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Effects of free capric acid, lauric acid, and coconut oil supplementation on performance, carcass, and some blood biochemical parameters of broiler chickens

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Abstract: In this study, it was aimed to investigate the effects of the addition of free capric (decanoic, C10:0) and lauric (dodecanoic, C12:0) acids and coconut (*Cocos nucifera*) oil to the broiler diets on performance, carcass yield, internal organ weights and some blood parameters. A total of 144 day-old broiler chicks (Ross 308) were used in the study, and four main groups were formed with four subgroups containing equal number of chicks. The control (C) group was fed with basal diet without any supplementation and the experimental groups were fed with 0.4% free capric acid (CA)-, lauric acid (LA)-, and coconut oil (CO)-supplemented basal diets and feeding was continued for 42 days. At the end of the process, the total average live weight (LW) of C, CA, LA, and CO groups reached 3048.63, 3009.88, 3052.13, and 3060.71 g, respectively. Moreover, average live weight gains (LWG) of groups were 3004.34, 2965.53, 3007.84, and 3015.82 g; average feed intakes (FI) were 4427.34, 4405.15, 4353.89, and 4375.54 g, and feed efficiency (FE) were 1.48, 1.50, 1.46, and 1.46. Average LW, LWG, FI, and FE values were similar at the end of the experiment ($p > 0.05$). From the carcass parameters, relative carcass rates and also carcass, bursa of Fabricius, pancreas, spleen, and gizzard weights were similar between the groups ($p > 0.05$). However, there were statistically significant changes in heart and liver weights between the groups; they were the lowest in the CA group and the highest in the LA group. There were no statistically significant differences between the groups in terms of serum biochemical parameters ($p > 0.05$). However, there were significant differences between the groups in terms of serum CK, Ca, and P values, and these values were the highest in the group fed with coconut oil. In conclusion, it is possible to state that the use of free capric acid, lauric acid, and coconut oil at the rate of 0.4% did not cause any significant difference in broiler performance, carcass, and serum biochemical parameters, but also no adverse effects were observed. It has been shown that feeding with coconut oil can significantly increase dissolved calcium and phosphorus in serum and affect their metabolism in the body and can also be an important antioxidant food additive for broiler with its effect of increasing the total antioxidant status (TAS) value.

Key words: Broiler, capric acid, lauric acid, virgin coconut, performance, antioxidant

1. Introduction

Besides the use of feed materials containing major nutrients, various feed additives with properties that improve the development and performance of animals are also used in animal nutrition. For this purpose, there are various active ingredient groups listed under the name of "growth promoter" in animal nutrition. In the past years, the use of antibiotics was common practice, especially in the poultry sector, in order to reduce microbial animal deaths and improve growth. However, due to the various drawbacks of antibiotic use in animal diets, this practice was prohibited.

Fatty acids are generally in the form of organic acids. Many studies have been conducted to investigate the effects of fatty acids on animal health and performance [1]. Several studies have shown that consuming foods containing free capric acid, lauric acid, and coconut oil containing the triglyceride form of these fatty acids can have positive effects on both animal and human health [2,3,4]. It has been reported that capric and lauric acids have antimicrobial, anticandidal, and anticoccidial activities [3,5,6]. Based on these properties, it is suggested that these types of organic free fatty acids and natural oils can be an alternative to synthetic chemicals and effective performance enhancer (growth promoter) when used in the poultry diets. In addition, it is thought that they can provide the opportunity to produce high quality and healthy foods without chemical/toxic residues in animal products and offer them to human consumption.

Capric acid with its ten-carbon chain structure and lauric acid with its twelve-carbon chain structure are

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accepted as medium chain fatty acids (MCFA) [7,8]. Triglyceride forms (medium chain triglycerides - MCT) are formed by esterification of these fatty acids with glycerol. The foods that naturally contain the most triglyceride forms of medium chain fatty acids are palm oil, coconut oil, and butter [7,9,10]. Among them, it was determined that the MCFA ratio in coconut oil constitutes approximately 57%–58% of the total fatty acids (C8, C10, and C12 ratios are 6.38%, 5.56%, and 45.46%, respectively) and the rate of MCFA in palm oil was between 52% and 53% (C8, C10, and C12 ratios were 3.43%, 3.23, and 46.14%, respectively) [11,12,13].

The aim of the study was to investigate the effects of the addition of free capric (C10:0) and lauric (C12:0) acids and coconut oil to the broiler diets on performance (live weight gain, feed intake, feed efficiency), carcass yield, internal organ weights, some blood parameters (hemoglobin, glucose, total protein, albumin, triglyceride, total cholesterol, AST, ALT, ALP, GGT, LDH, CK, Ca, P, and TAS) and to determine their usability as an alternative growth-promoting feed additive in the poultry industry.

2. Materials and methods

A total of 144 day-old broiler (Ross 308) chicks were used in the study. These chicks were randomly distributed to 4 main groups with 36 chicks, 1 for control and 3 for trial, and then to 4 subgroups with 9 chicks from each main group. The chicks were fed ad libitum with diets and drinking water for 42 days and were fed as group feeding.

Three basal diets, broiler starter, broiler grower, and broiler finisher were prepared according to NRC based on the nutritional requirements of broilers for all experimental groups [14]. Chicks in the control group consumed these basal diets without the addition of any additives. On the other hand, 0.4% free capric ($C_{10}H_{20}O_2$, Sigma-Aldrich W236403, Merck KGaA, Darmstadt, Germany) and lauric ($C_{12}H_{24}O_2$, Sigma-Aldrich W261408, Merck KGaA, Darmstadt, Germany) fatty acids and coconut oil (Macitefendi, Izmir, Turkey) were added to these basal diets of each of treatment groups. In this way, four experimental groups, namely the control and 3 treatment groups, were formed. The active ingredient purity degree of the additives used was ≥ 98%.

Throughout the experiment, live weight (LW) of each chick and amounts of feed intake (FI) by each subgroups were determined weekly, and the live weight gains (LWG) and the feed efficiency (FE) values of the broilers were calculated. At the end of the experiment, a total of 16 chicks from each main group, four chicks from each subgroup were randomly selected for carcass analysis and blood collection. During the slaughter phase of the chicks, the neck area was cleaned from the feathers and the skin was disinfected, and blood samples were collected by making a transverse incision on the jugular veins with a scalpel, and then slaughtering processes were completed and the weights of the hot carcass, heart, liver, spleen, pancreas, bursa of Fabricius, and gizzard were determined and dressing percentages and relative internal organ weights were calculated. Hemoglobin (HGB) levels were determined by using the "cyanmethemoglobin" method [15], whereas glucose (Glu), total protein (TP), albumin (Alb), triglyceride (TG), total cholesterol (Chol), aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma glutamyltransferase (GGT), alkaline phosphatase (ALP), lactate dehydrogenase (LDH), creatine kinase (CK), calcium (Ca), phosphorus (P), and total antioxidant status (TAS - Rel assay diagnostic) values were determined with a spectrophotometric autoanalyzer (Mindray BS-800M, Shenzhen, China).

The nutrient content of the diets used in the experiment was determined according to AOAC [16]. The ingredients and chemical contents of the diets used in the experiment are presented in Table 1.

All data obtained in the experiment were subjected to analysis of variance (one-way ANOVA) using the SPSS package program, and Duncan t-test was used to determine the difference between groups.

Approval for this study was obtained from the Animal Experiments Ethics Committee of Kırıkkale University with the number 07/36.

3. Results

Performance parameters (LW, LWG, FI, and FE) are presented in Table 2. The total mean live weights of the C, CA, LA, and CO groups were 3048.63, 3009.88, 3052.13, and 3060.71 g, respectively in the study. However, when the live weights of the groups were examined in weekly periods, the C, CA, and LA groups gained statistically more live weights than the CO group in the first 3 weeks ($p < 0.05$), and the live weights of groups were similar in the last 3 weeks of the experiment ($p > 0.05$).

Average live weight gains were 3004.34, 2965.53, 3007.84, and 3015.82 g for the C, CA, LA, and CO groups, respectively. When examined in weekly periods, there were significant differences between the groups in the first 3 weeks of experiment ($p < 0.05$), but mean live weight gains were similar among groups ($p > 0.05$) in the other weeks. While the mean weekly live weight gain was the lowest in the CO group during the first 3 weeks, it was the lowest in the CA group at the 6th week but not statistically significant ($p > 0.05$).

While the average feed intake values were 4427.34, 4405.15, 4353.89, 4375.54, the average feed efficiencies were 1.48, 1.50, 1.46, and 1.46 for the C, CA, LA, and CO groups, respectively throughout the experiment. Based on these results, it is understood that even though there was

Table 1. Ingredients and chemical contents of the diets used in the experiment.

Feedstuffs, %	Broiler starter (0–14 days)	Broiler grower (15–24 days)	Broiler finisher (25–42 days)
Boncalite	10	10	10
Corn	40	45	45
Soybean meal (CP 44%)	30	25	24
Full-fat soybean	10	10	10
Oil	3.5	5	6
Fish meal (CP 64%)	2.5	1	1
DL-methionine	0.35	0.3	0.3
L-lysine	0.1	0.1	0.1
DCP	1.9	1.9	1.9
Limestone	1	1	1
Sodium bicarbonate	0.35	0.4	0.4
Vitamin–mineral premix[1]	0.3	0.3	0.3
Chemical content based on analysis, % DM			
Dry matter	92.09	91.18	94.28
Crude protein	23.06	21.95	22.18
Crude cellulose	4.95	5.43	5.98
Ether extract	6.20	8.18	8.39
Starch	38.04	35.87	36.68
Sugar	5.73	6.03	6.18
Ash	5.98	6.05	5.95
Metabolizable energy[2] (kcal/kg)	3059	3103	3166

[1]Vitamin–mineral premix (2.5 kg/tons of feed). Each 2.5 kg contains: vit. A, 15,000,000 IU; Vit. D_3, 3,000,000 IU; vit. E, 100,000 mg; vit. K_3, 5000 mg; vit. B_1, 3000 mg; vit. B_2, 6000 mg; vit. B_6, 6000 mg; vit. B_{12}, 20 mg; vit. PP 50,000 mg; niacin, 50,000 mg; D-biotin, 150 mg; cal.D-pantothenate, 15,000 mg; folic acid, 1500 mg; apo carotenoic acid, 2500 mg; Cu, 5000 mg; Fe, 60,000 mg; Mn, 80,000 mg; Co, 200 mg; I, 1000 mg; Zn, 60,000 mg; Se, 150 mg.
[2]Formula used to calculate ME (TSE 1991; TS 9610), kcal/kg = (37.07 × % CP) + (82 × % CC) + (39.89 × % Starch) + (31.1 × % sugar)

a tendency to decrease in the FI value of the CO group in the first 3 weeks, there were no statistically significant differences between the groups in feed intake and feed efficiency values throughout the experiment ($p > 0.05$).

Parameters related to carcass are shown in Table 3. When the carcass parameters were examined, statistically significant changes were determined between the groups in terms of heart and liver weights ($p < 0.05$), the heart and liver weights were highest in the LA group and lowest in the CA group. There was no significant difference between the groups in terms of other carcass parameters ($p > 0.05$).

When the blood biochemical parameters were evaluated (Table 4), there were statistically significant differences in CK, Ca, P, and TAS values between the groups ($p < 0.05$), these values were highest in the CO group, and the lowest in the C group. There was no significant difference between the groups in terms of other serum parameters ($p > 0.05$).

4. Discussion

4.1. Performance parameters

Studies have shown that the addition of medium chain fatty acids from 0.1% to 0.3% into broiler diets did not cause any significant differences in live weight gain, feed intake, and feed efficiency values [17,18,19]. Similarly, it was noted that the addition of 0.2% and 0.4% medium chain fat to the diet did not affect live weight gain, feed intake, and feed efficiency in Japanese quails [20]. On the other hand, Van der Hoeven-Hangoor et al. [21] stated that the administration of a mixture of capric and lauric acid (0.3% + 2.7%, respectively) to broiler diets did not change live weight gain; however, it improved feed efficiency by reducing the amount of feed consumed. Bapeer et al. [22] have also reported that the addition of 0.15% medium chain fatty acid mixture (Aromabiotic®) to diet caused significant increases in weekly LWG of chickens. In another

Table 2. Performance parameter values of treatment groups.

Parameters	Experimental groups[1] (mean ± SEM[4])					
	Weeks	C (n = 36)	CA (n = 36)	LA (n = 36)	CO (n = 36)	p
LW[2] (g)	Initiation	43.58 ± 0.67	43.56 ± 0.75	43.56 ± 0.67	43.50 ± 0.66	1.000
	3rd	1078.34^{a} ± 11.42	1094.63^{a} ± 15.11	1059.78^{ab} ± 13.66	1025.00^{b} ± 12.86	0.003
	6th	3048.63 ± 39.42	3009.88 ± 47.53	3052.13 ± 50.98	3060.71 ± 43.36	0.865
LWG[2] (g)	1–3	1034.06^{a} ± 10.87	1050.28^{a} ± 14.45	1015.50^{ab} ± 13.23	980.84^{b} ± 12.32	0.002
	4–6	1970.28 ± 29.49	1915.25 ± 36.30	1992.34 ± 43.04	1997.10 ± 41.28	0.399
	1–6	3004.34 ± 38.88	2965.53 ± 46.96	3007.84 ± 50.50	3015.82 ± 42.89	0.863
FI[2] (g)	1–3	1214.84 ± 15.78^{a}	1219.02 ± 13.25^{a}	1201.27 ± 6.90^{ab}	1172.23 ± 7.50^{b}	0.054
	4–6	3212.50 ± 26.81	3186.13 ± 81.38	3152.63 ± 73.82	3203.32 ± 42.38	0.901
	1–6	4427.34 ± 33.45	4405.15 ± 91.08	4353.89 ± 67.08	4375.54 ± 49.77	0.856
FE[2,3]	1–3	1.18 ± 0.01	1.17 ± 0.02	1.19 ± 0.01	1.20 ± 0.02	0.415
	4–6	1.64 ± 0.03	1.68 ± 0.03	1.61 ± 0.04	1.63 ± 0.04	0.498
	1–6	1.48 ± 0.02	1.50 ± 0.03	1.46 ± 0.03	1.46 ± 0.02	0.627

[1]C: Control, the group fed with the basic diet without any additives. CA: The group fed with 0.4% capric acid supplemented diet. LA: The group fed with 0.4% lauric acid supplemented diet. CO: The group fed with 0.4% coconut oil supplemented diet.
[2]LW: Live weight. LWG: Live weight gain. FI: Feed intake. FE: Feed efficiency.
[3]Amounts of feed consumed kg/live weight gains kg. [4]SEM: Standard error of the mean.
[a, b]: There is a statistical difference between data with different letters in the same row ($p < 0.05$).

Table 3. Carcass parameters of treatment groups.

Parameters	Experimental groups[1] (Mean ± SEM[3])				
	C (n = 16)	CA (n = 16)	LA (n = 16)	CO (n = 16)	p
Live weight (g)	3052.63 ± 26.50	3050.53 ± 29.26	3098.40 ± 34.55	3058.40 ± 44.68	0.733
Carcass weight (g)	2438.69 ± 24.36	2445.67 ± 30.19	2451.47 ± 28.66	2443.60 ± 35.08	0.992
Dressing percentages, (LW/CW)[2]	79.88 ± 0.18	80.14 ± 0.31	79.12 ± 0.28	79.96 ± 0.79	0.404
Liver weigh (g)	42.14^{ab} ± 1.62	40.70^{b} ± 1.18	47.67^{a} ± 1.90	44.2^{ab} ± 1.23	0.011
Percentage of liver, (g/100 g LW)	1.38^{b} ± 0.05	1.35^{b} ± 0.03	1.57^{a} ± 0.07	1.46 ^{ab} ± 0.05	0.014
Heart weigh (g)	12.72^{ab} ± 0.30	11.97^{b} ± 0.29	13.73^{a} ± 0.46	13.12^{ab} ± 0.46	0.018
Percentage of heart, (g/100 g LW)	0.42^{ab} ± 0.01	0.40^{b} ± 0.01	0.45^{a} ± 0.01	0.43^{a} ± 0.01	0.018
Spleen weigh (g)	2.59 ± 0.23	2.22 ± 0.16	2.74 ± 0.21	2.68 ± 0.22	0.302
Percentage of spleen, (g/100 g LW)	0.09 ± 0.007	1.35 ± 0.005	1.57 ± 0.007	1.46 ± 0.007	0.235
Pancreas weigh (g)	3.93 ± 0.12	3.92 ± 0.15	4.17 ± 0.15	4.11 ± 0.16	0.515
Percentage of pancreas, (g/100 g LW)	0.13 ± 0.004	0.13 ± 0.005	0.14 ± 0.005	0.14 ± 0.004	0.395
Bursa of Fabricius weigh (g)	6.50 ± 0.38	5.90 ± 0.45	7.08 ± 0.56	6.07 ± 0.45	0.292
Percentage bursa of Fabricius, (g/100 g LW)	0.21 ± 0.01	0.20 ± 0.01	0.23 ± 0.02	0.20 ± 0.01	0.380
Gizzard weigh (g)	28.57 ± 0.82	28.25 ± 1.34	25.94 ± 0.90	27.82 ± 0.83	0.252
Percentage of gizzard (g/100 g LW)	0.94 ± 0.03	0.94 ± 0.05	0.85 ± 0.03	0.92 ± 0.02	0.240

[1]C: Control, the group fed with the basic diet without any additives. CA: The group fed with 0.4% capric acid supplemented diet. LA: The group fed with 0.4% lauric acid supplemented diet. CO: The group fed with 0.4% coconut oil supplemented diet.
[2]LW: Live weight. CW: Carcass weight. Dressing percentage = carcass weight / preslaughter live weight × 100. [3]SEM: Standard error of the mean.
[a, b]: There is a statistical difference between data with different letters in the same row ($p < 0.05$).

Table 4. Serum biochemistry parameters of treatment groups.

Parameters[2]	Experimental groups[1] (Mean ± SEM[3])				
	C (n = 16)	CA (n = 16)	LA (n = 16)	CO (n = 16)	p
Glu (mg/dL)	213.34 ± 3.04	212.69 ± 3.48	201.17 ± 4.52	209.08 ± 6.42	0.222
TP (g/dL)	2.73 ± 0.06	2.74 ± 0.06	2.84 ± 0.10	2.75 ± 0.06	0.711
Alb (g/dL)	1.11 ± 0.03	1.14 ± 0.03	1.17 ± 0.04	1.11 ± 0.03	0.560
TG (mg/dL)	31.82 ± 1.11	29.18 ± 1.53	33.68 ± 2.61	32.25 ± 2.06	0.416
Chol (mg/dL)	127.48 ± 2.48	119.54 ± 2.75	120.59 ± 2.19	125.95 ± 2.50	0.070
ALP (U/L)	1621.55 ± 120.49	1534.51 ± 92.92	1740.92 ± 84.05	1542.40 ± 93.02	0.425
CK (U/L)	22417.16^{b} ± 934.05	36296.54^{a} ± 2610.04	36190.30^{a} ± 3797.57	40893.33^{a} ± 3327.80	0.001
LDH (U/L)	2564.87 ± 170.31	2511.03 ± 147.81	2625.36 ± 286.51	2963.02 ± 292.53	0.522
ALT (U/L)	3.43 ± 0.66	4.18 ± 0.24	3.98 ± 0.63	3.89 ± 0.44	0.771
AST (U/L)	616.10 ± 23.71	627.40 ± 23.20	636.70 ± 34.45	628.37 ± 18.69	0.955
GGT (U/L)	15.19 ± 0.86	14.60 ± 0.45	14.16 ± 1.10	15.76 ± 0.73	0.547
Ca (mg/dL)	6.32^{c} ± 0.21	7.40^{ab} ± 0.22	6.82^{bc} ± 0.22	7.63^{a} ± 0.23	0.001
P (mg/dL)	4.82^{bc} ± 0.14	5.10^{ab} ± 0.11	4.59^{c} ± 0.15	5.42^{a} ± 0.18	<0.001
HGB (g/dL)	13.05 ± 0.51	12.71 ± 0.42	13.40 ± 0.23	13.63 ± 0.31	0.341
TAS (mmol Trolox Eq/L)	0.88^{b} ± 0.03	1.01^{ab} ± 0.04	1.04^{ab} ± 0.06	1.16^{a} ± 0.10	0.022

[1]C: Control, the group fed with the basic diet without any additives. CA: The group fed with 0.4% capric acid supplemented diet. LA: The group fed with 0.4% lauric acid supplemented diet. CO: The group fed with 0.4% coconut oil supplemented diet.
[2]Glu: Glucose. TP: Total protein. Alb: Albumin. TG: Triglyceride. Chol: Total cholesterol. ALP: Alkaline phosphatase. CK: Creatine kinase. LDH: Lactate dehydrogenase. ALT: Alanine aminotransferase. AST: Aspartate aminotransferase. GGT: Gamma glutamyltransferase. Ca: Calcium. P: Phosphorus. HGB: Hemoglobin. TAS: Total antioxidant status.
[3]SEM: Standard error of the mean.
[a, b]: There is a statistical difference between data with different letters in the same row ($p < 0.05$).

study, it was reported that 1% capric or lauric acid addition to the broiler diet did not show significant differences in feed intake and live weight values of broilers compared to the control group, but if the additive rate was increased to 3%, these parameters were negatively affected [23]. In addition, Hejdysz et al. [24] reported that the use of 0.85% capric acid in broiler diet significantly reduced LWG and feed intake values but did not change the feed efficiency. When the literature is reviewed, it is understood that in determining the effects of medium chain free fatty acids on performance parameters in poultry, a few of these fatty acids are combined and used in the range of about 0.1% to 0.4%, but studies in which these fatty acids are tested alone are limited. Furthermore, the results of the studies in the literature are quite different. Some studies have reported improvements in performance parameters, while others have reported no change. However, it is understood that no adverse effects are encountered in cases where the free fatty acid additive rate does not exceed 1% in the diets. In the present study, with the use of 0.4% capric acid, it was observed that all performance parameters of the group were similar to the control group and were consistent with the results obtained from studies mentioned above with similar rates. With this, in the use of lauric acid, it was observed that the LA group had a tendency to remain low in LW, LWG, and FI parameters compared to the C and CA groups in the same weeks, but it quickly closed this gap in the last few weeks and caught up with the other groups.

When the poultry studies with coconut oil are examined, it is understood that there are limited studies with this oil in the literature. In a study, when broiler chickens were fed diets containing 1.5%–3% of soybean oil, mainly long-chain fatty acids, and coconut oil, rich in medium chain fatty acid, no significant changes were observed in LWG, feed intake, and feed efficiency values between the groups [25]. Similarly, it was reported that the addition of 2% coconut oil to broiler diets did not cause any significant changes in the performance parameters of broilers [26]. However, it is also stated that FI and LW values of broiler chickens decrease significantly when this

ratio is increased to 7% [23]. In the present study, although the high ratio of coconut oil was not used as in the above studies, it was seen that LW and LWG values of CO group were significantly lower in the first couple of weeks but towards the end of the experiment, the group closed this gap and caught up with the other groups in terms of all performance parameters and became similar.

As a result, when these additives are used as 0.4%, it is understood that while the broiler initially reacted negatively to coconut oil and partially to lauric acid, in the further process, all the groups were freed from the effects of these additives and completed the breeding period with similar performance.

4.2. Carcass parameters

It was reported in one study that the addition of 0.3% MCFA to the broiler diets did not cause a significant change in the carcass, thigh, liver, gallbladder, and pancreas weights of the animals, but lower abdominal fat and higher breast meat ratios were achieved in the experimental groups compared to the control group [18]. Bapeer et al. [22] noted that the addition of 0.15% MCFA mixture to broiler diet did not result in significant differences in bursa of Fabricius and spleen weights of chickens compared to those fed control diet without supplementation. On the other hand, Saeidi et al. [20] reported that giving 0.2% and 0.4% MCFA mixture to Japanese quails did not cause significant differences in liver, spleen, bursa of Fabricius, breast and thigh meat ratios, but a significant decrease was observed in abdominal fat ratios. Also, Khatibjoo et al. [18] noted that the addition of 0.1% MCFA to broiler rations did not cause significant changes in carcass and visceral weights. Again, in these studies, it is seen that few of the medium chain free fatty acids are combined and used as a mixture in the range of 0.1%–0.4% in the determination of carcass parameters, and there are very few studies where their free forms are tested separately. However, the striking point in these studies is that while there are no significant changes in most of the carcass parameters, the decrease in abdominal fat is observed when the ratio of MCFA in diet is increased to 0.3% and above. This situation suggests that the use of MCFA may have a reducing effect on the fat deposit ratio in the body. However, amounts of abdominal fat were not determined in the present study.

There is also limited information on the effects of coconut oil on poultry carcass in the literature. It has been reported that the addition of 1.5% to 2% coconut oil to broiler diets did not cause significant changes in carcass parameters and relative weights of internal organs (liver, gizzard, heart, spleen, bursa of Fabricius) of the groups [26,27]. In the present study, it was determined that the heart and liver weights of the group fed with CO were similar to those of the C and LA groups, but they were significantly higher than those of the CA group ($p < 0.05$), and no significant changes were observed between the groups in terms of other carcass parameters ($p > 0.05$).

In summary, it is thought that the lower results of the heart and liver weights, especially in the CA group compared to the other groups, or the reasons for the elevations seen in the CO and LA groups with the same parameters, can be meaningful by the histological evaluation and interpretation of these organs in similar studies with these fatty acids.

4.3. Serum biochemical parameters

On this subject, Shokrollahi et al. [18] reported that the addition of 0.3% MCFA to the broiler diet did not cause a significant change in blood triglyceride levels, but blood glucose, total cholesterol, and LDL cholesterol levels decreased significantly, while HDL cholesterol levels increased significantly. Similarly, Saeidi et al. [20] stated that the addition of 0.2% and 0.4% MCFA mixture to Japanese quail diets resulted in significant decreases in serum parameters such as total cholesterol, LDL cholesterol, and triglyceride levels, and an increase in HDL cholesterol levels. However, Khatibjoo et al. [19] noted that the addition of 0.1% MCFA mixture to broiler diets resulted in significant decreases in serum glucose and total cholesterol levels, but no changes in triglyceride, HDL and LDL cholesterol levels. Based on the results obtained in these studies, it is thought that the addition of 0.2% or more MCFA to the diets affects the lipid metabolism of animals positively and this situation may provide positive contributions to the health of the animals.

Data on the effects of coconut oil on serum biochemical parameters of broilers are very limited. It is seen that the studies carried out are generally aimed at examining lipid parameters. Wang et al. [25] reported that when 1.5%–3% of soybean oil and coconut oil were added to broiler diets, there was no significant change in glucose and HDL values of the groups, but while serum total cholesterol and LDL values of those fed with coconut oil decreased, their triglyceride levels increased. In the present study, only triglyceride and total cholesterol levels were examined among the lipid parameters, and it was determined that there was no significant difference between the experimental groups in terms of these parameters. However, it is observed that the C and CO groups had similar and relatively higher total cholesterol levels, while there was a decreasing trend in the CA and LA groups.

In this study, one of the parameters that showed significant differences between the groups was the CK value. As it is known, serum CK increases are known to increase especially after the increase in body muscle activities (exercise, etc.) or conditions that cause skeletal-heart muscle cell degeneration (operation, trauma,

muscular infection, ketoacidosis, etc.) [28]. On the other hand, it was reported that serum CK elevation may be due to fatty acid oxidation metabolism disorder. In the present study, the higher results in all the supplemented groups compared to the control group suggest that these additives may cause increases in energy metabolism or inflammatory reactions in skeletal-cardiac muscle cells [29].

In the study, it was determined that serum Ca and P levels were high in CO and CA groups, and low in C and LA groups. It is well-known that the high fat content of the diet increases the formation of calcium soap in the digestive system and reduces its absorption. It has been reported that calcium absorption from the digestive tract and plasma calcium concentration may vary depending on the dietary fatty acid type, but such a change was not observed in phosphorus [30]. However, in the present study, the literature data on the reasons for the differences in serum calcium and phosphorus levels between the groups could not be found, and it is thought that this situation should be further studied.

Among the parameters examined in the study, the serum TAS value was the highest in the CO group, similar in the CA and LA groups, and the lowest in C group. According to these data, it was seen that the coconut oil created a significant antioxidant activity in broilers, and capric and lauric acids had also antioxidant activity-increasing properties in broilers.

In conclusion, addition of 0.4% capric acid, lauric acid, and coconut oil into broiler diets did not cause any significant difference in broiler performance, carcass, and serum biochemical parameters, but also no adverse effects were observed. Moreover, it seemed that feeding broilers with coconut oil can significantly increase the dissolved calcium and phosphorus ratios in the serum, as well as the TAS value, and can affect the body's calcium–phosphorus metabolism and can be an important antioxidant food additive for the body. Thus, it was thought that free capric and lauric acids and coconut oil containing these fatty acids can be recommended additives in the preparation of healthy-balanced diets.

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