elicited that the changes in the expression of *IGF-I* mRNA in liver was independent of broiler chicken strain, but varied with chicken age. Additionally, selection for growth rate and body size has altered the expression profiles of somatotropic axis genes in chickens (Jia et al., 2018). Jawasreha et al., (2019)elaborated also that a variation in the expression profile of *IGF-I*, *MSTN* and muscle marker genes MyoD and MyoG associated with growth performance and meat characteristics in four different commercial broiler strains. Xiao et al., (2017) reported an association between myogenic gene expression profiles with growth rate in broilers. Zhang et al., (2015) indicated a higher expression of *MUC2* post hatch in chickens. There was a significant ($P < 0.01$) expression of the *ESR2* gene in all three tissues of laying ducks than that of non-laying ducks (Asiamah et al., 2022).It is worth mentioning that, gene expression of gastrotropin (*FABP6*) and *MUC2* in mucosa may work as potential biomarkers for gut barrier health in chickens (Chen et al., 2015). Gastrotropin gene expression was also reported to be associated with growth and fatness traits in chickens (Wang et al., 2006; Unim et al., 2021).

The growth hormone (GH) that regulates the growth exerts its effects mainly by IGF-I, which is synthesized in the liver under GH control and secreted into the circulation (McMurtry et al., 1997). Generally, IGF-I and -II are responsible for proliferation of preadipocytes, chondrocytes, and fibroblasts through amino acid stimulation, glucose uptake, increased DNA synthesis, tissue growth stimulation, and overall embryogenesis regulation (Guernec et al., 2003).Noteworthy mentioning that layers had significantly higher pituitary GH and IGF-I mRNA levels than broilers (Reiprich et al., 1995). *GH* mRNA levels, but positively related to BW within lines, and that layer chickens showed a higher *GHR* mRNA level in muscles than did Avian broiler chickens (Zhao et al., 2004).

PGAM is an enzyme of the glycolytic pathway that converts 3-phosphoglycerate into 2-phosphoglycerate (Fontanesi et al., 2008). In mammalian tissues, PGAM is a dimer of 2 distinct 30 kDa subunits, including the ubiquitously expressed brain form (B form, known also as *PGAM1*) and the muscle form (M form, known also as *PGAM2*) expressed only in adult skeletal and cardiac muscle. In pigs, *PGAM2* is expressed at a high level in skeletal muscle during all stages of development, and is related to growth, feed conversion, and slaughter traits (Qiu et al., 2008). PGAM2 has also key roles in the glycolysis process controlling postnatal development and related meat quality parameters (Dunner et al., 2013). MSTN also known as growth/differentiation factor-8 (GDF-8), is mainly expressed in skeletal muscle. Its negative regulatory effects on muscle growth were demonstrated previously, where inactivation of MSTN resulted in increased muscle mass in animals (Grobet et al., 1997). In addition, targeted genome edition in the *MSTN* gene resulted in a 30% increase in the muscle weight in quail (Lee et al., 2020) and significantly increased the growth rate in chickens (Kim et al., 2022). Considering the anti-myogenic effect of MSTN, the expression levels of *MSTN* are not always negatively correlated with muscle growth, suggesting the existence of possible post-transcriptional regulatory mechanisms of MSTN. In fact, avian *MSTN* is found in several mRNA isoforms by alternative splicing mechanisms (Shin et al., 2015). Therefore, the temporal expression levels of *MSTN* isoforms were the focus of the current study, which compared broiler and layer chickens with distinct muscle growth characteristics. It has been reported that both myofiber hypertrophy and hyperplasia are contributing factors to the larger muscles in broilers compared to layers (Scheuermann et al., 2004). Therefore, considering the pro-myogenic activities of the PGAM2 and MSTN -B form and greater muscle accretion with muscle hypertrophy and hyperplasia in broilers (Scheuermann et al., 2004), the greater ratio of MSTN -B to -A in broilers compared to layers might be involved in the regulation of muscle growth in chickens. Consequently, the previous findings could decipher the marked *PGAM* and *MSTN* up-regulation in broiler than layer breeds. Furthermore, differences in *PGAM2* and *MSTN* expression among broiler and layer breeds could be attributed to long-term genetic selection or type of production (Zhang et al., 2018).Other factors such as physiological and environmental conditions (Yin et al., 2014), different genetic origins, skeletal muscle con-

tents (Li et al., 2014), and polymorphisms could also be involved in gene expression differences among chicken breeds (Zhu et al., 2010).Similarly, Kocamis and Killefer, 2002 reported that high expression levels of MSTN may be to prevent excessive muscle growth. Differences in *MSTN* expression among studied breeds could be attributed to the inhibitory effect of pro-peptide on the biological activity of the MSTN (Lee et al., 2001).

MUC2 is the major component of intestinal mucus which is produced by goblet cells and is in direct contact with gut bacteria (Jiang, 2011). In addition to its function as a physical barrier, mucus bound with a variety of bacterial species facilitates the formation of IgA mediated immune defense, which not only prevents invasion of the intestinal epithelial cells by gut bacteria but may selectively facilitate adherent growth of normal gut flora (McGuckin et al., 2011).Mucus provides colonization sites and nourishes mucolytic microbes by mucin carbohydrates to many commensal bacteria. In addition, mucus gel entraps invasive bacteria, inhibits their proliferation through corporation with other antimicrobial molecules, and eventually expels them with the luminal flow (McGuckin et al., 2011). The alteration in the expression profile of intestinal health markers within and between broiler and layer breeds may be due to a consequence of the removal of anti-microbial growth promoters, new multifactorial diseases causing enteritis and gut disorders of unknown origin have emerged in broilers, causing negative impacts in health and performance (Dahiya et al., 2006).

Estrogens belong to the gonadal steroid hormone family synthesized from cholesterol mainly in the ovaries, granulosa cells, and corpora lutea. In the reproductive system, estrogens regulate oogenesis, ovulation, estrous behavior, uterine propagation, vitellogenesis, endometrial gland secretions, gonadotropin secretions, male and female sex organ development, and secondary sex characteristics (Hamilton et al., 2014).The ERs act as transcription factors to initiate gene transcription through estrogen response elements (EREs) in the target tissues and interact with other transcription factors (Hall and McDonnell, 1999). In quails, the marked expression of *ERα* mRNA in the granulosa layer of the largest follicle may be related to the role of estrogens in cell proliferation and protein synthesis in the oviduct (Hrabia et al., 2004).This may be because an increase of estrogen levels in the ovary at the end of the follicular phase in laying duck may exert a positive feedback effect on the hypothalamus to trigger a preovulatory GnRH surge which in turn excites secretion of gonadotropins in the pituitary for preovulatory development, maturation and oviposition of follicles in the ovary (Zhu et al., 2017). ESR2 levels in laying ducks indicate that ESR2 may play essential roles in the ovary during follicle development and egg-laying in Leizhou black ducks (Kang et al., 2012). The latter could decipher the significant up-regulation of *ESR* in laying hens than broiler ones.

Owing to our results, the mRNA level of osteocalcin is higher in layers than broilers. Osteocalcin is of the non-collagenous proteins in the bone and tooth. It is generated by osteoblasts. Also, the metabolism of the bone and body is partly controlled by osteocalcin that is also an indicator of the condition of the bone, and is used for the evaluation of bone diseases (Liang et al., 2015). Bone metabolism in female birds is special in that they produce a medullary bone, which serves as a reservoir for calcium used in production of the eggshell (Jilka, 2003). Avian bone remodelling is quicker than mammalian and coordinated with the laying cycle (Feng and Mcdonald, 2011). Osteoporosis, loss of bone density, and bone fractures are a major health issue for layer chickens in production, likely exacerbated by the strains that high egg production and quick growth put on domestic chickens (Guimaraes et al., 2012).

Walz et al., (1988)identified the primary structure of gastrotropin (FABP6) to be similar to that of fatty acid binding proteins. The binding of FABP6 to bile salts and bilirubin is indicative of the mechanism of transport of FABP6 in the blood to be cleared by the liver. It therefore was thought that FABP6 was the first FABP to have an extracellular function (Duggavathi et al., 2015). Each FABP gene exhibits specific expression patterns of tissue, but they are expressed most abundantly in tissues involved in tissue-specific coordinated lipid responses, such as liver, adipose, and small intestine, where fatty acids are major materials for lipid metabolism (Duggavathi et al., 2015).

Lipogenesis is documented to take place in liver, adipose tissue and mammary gland in mammalian species however in avian species, it occurs mainly in liver (Bergen and Mersmann, 2005). Consequently, during laying eggs, fat synthesis process in liver is activated (Klasing, 1998). In the present study, it was noticed that, serum levels of cholesterol and TG was significantly increased in layer species than broiler

ones. These data was consistent with the previous data of Li et al., 2015who reported up regulation of lipogenesis related genes in liver of layer hen than that found in juvenile ones. During the hen laying cycle, triacylglycerols, cholesteryl esters, cholestery esters, and free fatty acids are synthesized in the liver and assembled to form egg-yolk precursors such as VLDL and vitellogenin particles. The particles are then secreted into the circulation and transferred to the developing oocyte to meet the requirements for embryo growth and development as ovary of hen unable to form lipogenesis (Wiskocil et al., 1980).In the same respect, Paech et al.,1997 concluded that lipid synthesis, secretion and transfer in the liver of laying hens are regulated mainly by estrogen that is higher in layer breeds than broiler one.

In broiler chickens, about 80 - 85% of the fatty acids that accumulate in the adipose tissue are derived from plasma lipids (Griffin et al., 1992). These finding might explain the significance increased levels of cholesterol in broiler breed specially avian than layers as it directed to fattening purposes. It was noticed that T3 is the main regulator of cholesterol synthesis and LDL formation (Faure et al., 2004). These results could explain our results that indicate significant higher levels of T3, cholesterol and LDL in Avian breed than the other studied breeds in this experiment.

Regarding economic evaluation of layers, there was non-significant difference among the different layer breeds in TVC and TC values. Whereas, there is a significant difference ($P < 0.01$) in TR and NR values with the highest values in Gimmizi breed followed by Dokki4 breed and the lowest TR and NR were observed in Fayoumi breed. The non-significant differences in TVC and TC attributed mainly to that there is no differences among layer breeds in the costs related to production process especially the costs of feed intake, drug, vaccine, disinfectant, labor and other variable costs. The total return and net return values showed that the breed has a significant effect on the TR and NR among the different layer breeds (Tauson, 2005).These differences in TR and NR results is owed to that TR depends on sales of total number of eggs/year or EP% for each breed and includes in its calculation the total costs of production and NR is a net revenue or profit after subtracting the production costs which has no differences among the breeds (Alamgir and Haque, 2007). In regards to the economic efficiency%, from the economical point of view, Gimmizi breed gave the best efficiency value 25% followed by Dokki breed gave 23%, while the lowest efficiency value was in Fayoumi breed gave 12%. This is attributed to that Gimmizi breed has the highest net profit that impact the efficiency calculation even if there is no significant difference in the costs values among the breeds (Alamgir and Haque, 2007).

Concerning broilers,a significant difference among the broiler breeds in TVC and TC values was observed. The highest TVC and TC were in Cobb breed, whereas, the lowest TVC and TC were in Ross breed. These differences in TVC and TC values owed to the impact of feed intake costs among the breeds which represents about 70% of the production costs in broiler farms, as the highest feed intake recorded for Cobb breed (Chhikara, 1990). Results of TR and NR revealed a significant difference ($P < 0.01$) with the highest values were in Ross breed followed by Cobb breed and the lowest TR and NR were recorded in Avian breed. The total return and net return values showed that the breed has a significant impact on the TR and NR among the broiler breeds. These differences in TR and NR results is attributed to that returns depends on sales of the final body weight for each breed which differs significantly and includes in its calculation the total cost of production which is significantly different (Thirumalesh,and Mallikarjunappa, 2005). Referring to the economic efficiency%, economically, Ross breed gave the best economic efficiency value 56% followed by Cobb breed gave 51%, while the lowest efficiency value was in Avian breed gave 39%. The result is interpreted on the basis of that Ross breed has the highest net return and lowest costs that impact the efficiency parameter (Al-Wassity et al., 2019; Carvalho et al., 2015).

CONCLUSION

The results herein confirm that the chicken breed has a remarkable impact on productive performance, gene expression, serum profile and economic parameters in both layer and broiler breeds. Gimmizi and Ross recorded higher productive performance than other layer and broiler breeds respectively. Additionally, higher gene expression and serum profiles of productive markers as well as net profit were observed in Gimmizi and Ross breeds. The variability in productive performance, gene expression, serum profile and economic parameters could be used as proxy markers for selection and improvement within and between layer and broiler chicken breeds.

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CONFLICT OF INTEREST

No potential conflict of interest was reported by the author(s).

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