Scientific Research Publishing

Open Journal of Animal Sciences, 2022, 12, 287-302
https://www.scirp.org/journal/ojas
ISSN Online: 2161-7627
ISSN Print: 2161-7597

Serum Biochemical and Meat Fatty Acid Profiles of Different Chicken Genotypes

Atsbaha Hailemariam[1*], Wondmeneh Esatu[2], Solomon Abegaz[3], Mengistu Urge[4], Getnet Assefa[5], Tadelle Dessie[2]

[1]Ethiopia Agricultural Research Institute, Mehoni Agricultural Research Center, Mehoni, Ethiopia
[2]International Livestock Research Institute, Addis Ababa, Ethiopia
[3]Ethiopia Agricultural Research Institute, Debrezeit Agricultural Research Center, Bishoftu, Ethiopia
[4]Haramaya University School of Animal and Range Sciences, Dire Dawa, Ethiopia
[5]Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia
Email: *atsbaba@yahoo.com

How to cite this paper: Hailemariam, A., Esatu, W., Abegaz, S., Urge, M., Assefa, G. and Dessie, T. (2022) Serum Biochemical and Meat Fatty Acid Profiles of Different Chicken Genotypes. *Open Journal of Animal Sciences*, **12**, 287-302.
https://doi.org/10.4236/ojas.2022.122022

Received: October 6, 2021
Accepted: April 12, 2022
Published: April 15, 2022

Abstract

Serum biochemical and meat fatty acid profile of different chickens were studied. A total of 144 mixed sex matured chickens of Cosmopolitan (C), Improved Horro (H), Cosmopolitan ♂ *Improved Horro ♀ (CH), Improved Horro ♂ *Cosmopolitan ♀ (HC), Indigenous (L) and Koekkoek (KK) were used to determine serum biochemical, of which 36 chickens were also used for fatty acid profile study. Completely randomized design in 6 × 2 factorial arrangements was set up. Serum biochemical and fatty acid profiles were determined by Roche/Hitachi cobas c 501 and gas liquid chromatography (GC) procedures, respectively. There were significant differences ($P \leq 0.001$) in Total cholesterol (TC), Triglyceride (TG), Low-density lipoprotein (LDL) and High-density lipoprotein (HDL) among genotypes and between sexes. HDL was inversely related with TC, TG and LDL. Male had significantly higher ($P \leq 0.001$) TC, TG, LDL but lower HDL than female. SFA, (Myristic, Pentadecanoic and Palmitic acids) had significantly ($P < 0.05$) varied among genotypes. However, Margaric ($P \leq 0.01$) and stearic ($P \leq 0.001$) acids were significantly different between sexes. Myristoleic and Palmitoleic acids significantly vary ($P \leq 0.05$) among genotypes and between sexes. Oleic ($P \leq 0.01$) and Eicosenoic ($P \leq 0.001$) significantly influenced by sex. Moreover, Linoleic had significantly ($P \leq 0.01$) affected by genotypes. Nevertheless, α-linolenic acid significantly ($P \leq 0.01$) varied between sexes. The serum biochemical differed across genotypes and between sexes. The difference in the number of carbons, double bond and position of the double bond could affect fatty acid profile among genotypes and between sexes. Chicken products with higher level TC, TG, LDL and SFA might affect human health problems. It could also be interesting topic for future studies.

Keywords

Chicken, Biochemical Parameter, Sex, Meat Fatty Acid Profile, Correlation

1. Introduction

The poultry sector is possibly the fastest growing and most flexible of all livestock sectors expanding in countries of all income levels [1]. Cholesterol has been defined to be a member of class of lipids that contain the same four ring system [2] and serve as component of cell membrane and precursor for synthesis of all other steroids [3]. References have confirmed that Triglycerides can be defined as ester of fatty acids with trihydric alcohol [4]. Lipoproteins like HDL have been witnessed as aggregate of lipids and proteins that carry cholesterol from the body to the liver as opposed to LDL [5]. The lipoproteins in serum could be transported in association with apoproteins as special hydrophilic mechanism to transport in blood [6]. Reports have also noted that lipids in serum could primarily found as cholesterol, triglyceride, and fatty acids [7].

The quality of meat and egg can be measured from the standpoint of consumers and industries [8] [9] [10]. Meats and eggs of chickens deliver essential nutrients for efficient and balanced nutrition in humans [11] [12]. Likewise, meats and eggs have relatively low-fat content, good source of proteins, vitamins, and mineral sources [13] [14] [15] findings. Studies revealed that intake of saturated fat as a percentage of calories had strong correlation with coronary death rates, where each 5% increase of energy from saturated fat was associated with 17% increase in coronary heart diseases and characterized by amyloid beta (AB) deposition in brain impact for age related memory problems [16]. The genetic variability of chickens can influence serum, meat, and egg by affecting Stearoyl-CoA Desaturase (SCD) gene expression and Lipogenic enzymes activity [17] studies.

Proportion of saturated fatty acid and unsaturated fatty acid in chickens could affect human health [18]. Polyunsaturated (PUFA) and monounsaturated fatty acid (MUFA) have cholesterol-lowering properties [19]. Polyunsaturated (PUFA) to monounsaturated fatty acid (MUFA) regularly used to describe the balance of fatty acid composition of nutritional ingredients and health importance as stated in [20].

The rationale for the initiation of this research was that the serum biochemical and meat fatty acid profiles of the Cosmopolitan (C), Improved Horro (H), Cosmopolitan ♂*♀Improved Horro (CH), Improved Horro ♂*♀Cosmopolitan (HC), indigenous (L) and Koekkoek (KK) chickens and the role of genetics to produce healthy eggs and meats for consumption and marketing were not studied. Therefore, the objective of this study was to compare the selected chicken genotypes and sexes on serum biochemical parameters, meat fatty acid profiles and their correlations.

2. Materials and Methods

2.1. Description of the Study Areas

The experiment was conducted at Werer Agricultural Research Centre (WARC) of 280 km way from Addis Ababa. The Werer Agricultural Research Center was found at an altitude of 820 meters above sea level and at 9˚55'N latitude and 40˚40'E longitude. The annual rainfall and average minimum and maximum temperatures for Werer Agricultural Research Center ranges from 400 mm to 600 mm, and 19.3˚C and 45˚C, respectively.

2.2. Sampling Procedures and Experimental Animals

A total of 144 chickens were transported from Werer Agricultural Research Center and three-day rest periods were provided before slaughter at Debrezeit Agricultural Research Center at 24 weeks of age from six genotypes and sexes (72 males and 72 females). The chickens were slaughtered following the guidelines approved by the institutional animal care and use committee (IACUC). Moreover, after stunning the chickens were slaughtered. The chickens were scalded at recommended water temperature 53˚C. The scalded chickens were defeathered. The defeathered carcasses were eviscerated, washed and placed in airtight plastic bags and carcasses were chilled for 24 h at 4˚C. After chilling, the carcass samples were prepared and taken for farther laboratory analyses.

2.3. Determination of Serum Biochemical Parameters

Blood samples were collected from six genotypes and sexes of the chickens under study. Moreover, from each chicken sex twelve blood samples were collected. The total blood samples collected were 144 from all chickens considered. Then each chicken was taken as much as 10 ml from axillary vein by using disposable syringe. Blood sample inserted into vacuum tubes containing anticoagulant ethylene diamine tetra acetic acid (EDTA). The blood samples were centrifuged at 3000 g for 10 min, and the serum was stored in a freezer at −20˚C until analyses. The blood sample collection and serum separation were done. The methods used for total cholesterol, Triglycerides, High density lipoproteins and Low-density lipoproteins determination from serum samples collected from each chicken were automatically determined by Roche/Hitachi cobas c 501 systems using the Enzymatic colorimetric method (Roche 501). The results were expressed in mg/dl.

2.4. Fatty Acid Profile Determination

The meat was dried at temperature of 60˚C for 72 h using an oven according to the standard meat drying method. After drying, the meat size was reduced by grinder. Fatty acid methyl ester (FAME) was prepared. Ten gram of homogenate meat was weighed into a screw cap glass vial along with an internal standard solution of tridecanoic acid (0.5 mg/mL in methanol). The Vials were placed in a water bath for incubation at 55˚C. Hexane was used to extract FAME prior to

analysis by gas liquid chromatography (GC). Separation of FAME was carried. The separation of FAME was equipped with a flame ionization detector (FID). The Gas Chromatography (GC) was operated. The injector was held at 250˚C fitted with deactivated split/splitless liner packed with glass wool. The column head pressure was 195.6 kPa and a total flow rate of 129.1 mL/min. The oven method was carried on in such a way by increasing temperature at 35˚C held for 2 min, increased to a temperature of 170˚C at the rate of 4˚C/min, held for 4 min, then increased to a temperature of 240˚C at the rate of 3.5˚C/min, held for 7 min. The Hydrogen was used as the carrier gas and the FID was operated at 250˚C. Fatty acids was identified based on the similarity of retention times with the GC reference standards. Finally, 36 meat samples were analyzed for fatty acid profile determination study.

2.5. Experimental Design

A factorial arrangement having two factors (Genotypes and Sex) was used. The study was employed in CRD design. There were about 12 blood samples collected and separated from each sex of the chickens used. A total of 144 serum samples were taken to Ethiopian Public Health Institute for total cholesterol (TC), triglyceride (TG), low density lipoprotein (LDL) and high-density lipoprotein (HDL) laboratory analysis for the study.

2.6. Statistical Analyses

The data was recorded as per the prepared recording sheet and was entered into excel regularly. The data collected was summarized and analyzed by GLM model using SAS software. When the GLM showed presence of significant difference among the different samples at $P < 0.05$, the Duncan's multiple range tests was used for mean separation.

The model used for the analysis was:

$$Y_{ijk} = \mu + \beta_{1i} + \beta_{2j} + (\beta_1\beta_2)_{ij} + e_{ijk}$$

where,

Y_{ijk} = the response variables.

μ = the overall Mean.

β_{1i} = the effect of sex.

β_{2j} = the effect of genotype.

$(\beta_1\beta_2)_{ij}$ = The effect of interaction between sex and genotype.

e_{ijk} = Random error.

3. Results and Discussion

Effect of Sex and Genotype on Serum Biochemical Parameters

Mean concentration of serum biochemical parameters of KK, CH, HC, C, H and L chickens at 24 weeks of age were in Table 1. In this study, it was revealed that mean values of TC for KK, CH, HC, C, H and L were 170.90 ± 6.17, 159.98 ±

Table 1. Effect of sex and genotype on chicken serum biochemical parameters.

	Serum biochemical parameters			
	TC	TG	LDL	HDL
Category Genotype (G)	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
KK	170.90 ± 6.17^{a}	133.94 ± 2.63^{a}	91.03 ± 5.22^{a}	76.01 ± 3.27^{c}
CH	159.98 ± 4.44^{ba}	130.19 ± 2.02^{b}	88.16 ± 7.73^{ba}	78.38 ± 3.67^{bc}
HC	154.29 ± 3.39^{b}	128.64 ± 1.57^{cb}	87.49 ± 3.91^{ba}	78.63 ± 3.56^{bc}
C	153.65 ± 4.82^{b}	126.31 ± 1.06^{cd}	83.88 ± 2.78^{ba}	79.86 ± 3.63^{bc}
H	151.79 ± 3.87^{b}	125.61 ± 1.06^{d}	80.78 ± 2.86^{ba}	84.37 ± 3.43^{ba}
L	148.88 ± 2.96^{b}	124.65 ± 0.94^{d}	78.88 ± 3.19^{b}	86.45 ± 3.20^{a}
P-value	***	***	***	***
Sex(S)				
Male	167.50 ± 2.59^{a}	132.26 ± 1.09^{a}	91.54 ± 2.31^{a}	71.40 ± 1.33^{b}
Female	145.66 ± 1.28^{b}	124.19 ± 0.44^{b}	78.53 ± 1.38^{b}	89.83 ± 1.29^{a}
P-value	***	***	***	***
Overall	156.58 ± 1.93	128.22 ± 0.75	85.03 ± 1.55	80.62 ± 1.43
G*S	Ns	***	Ns	Ns
CV	10.47	4.99	15.42	15.04

^{abcd}Mean values under the same category across column that bear different superscript letters are significantly different, Ns = P > 0.05, *** = P < 0.001, ** = P < 0.01, * = P < 0.05, SE = standard error of mean, KK = Koekoek, H = Horro, C = Cosmopolitan, HC = Horro male and Cosmopolitan female crosses, CH = Cosmopolitan male and Horro female crosses.

4.44, 154.29 ± 3.39, 153.65 ± 4.82, 151.79 ± 3.87 and 148.88 ± 2.96 mg/dl, respectively. Moreover, KK had significantly higher TC concentration (P ≤ 0.001) than CH, HC, C, H and L genotypes.

There were significantly higher TC concentrations (P ≤ 0.001) in male (167.50 ± 2.59) than female (145.66 ± 1.28) among genotypes. TC concentration of male and female for KK and L chickens were 189.41 ± 4.62, 152.38 ± 3.01, 157.62 ± 2.72 and 140.13 ± 0.71 mg/dl, consecutively. In addition, significantly higher TC concentrations (P ≤ 0.001) were obtained in male than female KK and L chickens. TC concentration of male and female for CH and HC chickens were 171.73 ± 4.60, 148.24 ± 3.21, 163.18 ± 3.94 and 145.40 ± 1.87 mg/dl, respectively. Similarly, male had significantly higher TC concentration (P ≤ 0.01) than female CH and HC chickens. TC concentration of male and female for C and H chickens were 162.39 ± 7.02, 144.91 ± 4.74, 160.68 ± 5.39 and 142.90 ± 2.27 mg/dl, consecutively. Besides, significantly higher TC concentrations (P ≤ 0.05) were observed in male than female C and H within chickens.

Slow growing chickens had significantly (P < 0.05) lower serum TC concentration (152.25 ± 5.39 mg/dl) than fast growing (180.91 ± 6.49 mg/dl) chickens

[21]. Likewise, indigenous (146.44 ± 2.28 mg/dl) chicken had significantly ($P < 0.001$) lower serum TC content than broiler (170.63 ± 3.02 mg/dl) chickens [22]. Similarly, indigenous (107.13 ± 12.26 mg/dl) chicken had significantly ($P < 0.01$) lower serum TC content than broiler (209.50 ± 5.67 mg/dl) chickens [23]. Male showed significantly ($P < 0.01$) higher level of TC than female in Anka and Rugao chickens as observed in [24] scrutiny. TH slow growing chickens had significantly ($P < 0.05$) lower meat TC compared to SH, BPR and THB fast growing chickens [25]. Lipogenic enzymes such as lipoprotein lipase, hepatic lipase, HMGCoA-reductase, and cholesterol 7a-hydroxylase might affect endogenous TC concentration [26] [27] studies. Lipoproteins were found highly sensitive to hormonal and genetic modulation [7] [28]. The difference in cholesterol and other steroid levels could affect the production and reproduction performances [21] [29].

Mean values of TG for KK, CH, HC, C, H and L were 133.94 ± 2.63, 130.19 ± 2.02, 128.64 ± 1.57, 126.31 ± 1.06 and 125.61 ± 1.06 and 124.65 ± 0.94 mg/dl, in that order. Moreover, KK had significantly higher TG concentration ($P \leq 0.001$) than CH, HC, C, H and L genotypes. Likewise, there were significantly higher TG concentration ($P \leq 0.001$) in male (132.26 ± 1.09) than female (124.19 ± 0.44) among chickens. It was noted that TG concentration of male and female for KK and L were 141.82 ± 2.01, 126.07 ± 1.27 and 126.76 ± 1.19 and 122.54 ± 0.83 mg/dl, congruently. Additionally, significantly higher TG concentrations ($P \leq 0.001$) were noted in male than female KK and L chickens. TG concentration of male and female for CH and HC were 135.43 ± 2.45, 124.96 ± 0.96, 133.32 ± 1.05 and 123.96 ± 1.00 mg/dl, respectively. Further, male had significantly higher TG concentration ($P \leq 0.01$) than female for CH but significantly higher ($P \leq 0.001$) for HC chickens. TG concentration of male and female for C and H chickens were 128.82 ± 1.39, 123.80 ± 0.70 and 127.43 ± 1.23 and 123.79 ± 1.45 mg/dl, successively. Significantly higher TG concentrations ($P \leq 0.05$) were found in male than female for C and H chickens. TG was significantly affected ($P \leq 0.001$) by genotype and sex interaction among the chickens.

There were significantly ($P < 0.05$) lower serum TG levels observed Dandarawi (139.15 mg/dl) than in Dokki (143.16 mg/dl) of native Egyptian chickens [30]. There were significant ($P < 0.01$) variations in serum TG levels among the chickens [26] [31]. TH slow growing chickens had significantly ($P < 0.05$) lower meat TG compared to SH, BPR and THB fast growing chickens [25]. TG concentration might be varied due to acetyl-CoA carboxylase [18] and fatty acid synthase [24]. Similarly, TG concentration might be influenced due to insulin activities [2]. TG concentration might be affected due to acyl-Coenzyme oxidase1 (ACOX1) and carnitine palmitoyltransferase1 (CPT1) [5]. Added, TG concentration might be affected due to stearoyl-coa desaturase (SCD) [27]. Likewise, TG concentration might be affected due to Triglyceride lipase (TAG-Lipase) [5]. Adipogenesis inhibitors (1,25-(OH)2D3) could also affect mRNA abundance and expression of genes to influence fat and TG [28].

Mean values of LDL for KK, CH, HC, C, H and L were 91.03 ± 5.22, 88.16 ± 7.73, 87.49 ± 3.91, 83.88 ± 2.78, and 80.78 ± 2.86 and 78.88 ± 3.19 mg/dl, in order. Moreover, KK had significantly higher LDL concentration ($P \leq 0.001$) than CH, HC, C, H and L genotypes. Likewise, there were significantly higher LDL concentration ($P \leq 0.001$) in male (91.54 ± 2.31) than females (78.53 ± 1.38) among chickens. The study discovered that LDL concentration of male and female for KK and L chickens were 98.14 ± 7.75, 83.92 ± 6.28, 85.21 ± 4.71 and 72.54 ± 2.57 mg/dl, sequentially. Moreover, significantly higher LDL concentration ($P \leq 0.05$) were found in male than female KK and L chickens. Results have shown that LDL concentration of male and female for CH and HC chickens were 95.55 ± 5.94, 80.76 ± 2.03, 94.22 ± 6.71, 80.76 ± 2.03 mg/dl, chronologically. Similarly, significantly higher LDL concentration ($P \leq 0.05$) were found in male than female CH and HC chickens. It had also shown that LDL concentration of male and female for C and H chickens were 90.75 ± 3.24, 77.00 ± 2.13, and 85.38 ± 4.75 and 76.17 ± 2.23 mg/dl, in sequence. Further, significantly higher LDL concentration ($P \leq 0.05$) were found in male than female C and H chickens.

Indigenous (25.80 ± 9.06 mg/dl) chicken had significantly ($P < 0.001$) lower serum LDL content than broiler (81.94 ± 4.19 mg/dl) chickens [23]. Male showed significantly ($P < 0.05$) higher level of LDL than female in Anka (52.66 ± 5.63, 34.22 ± 5.21) and Rugao (46.58 ± 7.05, 24.54 ± 5.57) chickens [30], respectively. Lipoprotein lipase and apoB-100 and apoE can regulate the LDL contents [7]. Hepatic lipase may influence the activity of serum LDL levels [6] [23] [27]. The suppression of hepatic lipogenic enzymes is attributed to their ability to suppress or inhibit the expression of genes coding for lipogenic proteins [5] [32]. Aspartate transaminase (AST) and Alanine transaminase (ALT) may determine the liver function and LDL concentration [23] study.

Mean values of HDL for L, H, C, HC, CH, and KK were 86.45 ± 3.20, 84.37 ± 3.43, 79.86 ± 3.63, 78.63 ± 3.56, and 78.38 ± 3.67 and 76.01 ± 3.27 mg/dl, uninterruptedly. Moreover, KK had significantly higher HDL concentration ($P \leq 0.001$) than CH, HC, C, H and L genotypes. Likewise, there were significantly higher HDL concentration ($P \leq 0.001$) in Female (89.83 ± 1.29) than male (71.40 ± 1.33) among chickens. Study has noted that HDL concentration of female and male for L and KK chickens were 96.04 ± 1.78, 76.85 ± 2.26, 85.45 ± 2.05 and 66.57 ± 2.69 mg/dl, in turn. Besides, significantly higher HDL concentrations ($P \leq 0.001$) were found in female than male L and KK chickens. It had observed that HDL concentration of female and male for HC and CH chickens were 88.35 ± 3.58, 68.92 ± 2.25, 88.35 ± 3.58 and 68.42 ± 2.56 mg/dl, in turn. Significantly higher HDL concentrations ($P \leq 0.001$) were found in female than male in HC chicken. Besides, significantly higher HDL concentrations ($P \leq 0.01$) were found in female than male in CH chicken. It had witnessed that HDL concentration of female and male for H and C chickens were 92.13 ± 1.75, 76.61 ± 4.95, 88.68 ± 4.45 and 71.03 ± 2.65 mg/dl, in turn. Significantly higher HDL concentrations ($P \leq 0.05$) were found in female than male in H chicken. Furthermore, significantly

higher HDL concentrations ($P \leq 0.01$) were found in female than male in H chicken (see Table 2).

Table 2. Effect of sex on serum biochemical parameters.

		Serum biochemical parameters			
		TC	TG	LDL	HDL
Genotype (G)	Sex	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
KK	M	189.41 ± 4.62[a]	141.82 ± 2.01a	98.14 ± 7.75[a]	66.57 ± 2.69[b]
	F	152.38 ± 3.01[b]	126.07 ± 1.27b	83.92 ± 6.28[b]	85.45 ± 2.05[a]
P-value		***	***	*	***
Overall		170.89 ± 6.17	133.94 ± 2.63	91.03 ± 5.22	76.01 ± 3.27
CV		12.51	6.80	19.85	14.91
CH	M	160.68 ± 5.39[a]	127.43 ± 1.23[a]	85.38 ± 4.75[a]	76.61 ± 4.95[b]
	F	142.90 ± 2.27[b]	123.79 ± 1.45[b]	76.17 ± 2.23[b]	92.13 ± 1.75[a]
P-value		*	*	*	*
Overall		151.79 ± 10.13	125.61 ± 1.06	80.78 ± 2.86	84.37 ± 3.43
CV		6.67	2.92	12.27	14.07
HC	M	162.39 ± 7.02[a]	128.82 ± 1.39[a]	90.75 ± 3.24[a]	71.03 ± 2.65[b]
	F	144.91 ± 4.74[b]	123.80 ± 0.70[b]	77.00 ± 2.13[b]	88.68 ± 4.45[a]
P-value		*	**	**	**
Overall		153.65 ± 4.82	126.31 ± 1.06	83.88 ± 2.78	79.85 ± 3.63
CV		10.87	2.91	11.47	15.75
C	M	163.18 ± 3.94[a]	133.32 ± 1.05[a]	94.22 ± 6.71[a]	68.92 ± 2.25[b]
	F	145.40 ± 1.87[b]	123.96 ± 1.00[b]	80.76 ± 2.03[b]	88.35 ± 3.58[a]
P-value		**	***	*	***
Overall		154.29 ± 3.39	128.64 ± 1.57	87.49 ± 3.91	78.63 ± 3.56
CV		7.61	4.23	15.49	15.67
H	M	171.73 ± 4.60[a]	135.43 ± 2.45[a]	95.55 ± 5.94[a]	68.42 ± 2.56[b]
	F	148.24 ± 3.21[b]	124.96 ± 0.96[b]	80.76 ± 2.03[b]	88.35 ± 3.58[a]
P-value		**	**	*	**
Overall		159.98 ± 4.44	130.19 ± 2.02	88.16 ± 3.73	78.38 ± 3.67
CV		9.61	5.37	14.66	16.20
L	M	157.62 ± 2.72[a]	126.76 ± 1.19[a]	85.21 ± 4.71[a]	76.85 ± 2.26[b]
	F	140.13 ± 0.71[b]	122.54 ± 0.83[b]	72.54 ± 2.57[b]	96.04 ± 1.78[a]
P-value		***	*	*	***
Overall		148.88 ± 2.96	124.65 ± 0.94	78.88 ± 3.19	86.45 ± 3.20
CV		6.88	2.61	14.02	12.82

[abcd]Mean values each sex of a genotype under the same category across column that bear different superscript letters are significantly different, Ns = $P > 0.05$, *** = $P < 0.001$, ** = $P < 0.01$, * = $P < 0.05$, SE = standard error of mean, KK = Koekoek, H = Horro, C = Cosmopolitan, HC = Horro male and Cosmopolitan female crosses, CH = Cosmopolitan male and Horro female crosses.

Significantly (P < 0.01) higher HDL levels were observed in Rugao (118.15 ± 3.99) than Anka (93.97 ± 2.78) chickens [24]. Indigenous (131.31 ± 5.84 mg/dl) chicken had significantly (P < 0.01) higher HDL content than broiler (103.33 ± 12.61 mg/dl) chickens [23]. There were significant (P < 0.05) differences in serum HDL levels among the six chicken lines [26]. Male (91.97 ± 4.16; 125.47 ± 5.76 mg/dl) had comparable (P > 0.05) HDL concentration with female (95.97 ± 3.71; 110.82 ± 5.28 mg/dl) in Rugao and Anka chickens, respectively [24]. Lipoprotein lipase and apolipoproteins (apoA-I; apoE; apoC-II) can regulate the HDL contents [7]. Hepatic lipase may impress the bustle of HDL concentration [6] [27]. HDL concentration might be affected due to esterase and oxidase [2].

The fatty acid content of meats obtained from KK, CH, HC, C, H and L chickens were indicated in **Table 3**. There were significantly higher (P ≤ 0.05) Myristic acid contents in HC meat (1.23 ± 0.34) followed by H (1.02 ± 0.08), C (0.88 ± 0.05), CH (0.71 ± 0.04), L (0.56 ± 0.01) and KK (0.53 ± 0.12) chickens. There were significantly lower (P ≤ 0.05) Pentadecanoic acid contents in L meat (1.48 ± 0.11) than C (2.07 ± 0.06), CH (2.06 ± 0.13), KK (2.02 ± 0.04), HC (1.92

Table 3. Saturated, monounsaturated and polyunsaturated fatty acid profile of meats of KK, CH, HC, C, H and L chickens.

Category	Genotype(G)						Sex(S)		P-value		
	KK	CH	HC	C	H	L	Male	Female			
FA (mg/g)	Mean ± SE								G	S	G*S
Myristic	0.53 ± 0.12^{b}	0.71 ± 0.04^{ba}	1.23 ± 0.34^{a}	0.88 ± 0.05^{ba}	1.02 ± 0.08^{ba}	0.56 ± 0.01^{b}	0.77 ± 0.06	0.87 ± 0.17	*	Ns	Ns
Pentadecanoic	2.02 ± 0.04^{a}	2.06 ± 0.13^{a}	1.92 ± 0.07^{a}	2.07 ± 0.06^{a}	1.82 ± 0.05^{a}	1.48 ± 0.11^{b}	1.82 ± 0.10	1.97 ± 0.09	*	Ns	Ns
Palmitic	20.20 ± 0.14^{ba}	19.90 ± 0.88^{ba}	19.56 ± 1.71^{ba}	17.14 ± 0.97^{b}	18.41 ± 0.80^{ba}	21.14 ± 0.23^{a}	18.97 ± 0.56	19.81 ± 0.80	*	Ns	Ns
Margaric	0.49 ± 0.08	0.47 ± 0.11	0.40 ± 0.10	0.46 ± 0.15	0.35 ± 0.05	0.30 ± 0.09	0.51 ± 0.04^{a}	0.32 ± 0.03^{b}	Ns	**	*
Stearic	10.10 ± 2.08	9.31 ± 0.80	10.02 ± 1.79	10.33 ± 1.72	9.81 ± 1.96	10.04 ± 1.40	11.56 ± 0.31^{a}	8.31 ± 0.13^{b}	Ns	***	***
SFA	33.34 ± 2.38	32.46 ± 0.06	33.12 ± 0.24	30.87 ± 2.73	31.41 ± 1.09	33.53 ± 1.15	33.63 ± 0.54^{a}	31.28 ± 0.77^{b}	Ns	*	Ns
Myristoleic	0.27 ± 0.02^{a}	0.27 ± 0.03^{a}	0.26 ± 0.03^{a}	0.28 ± 0.04^{a}	0.27 ± 0.01^{a}	0.20 ± 0.02^{b}	0.28 ± 0.01^{a}	0.23 ± 0.01^{b}	*	*	Ns
Palmitoleic	3.10 ± 0.04^{a}	2.34 ± 0.19^{ba}	2.40 ± 0.43^{ba}	1.28 ± 0.63^{b}	3.57 ± 0.28^{a}	2.42 ± 0.50^{ba}	2.86 ± 0.26^{a}	2.18 ± 0.39^{b}	*	*	NS
Oleic acid	42.60 ± 2.42	41.81 ± 0.74	41.47 ± 1.14	42.97 ± 2.81	42.79 ± 1.61	38.52 ± 1.61	39.97 ± 0.64^{b}	43.41 ± 0.84^{a}	Ns	**	*
Eicosenoic	1.03 ± 0.22	1.03 ± 0.24	1.27 ± 0.61	1.01 ± 0.30	0.87 ± 0.28	0.84 ± 0.20	1.32 ± 0.12^{a}	0.70 ± 0.03^{b}	Ns	***	**
MUFA	47.00 ± 2.13^{a}	45.46 ± 0.27^{ba}	45.40 ± 0.06^{ba}	45.53 ± 1.84^{ba}	47.51 ± 1.05^{a}	41.98 ± 0.89^{b}	44.44 ± 0.76^{b}	46.52 ± 0.94^{a}	*	*	Ns
Linoleic	18.57 ± 0.47^{d}	20.96 ± 0.17^{bc}	20.47 ± 0.15^{c}	22.50 ± 1.05^{b}	20.16 ± 0.19^{dc}	23.72 ± 0.39^{a}	20.76 ± 0.71	21.36 ± 0.82	**	Ns	Ns
α-linolenic	1.08 ± 0.22	1.11 ± 0.16	1.01 ± 0.15	1.10 ± 0.15	0.92 ± 0.15	0.77 ± 0.13	1.16 ± 0.06^{a}	0.84 ± 0.05^{b}	Ns	**	*
PUFA	19.65 ± 0.25^{c}	22.07 ± 0.33^{b}	21.48 ± 0.30^{cb}	23.60 ± 0.90^{ab}	21.08 ± 0.04^{cb}	24.49 ± 0.25^{a}	21.93 ± 0.67	22.20 ± 0.80	**	Ns	Ns
UFA	66.66 ± 2.38	67.54 ± 0.06	66.88 ± 0.24	69.13 ± 2.73	68.59 ± 1.09	66.47 ± 1.15	66.37 ± 0.54^{b}	68.72 ± 0.77^{a}	Ns	*	Ns
PUFA/MUFA	0.42 ± 0.01^{e}	0.49 ± 0.01^{c}	0.47 ± 0.01^{dc}	0.52 ± 0.01^{c}	0.44 ± 0.01^{de}	0.58 ± 0.01^{a}	0.50 ± 0.02	0.48 ± 0.02	***	Ns	Ns
UFA/SFA	2.01 ± 0.22	2.08 ± 0.02	2.02 ± 0.02	2.26 ± 0.29	2.19 ± 0.11	1.99 ± 0.10	1.98 ± 0.05^{b}	2.21 ± 0.08^{a}	Ns	*	Ns

^{abcd}Mean values each sex and genotype that bear different superscript letters are significantly different, Ns = P > 0.05, *** = P < 0.001, ** = P < 0.01, * = P < 0.05, SE = standard error of mean, KK = Koekoek, H = Horro, C = Cosmopolitan, HC = Horro male and Cosmopolitan female crosses, CH = Cosmopolitan male and Horro female crosses.

± 0.07) and H (1.82 ± 0.05) chickens. However, there were significantly higher (P ≤ 0.05) Palmitic acid contents in L meat (21.14 ± 0.23) followed by KK (20.20 ± 0.14), CH (19.90 ± 0.88), HC (19.56 ± 1.71), H (18.41 ± 0.80) and C (17.14 ± 0.97) chickens. Regarding to SFAs, Myristic, Pentadecanoic and Palmitic showed significant differences (P ≤ 0.05) among genotypes due to difference in the number of carbon atoms and the least calories could be metabolized due to unavailability of double bond. However, Margaric (P ≤ 0.01) and Stearic (P ≤ 0.001) acids were significantly varied within sex. Margaric (P ≤ 0.05) and Stearic (P ≤ 0.001) acids were significantly influenced by genotype and sex interaction of chickens.

Myristoleic acid and Palmitoleic acid showed significantly (P ≤ 0.05) affected among genotypes and between sex due to difference in number of carbon and SCD activity. Nevertheless, Oleic acid and Eicosenoic were affected in sex. Oleic and Eicosenoic acids were also significantly (P ≤ 0.01) affected by genotype and sex interaction of the chickens due to stearoyl-CoA desaturase (SCD) and lipase activities. However, Linoleic acid had significantly (P ≤ 0.01) influenced among genotypes. Whereas, *α*-linolenic showed significant (P ≤ 0.01) difference between sex. *α*-linolenic acid contents were also significantly (P ≤ 0.05) affected by genotype and sex interaction of the chickens. The Linoleic and *α*-linolenic acid contents varied due to difference in the number and position of the double bonds. Saturated fatty acid (SFA) significantly (P < 0.05) higher for male (33.63 ± 0.54) than female (31.28 ± 0.77) chickens due to Adipogenesis inhibitors (1,25-(OH)2D3) might affect mRNA in sex [28], acetyl-CoA carboxylase [24] and SCD activity [27] [28]. [29] also noted saturated fatty acid (SFA) significantly (P < 0.05) higher for male (33.24 ± 2.19) than female (28.69 ± 1.32) Naked-Neck chickens.

MUFA had significantly (P ≤ 0.05) influenced among H (47.51 ± 1.05), KK (47.00 ± 2.13), C (45.53 ± 1.84), CH (45.46 ± 0.27), HC (45.40 ± 0.06) and L (41.98 ± 0.893) genotypes. MUFA had also significantly (P ≤ 0.05) affected between male (44.44 ± 0.76) and female (46.52 ± 0.94) chickens. MUFA had significantly affected among genotypes and within sex [14] [33]. MUFA had significantly (P ≤ 0.05) affected among Fast-growing (38.00), Medium-growing (34.80) and Slow-growing (28.70) chickens [34]. The results could be varied among genotypes due to difference in number of carbons as noted by [35], SCD in line with [28] and fatty acid lipase in agreement with [36]. Female might have superior bioactivity than male except effect of isoproterenol in agreement with [29]. PUFA significantly (P ≤ 0.05) varied among L (24.49 ± 0.25), C (23.60 ± 0.90), CH (22.07 ± 0.33), HC (21.48 ± 0.30), H (21.08 ± 0.04) and KK (19.65 ± 0.25) genotypes. PUFA had significantly (P ≤ 0.001) varied among chicken genotypes as similarly noted by [14] [37]. The results could be varied among genotypes due to difference in number and position of double bonds as noted by [37], SCD in line with [28] and internal factors in agreement with [33].

UFA had significantly (P ≤ 0.05) affected between male (66.37 ± 0.54) and female (68.72 ± 0.77) chickens. The UFA might be varied between sex due to glo-

bulin and albumin [2] [12] [37] [38] and Desaturases [18] [33]. PUFA/MUFA had significantly ($P \leq 0.001$) influenced among L (0.58 ± 0.01), C (0.52 ± 0.01), CH (0.49 ± 0.01), HC (0.47 ± 0.01), H (0.44 ± 0.01) and KK (0.42 ± 0.01) chickens. The results might be affected among genotypes due SCD activity in line with [32] and internal factors in agreement with and PUFA/MUFA of meat with less 0.40:1 ratio could affect the dietary balance [39]. UFA/SFA had significantly ($P < 0.05$) influenced in male (1.98 ± 0.05) and female (2.21 ± 0.08) chickens. UFA/SFA of meat with above 4:1 ratio could affect the dietary balance [34] and oxidative effect by isoproterenol [25]. Eggs obtained from indigenous chickens had higher PUFA than commercial chickens [18] [35]. Indigenous chickens produced healthier eggs than commercial chickens and the eggs of low growing chickens had lower pathogenic risk than eggs of fast-growing chickens [35].

Correlation coefficient (r) of serum biochemical parameter and meat fatty acid profile of different chickens indicated in **Table 4**. The UFA/SFA was strongly ($P \leq 0.001$) and positively correlated with UFA ($r = 0.997$) but strongly ($P \leq 0.001$) and negatively correlated with SFA ($r = -0.997$). Moreover, the PUFA/MUFA was strongly ($P \leq 0.001$) and positively correlated with PUFA ($r = 0.974$) but strongly ($P \leq 0.01$) and negatively correlated with MUFA ($r = -0.929$). However, UFA was perfectly ($P \leq 0.001$) and negatively correlated with SFA ($r = -1.000$). Likewise, PUFA was significantly ($P \leq 0.05$) and negatively correlated with MUFA ($r = -0.828$). Also, TC was strongly ($P \leq 0.01$) and positively ($r = 0.973$) correlated with TG. TC had also significant ($P \leq 0.05$) and positive($r = 0.877$) and negative correlation ($r = -0.826$) with LDL and HDL, respectively. Similarly, TG was strongly ($P \leq 0.01$) and positively ($r = 0.949$) correlated with

Table 4. Pearson's correlation (r) between serum biochemical parameters and meat fatty acid profile of KK, CH, HC, C, H and L Chickens.

Parameters	UFA/SFA	PUFA/MUFA	UFA	PUFA	MUFA	SFA	TC	TG	LDL	HDL
UFA/SFA	1.000	−0.059^{Ns}	0.997***	0.160^{Ns}	0.420^{Ns}	−0.997***	−0.282^{Ns}	−0.387^{Ns}	−0.269^{Ns}	0.089^{Ns}
PUFA/MUFA		1.000	−0.083^{Ns}	0.974***	−0.929**	0.083^{Ns}	−0.655^{Ns}	−0.656^{Ns}	−0.625^{Ns}	0.589^{Ns}
UFA			1.000	0.138^{Ns}	0.442^{Ns}	−1.000***	−0.290^{Ns}	−0.384^{Ns}	−0.259^{Ns}	0.086^{Ns}
PUFA				1.000	−0.828*	−0.138^{Ns}	−0.745^{Ns}	−0.759^{Ns}	−0.694^{Ns}	0.619^{Ns}
MUFA					1.000	−0.442^{Ns}	0.510^{Ns}	0.470^{Ns}	0.481^{Ns}	−0.511^{Ns}
SFA						1.000	0.290^{Ns}	0.384^{Ns}	0.259^{Ns}	−0.086^{Ns}
TC							1.000	0.973**	0.877*	−0.826*
TG								1.000	0.949**	−0.884*
LDL									1.000	−0.976**
HDL										1.000

UFA/SFA = Unsaturated Fatty Acid Ratio Saturated Fatty Acid, PUFA/MUFA = Poly Unsaturated Fatty Acid Ratio Monounsaturated Fatty Acid, SFA = Saturated Fatty Acid, UFA = Unsaturated Fatty Acid, PUFA = Poly Unsaturated Fatty Acid, MUFA = monounsaturated Fatty Acid, LDL = Low Density Lipoprotein, HDL = High Density Lipoprotein, TG = Triglycerides, TC = Total Cholesterol, ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$, Ns = Nonsignificant.

LDL. Nonetheless, TG had significant ($P \leq 0.05$) negative ($r = -0.884$) correlation with HDL. Equally, LDL was strongly ($P \leq 0.01$) and negatively ($r = -0.976$) correlated with HDL. The serum lipid profile of broilers has positive correlation with the muscle lipid [32] [40]. There was positive significant ($P < 0.05$) correlation between abdominal fat weight and serum cholesterol content of each Rugao ($r = 0.440$) and Anka ($r = 0.089$) chicken genotypes [23]. Significant ($P < 0.05$) positive correlations ($r = 0.669$) for white and ($r = 0.240$) brown chickens were determined between serum TC level and egg production and correlation of serum lipids and egg lipids could be significantly varied [38] [39]. However, serum cholesterol was negatively correlated with egg cholesterol in white and brown chickens [39]. The serum lipid profile of chickens had positive correlation with the egg lipid and could direct much research towards enabling to produce low cholesterol eggs and might have market implication [27]. BPR and SH chickens have faster growth rate and accumulate more fat than TH chickens. TG had positive correlation with fat accumulation in meat of chickens [25] [41].

Saturated fatty acids would be related to increased levels of total cholesterol, LDL, and triglyceride while UFA associated to increase the LDL level in chickens [40] [42]. The result of this study suggests that lipoproteins in serum could be directly related with lipoproteins of chicken products [43]. PUFA/SFA ratio below 0.45 in chicken meats had been reported unhealthy for consumers [31]. Fast growing chicken strains had higher fatty meats than slow growing strains [31] [38]. Slow growing breast and thigh meats of chickens had shown lower composition of lipids than fast growing chickens [34] [44]. PUFA and PUFA n-6 resulted significantly ($P < 0.01$) higher in both thigh and breast meat of slow growing than fast growing chickens [34] [45] and slow growing chickens could be better sources of desirable FA than fast growing chickens [22] [46]. Padovana meat had indicated significantly ($P < 0.05$) higher UFA/SFA and lower n-6/n-3 than Polverara chickens [47].

4. Conclusion and Recommendation

In this study, it was revealed that TC, TG, LDL and HDL concentrations had significantly higher difference ($P \leq 0.001$) among and within KK, CH, HC, C, H and L chickens. TC, TG and LDL concentration of the chickens were in the order of KK > CH > HC > C > H > L except HDL. Male had significantly higher TC, TG, LDL but lower HDL ($P \leq 0.001$) than female. L had lower Myristic and Pentadecanoic but higher Palmitic deposition than others. Female had significantly lower ($P \leq 0.05$) SFA deposition than male chickens. H chicken had higher MUFA deposition than others. L chicken had higher PUFA deposition than others. Female had significantly higher ($P \leq 0.05$) UFA deposition than male. UFA values were higher than SFA across genotypes and sexes. Serum biochemical and meat fatty acid profile varied across and within genotypes and sexes. Level of serum biochemical parameters can be transferred into human. All in all, chicken products with higher level TC, TG, LDL and SFA might have human health

problems. Recommendation, dietary manipulation may improve lipids in chicken products. It could also be interesting topic for future studies.

Acknowledgements

The authors express gratitude to International Livestock Research Institute (ILRI-ACGG program) for funding the research, Ethiopian Institute of Agricultural Research (EIAR) for providing necessary opportunities. We also Haramaya University and those who directly or indirectly contributed to the accomplishment of this study.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this article.

References

[1] FAO (Food and Agriculture Organization of the United Nations) (2013) Organic Agriculture and Genetic Resources for Food and Agriculture: Rearing Native Chickens through Organic Agriculture.

[2] Wilhelm, P., Julio, L., Marko, B., Maria, C., Ali, M. andrej, S. and Suzanne, E. (2012) Lipoproteins in *Drosophila melanogaster*—Assembly, Function, and Influence on Tissue Lipid Composition. *PLOS Genetics*, **8**, e1002828. https://doi.org/10.1371/journal.pgen.1002828

[3] Zamora, A. (2019) Lipoproteins Good Cholesterol (HDL), Bad Cholesterol (LDL). https://www.scientificpsychic.com/health/lipoproteins-LDLHDL.html

[4] Nguyen, T., Nguyen, D., Huynh, T., Phan, T., Nguyen, V., Takeshi, S. and Do, V. (2020) Serum Biochemical Properties of Vietnamese Indigenous Noi Chicken at 56 Days Old. *Biotechnology in Animal Husbandry*, **36**, 329-339.

[5] Varshil, M. and Kavya, B. (2017) Lipids and Its Metabolism. *Journal of Cardiology and Cardiovascular Therapy*, **4**, Article ID: 555635.

[6] Zohreh, K., Parvaneh, K., Solmaz, C. and Soheila, K. (2010) Comparative Study of Serum Lipid Profile in Chicken, Ostrich, Cattle, and Sheep.

[7] Sharadendu, B. and Maneshwar, S. (2019) Serum Lipids and Lipoproteins: A Brief Review of the Composition, Transport and Physiological Functions. *International Journal of Scientific Reports*, **5**, 309-314.

[8] Kasperek, K., Drabik, K., Miachalak, K., Pietras, D.O., Winiarczyk, S., Zi, G.E. and Batkowska, J. (2021) The Influence of Sex on the Slaughter Parameters and Selected Blood Indices of Green Leg Partridge, Polish Native Breed of Hens. *Animals*, **11**, 517. https://doi.org/10.3390/ani11020517

[9] Cassandro, M., Marchi, M.D., Penasa, M. and Rizzi, C. (2015) Carcass Characteristics and Meat Quality Traits of the Padovana Chicken Breed, a Commercial Line, and Their Cross. *Italian Journal of Animal Science*, **14**, 3848. https://doi.org/10.4081/ijas.2015.3848

[10] Rizzi, C., Baruchello, M. and Chiericato, G.M. (2009) Slaughter Performance and Meat Quality of Three Italian Chicken Breeds. *Italian Journal of Animal Science*, **8**, 228-230. https://doi.org/10.4081/ijas.2009.s3.228

[11] Tasoniero, G., Cullere, M., Baldan, G. and Zotte, A.D. (2018) Productive Perfor-

mances and Carcass Quality of Male and Female Italian Padovana and Polverara Slow-Growing Chicken Breeds. *Italian Journal of Animal Science*, **17**, 530-539. https://doi.org/10.1080/1828051X.2017.1364611

[12] Khawaja, T., Khan, S., Mukhtar, N., Ali, A., Ahmed, T. and Ghafar, A. (2012) Comparative Study of Growth Performance, Egg Production, Egg Characteristics and Biochemical Parameters of Desi, Fayoumi and Rhode Island Red Chicken. *Journal of Applied Animal Research*, **40**, 273-283. https://doi.org/10.1080/09712119.2012.672310

[13] Molee, P.P. and Khempaka, S. (2012) Effect of Rearing Systems on Fatty Acid Composition and Cholesterol Content of Thai Indigenous Chicken Meat. *International Science Index, Animal and Veterinary Sciences*, **6**, 746-748.

[14] Russel, P., Elsje, P. and Louw, H. (2014) Comparison of Production Parameters and Meat Quality Characteristics of South African Indigenous Chickens. Stellenbosch Universit, Stellenbosch.

[15] Tabinda, K., Sohail, H.K., Nasir, M., Abida, P. and Ghulam, F. (2013) Production Performance, Egg Quality and Biochemical Parameters of Three-Way Crossbred Chickens with Reciprocal F1 Crossbred Chickens in Sub-Tropical Environment. *Italian Journal of Animal Science*, **12**, e21. https://doi.org/10.4081/ijas.2013.e21

[16] Bora, S., Gurram, S., Sagi, R., Tungani, R., Kandula, S. and Bobbili, R. (2017) Effect of Sex on Hematological and Biochemical Parameters in Three Indigenous Chickens in Telangana Region. *International Journal of Livestock Research*, **7**, 212-218. https://doi.org/10.5455/ijlr.20170729050755

[17] Fanatico, A.C., Pillai, P.B., Emmert, J.L. and Owens, C.M. (2007) Meat Quality of Slow- and Fast-Growing Chicken Lines Fed Low-Nutrient or Standard Diets and Reared Indoors or with Outdoor Access. *Poultry Science*, **86**, 2245-2255. https://doi.org/10.1093/ps/86.10.2245

[18] Imasuen, J. and Otoikhian, C. (2012) Preliminary Investigation on the Relationship between Blood Lipid Profile and Egg Lipid Profile in Different Breeds of Layers.

[19] Milicevic, D., Vranic, D., Masic, Z., Parunovic, N., Trbovic, D., Nedeljkovic, T.J. and Petrovic, Z. (2014) The Role of Total Fats, Saturated/Unsaturated Fatty Acids and Cholesterol Content in Chicken Meat as Cardiovascular Risk Factors. *Lipids in Health and Disease*, **13**, Article No. 42. https://doi.org/10.1186/1476-511X-13-42

[20] Parunovic, N., Petrovic, M., Matekalo, S., Trbovic, D., Mijatovic, M. and Radovic, C. (2012) Fatty Acid Profile and Cholesterol Content of Chickens. *South African Journal of Animal Science*, **42**, 101-113.

[21] Kalita, D., Sultana, R., Roy, M. and Bharali, K. (2018) Comparative Study of Certain Biochemical Profile of Broiler and Indigenous Chicken of Assam. *Approaches in Poultry, Dairy and Veterinary Sciences*, **2**, 175-177. https://doi.org/10.31031/APDV.2018.02.000544

[22] Subhadarsini, M., Silpa, M. and Gayatri, A. (2020) Comparative Hematology and Biochemical Parameters of Indigenous and Broiler Chicken. *International Journal of Scientific & Technology Research*, **9**, 972-979.

[23] Masud, A., Mohammad, O., Syeda, U. and Mohammad, S. (2020) Broiler and Indigenous Chickens: A Comparison through Biochemical Parameters. *International Journal of Sustainable Agricultural Research*, **7**, 228-233. https://doi.org/10.18488/journal.70.2020.74.228.233

[24] Wang, K. and Musa, H. (2007) The Impact of Obesity on Serum Biochemical Components. *Journal of Cell and Animal Biology*, **1**, 87-91. http://www.academicjournals.org/JCAB

[25] Sanchai, J., Autchara, K. and Michael, W. (2008) Carcass and Meat Characteristics of Male Chickens between Thai Indigenous Compared with Improved Layer Breeds and Their Crossbred.

[26] Kamil, F.A., Khudhair, N. and Khalid, A (2020) A Comparative Study of Some Biochemical Blood Characteristics of Six Lines of Iraqi Local Female Chickens. *Systematic Reviews in Pharmacy*, **11**, 1121-1124.

[27] Ibrahim, A., Aliyu, J., Wada, N. and Hassan, A. (2012) Effect of Sex and Genotype on Blood Serum Electrolytes and Biochemical Parameters of Nigerian Indigenous Chickens. *Iranian Journal of Applied Animal Science*, **2**, 361-365.

[28] Ramesh, A., Anand, M., Shambulingappa, B. and Ananda, K. (2009) Study of Lipid Profile and Production Performance in Layers as Influenced by Herbal Preparations Abana and Garlic Paste. *Veterinary World*, **2**, 426-428.

[29] Benabdelmoumene, D., Benakriche, B., Beghdadi, F. and Halbouche, M. (2016) Effects of Genotype and Sex on Lipid Oxidation and Fatty Acid Profile of Chicken Breast Meat. *Pakistan Journal of Nutrition*, **15**, 187-193. https://doi.org/10.3923/pjn.2016.187.193

[30] Hassan, H., Chen, G.H., Wang, K.H., Li, B.C., Mekki, D.M., Shu, J.T. and Ju, H.P. (2007) Relation between Abdominal Fat and Serum Cholesterol, Triglycerides, and Lipoprotein Concentrations in Chicken Breeds Turk. *Journal of Veterinary and Animal Sciences*, **31**, 375-379.

[31] Aline, G., Marcel, M., Juliana, L., Rodrigo, A., Fabio, B., Pedro, A. and Hirasilva, B. (2020) Lipid Assessment, Cholesterol and Fatty Acid Profile of Meat from Broilers Raised in four Different Rearing Systems.

[32] Ozlem, K., Tarkan, S., Mukremin, O., Akın, Y. and Bulent, O. (2020) Changes in Serum Biochemical and Lipid Profile, and Fatty Acid Composition of Breast Meat of Broiler Chickens Fed Supplemental Grape Seed Extract. *Turkish Journal of Veterinary and Animal Sciences*, **44**, 182-190. https://doi.org/10.3906/vet-1906-37

[33] Lenka T., Peter, H., Juraj, C., Marek, B. and Adriana, P. (2016) Fatty Acids Profile of Breast and Thigh Muscles of Broiler Chickens Fed Diets with Propolis and Probiotics.

[34] Adele, M., Federico, S., Cesare, C., Alessandra, R., Paolo, M. and Achille, F. (2016) Influence of Genotype and Feeding on Chemical Composition of Organic Chicken Meat. *Italian Journal of Animal Science*, **8**, 766-768. https://doi.org/10.4081/ijas.2009.s2.766

[35] Stefano, P., Luisa, Z., Manuela, M., Ahmad, A., Maria, G., Maria, G. and Silvia, C. (2020) Physical Parameters and Fatty Acids Profiles in Milanino, Mericanel Della Brianza, Valdarnese Bianca and Commercial Hybrids (Gallus Gallus Domesticus) Table Eggs.

[36] Jesse, B., Middleton, L., Ben, E., Arnold, M., Susan, J., Shawn, R. and Brynn, H. (2014) Molecular and Metabolic Profiles Suggest That Increased Lipid Catabolism in Adipose Tissue Contributes to Leanness in Domestic Chickens.

[37] Cesare, C., Alessandro, D., Cecilia, M. and Martina, P. (2006) Comparison of Two Chicken Genotypes Organically Reared: Oxidative Stability and Other Qualitative Traits of the Meat. *Italian Journal of Animal Science*, **5**, 355-368. https://doi.org/10.4081/ijas.2006.29

[38] Madalena, L., Joana, C., Claudia, M., Susana, P., Rui, J. and Carolino, I. (2020) A Comparison between the Quality of Eggs from Indigenous Chicken Breeds and That from Commercial Layers. *Poultry Science*, **99**, 1768-1776. https://doi.org/10.1016/j.psj.2019.11.023

[39] Alrekabi, M., Ali, N., Aldulaimi, I., Alobaidi, O., Aldulaimi, K. and Alziadi, H. (2018) The Effect of Sex and Slaughter Age in Some Blood Traits of Broiler Chicks Ross 308. *International Conference Food and Agricultural Sciences*, Mashhad, 361-366. https://civilica.com/doc/797936.PaperCOICode:CFAS01_257

[40] Rasheed, S. and Olusegun, O. (2017) Influence of Age and Strain on Hematological and Blood Biochemical Indices in Broiler Chickens Reared in Derived Savanna Environment of Nigeria. *American Journal of Biology and Life Sciences*, **5**, 34-38.

[41] Saklani, S., Singh, G., Vij, R. and Sankhyan, V. (2019) Biochemical Parameters of Native Chicken of Himachal Pradesh, Dahlem Red and Their Crosses. *International Journal of Livestock Research*, **9**, 127-132. https://doi.org/10.5455/ijlr.20190719082925

[42] Shanmathy, M., Tyagi, J., Gopi, J., Mohan, J. and Beulah, P. (2020) Effect of Various Factors on Hematology and Serum Biochemistry Values of Aseel and Kadaknath Chicken. *International Journal of Current Microbiology and Applied Sciences*, **9**, 1695-1703. https://doi.org/10.20546/ijcmas.2020.908.195

[43] Swathi, B., Srinivas, G., Raju, S., Ravi, T., Srikanth, K. and Rajender, B. (2017) Effect of Sex on Hemato-Biochemical Parameters of Indigenous Chicken Breeds in Telangana State.

[44] Antonella, D., Giulia, T., Gabriele, B. and Marco, C. (2019) Meat Quality of Male and Female Italian Padovana and Polverara Slow-Growing Chicken Breeds. *Italian Journal of Animal Science*, **18**, 398-404. https://doi.org/10.1080/1828051X.2018.1530963

[45] Rehman, S.A., *et al.* (2016) A Comparative Study on Quality, Proximate Composition and Cholesterol Content of Eggs and Meat in Fayoumi and Commercial White Leghorn Chickens. *Cogent Food & Agriculture*, **2**, Article ID: 1195539. https://doi.org/10.1080/23311932.2016.1195539

[46] Mahiza, M., Lokman, H. and Ibitoye, E. (2021) Fatty Acid Profile in the Breast and Thigh Muscles of the Slow and Fast-Growing Birds under the Same Management System. *Tropical Animal Health and Production*, **53**, 409. https://doi.org/10.1007/s11250-021-02777-1

[47] Mahmoud, A., Shaaban, S., Mayada, R., Mohamed, E., Asmaa, F., Ayman, E., Ruchi, T., Prakash, B., Sandip, K. and Kuldeep, D. (2019) Omega-3 and Omega-6 Fatty Acids in Poultry Nutrition: Effect on Production Performance and Health.