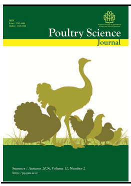

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Performance and Some Blood Biochemical Parameters of Broilers Fed Diets Containing Hemp Seed Oil

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Abstract
This study aimed to explore the impact of incorporating hemp seed oil (*Cannabis sativa L.*) at 1.5% and 3% levels in broiler diets on broiler performance, carcass yield, weights of some internal organs, and some blood parameters. In total, 132 day-old broiler chicks (Ross 308) were utilized, with the control group (C) receiving a basal diet without supplementation. Experimental groups included 1.5% hemp seed oil (HO_A) and 3% hemp seed oil (HO_B) added to the basal diet. The 42-day experiment concluded with the total average live weight (LW) for control, HO_A, and HO_B groups reaching 2637.90, 2647.81, and 2665.68 g, respectively. Average live weight gains (LWG) were 2595.03, 2605.16, and 2622.54 g; average feed intake (FI) amounted to 4044.25, 3880.78, and 3900.36 g, and feed conversion ratio (FCR) values were 1.56, 1.50, and 1.49, respectively. While LW, LWG, and FI values did not differ significantly between groups ($P > 0.05$), the addition of hemp seed oil notably improved FCR ($P < 0.05$). Relative carcass rates and weights of carcass, heart, pancreas, and spleen were similar across groups ($P > 0.05$). However, liver weight was lowest in the HO_A group, and the bursa of Fabricius weight was lowest in the C group ($P < 0.05$). No statistical differences were observed in serum glucose, albumin, triglyceride, and total cholesterol parameters among groups ($P > 0.05$). Total protein, HDL-c, non-HDL-c, LDL-c, TAC, and TOC values were significantly influenced by hemp seed oil ($P < 0.05$). In conclusion, the data suggest that adding up to 3% hemp seed oil to broiler diets can have notable effects on feed conversion ratio and serum biochemical parameters, offering critical health benefits, particularly in improving serum lipid profiles. However, the antioxidant properties of hemp seed oil were found to be weak.

Introduction

Hemp plant, which is grown in various regions of Turkey, has nausea, vomiting, anorexia, anti-inflammatory, anti-anxiety, antiepileptic, pain reliever, pleasant and narcotic properties, while the seed has aphrodisiac, laxative, menstrual and diuretic effects. In addition, the fibers obtained from the plant body can be used as rope, paper, fabric, etc. Since it is a suitable raw material for the construction of materials, it has been a known and cultivated plant since ancient times (Baytop, 1999; Della and Di Salvo, 2020).

The extract, which has pleasure-inducing and narcotic effects, is obtained from the flower buds and leaves of the plant. Due to this feature, many countries have banned the agricultural cultivation of this plant. However, cannabis species produced for industrial purposes should not be confused with that are produced for narcotic purposes. It is distinguished by the level of the psychoactive substance of the plant called "Tetrahydrocannabinol (THC)". This substance is found at very low levels (THC $\leq$ 0.3%) in species developed and grown for industrial purposes (Small and Marcus, 2003; Callaway, 2004; Farinon *et al.*, 2020). With worldwide breeding

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studies, many cannabis varieties can be produced for industrial purposes and those with low THC content have been developed. Similarly, different domestic cannabis varieties (e.g., Narlı and Vezir) have been developed with the breeding studies carried out in Turkey in recent years (Gizlenci *et al.*, 2019). The seeds of the cannabis species grown for industrial purposes do not contain any harmful or illegal ingredients. The seeds are used for spice or snack purposes, but the oil is used for cosmetics, pharmaceuticals and industrial chemistry (biofuel, paint, alcohol industry, etc.). At the same time, a high level of agricultural cultivation of this plant species can be carried out both in Turkey and in some other countries due to its features such as the use of stem fibers. However, this can be done by obtaining permission from the relevant government institutions (as this plant is classified in the group of "the plant species subject to conditional / under surveillance cultivation") (Gizlenci *et al.*, 2019).

Hemp seeds contain 25 - 36% oil, 20 - 34% carbohydrates, 20 - 27% protein and approximately 5260 - 6258 kcal/kg of gross energy. With these features, it has the characteristics of being an alternative food/feed raw material/additive with nutraceutical effects in both human and animal nutrition (Deferne and Pate, 1996; Farinon *et al.*, 2020; Leizer *et al.*, 2000; Callaway, 2004; Gakhar *et al.*, 2012; Fallahi *et al.*, 2022). Polyunsaturated fatty acids (75 - 80%) constitute a significant portion of hemp seed oil, and omega-3 fatty acids (17 - 19% α-linolenic acid) constitute a significant portion of them (Parker *et al.*, 2003; Klir *et al.*, 2019). Hemp seeds are generally used as feed for exotic bird species, and the oil is extracted, and the remaining meal can be used as feed for other animal species (Hessle *et al.*, 2008). In the studies conducted with laying hens, it was determined that the color intensity of the egg yolk and the polyunsaturated fatty acids (omega 3) ratios in the egg white and yolk increasedwhile the ratios of the egg yolk and saturated fatty acids decreased with the use of hemp seeds, meal or oil in the diet (Neijat *et al.*, 2016). It has been reported that up to 20% of the seed, 10% of the meal and 12% of the oil can be used as feed in laying hen diets without any adverse effects and yield losses (Silversides and Lefrançois, 2015; Gakhar *et al.*, 2012; Goldberg *et al.*, 2012; Halle and Schöne, 2013; Stastnik *et al.*, 2015; Konca *et al.*, 2019). Several studies have been carried out using hemp seed and hemp seed meal in broiler, however, there is a limited study conducted with broiler chickens using hemp seed oil.

This study aimed to investigate the effects of the addition of hemp seed oil (*Cannabis sativa* L.) to the broiler diets at the rate of 1.5% and 3% on the performance, carcass yield, weights of some internal organs, serum glucose, albumin, total protein, triglyceride and also total, HDL, none-HDL, LDL cholesterols and plasma total oxidant (TOC) and antioxidant capacity (TAC).

Material and Methods

A total of 132 one-day-old broiler (Ross 308) chicks were used in the study. Chicks were randomly distributed into three main groups consisting of 44 chicks, one control and two treatment groups. Each main group was arranged as four subgroups, with 11 chicks within each main group. Chicks were fed with diets and drinking water ad libitum levels for 42 days. Basically, all groups were given isocaloric and isonitrogenous formulated broiler starter and grower diets prepared based on (NRC, 1994). While the control group was fed a basal diet without any additives, the two experimental groups named HO_A and HO_B were fed basal diets containing 1.5% (15 g/kg) and 3% (30 g/kg) hemp seed oil, respectively. The hemp seed oil (Macitefendi, Izmir, Turkey) used in the study is a 100% purity-natural product produced from raw seeds by cold pressing method.

During the experiment, all chicks and amounts of feed consumed by each sub-group were weighed weekly. Then, the average live weight (LW) and live weight gains (LWG), feed intake (FI), and feed conversion ratio (FCR) of the broilers were determined. At the end of the experiment, four chicks from each subgroup and 16 chicks from each main group were randomly selected. Blood samples were taken from V. jugularis just before slaughtering from these selected chicks. Afterward, these chicks were slaughtered and plucked, and after the internal organs were removed the weights of the hot carcass, heart, liver, spleen, pancreas, and bursa of Fabricius were observed. Dressing percentages and relative internal organ weights were calculated using the carcass and the weights of internal organs. In the blood samples taken, glucose, total protein, albumin, triglyceride, total cholesterol, high-density lipoprotein-cholesterol (HDL-C), low-density lipoprotein-cholesterol (LDL-C) and total oxidant and antioxidant capacity (Rel assay diagnostic, Gaziantep, Türkiye) values with spectrophotometric autoanalyzer (Mindray BS-800M, Shenzhen, China) were determined; none-HDL cholesterol (none-HDL-C) value was calculated. Nutrient contents of diets were determined according to AOAC (2005). Ingredient and chemical composition diets used in the experiment are seen in Table 1. All data were subjected to analysis of variance (One-Way ANOVA) utilizing the SPSS® package program, and means were separated by Duncan t-test groups (SPSS, 1998).

Table 1. Feed ingredient content and chemical composition of the diets used in the experiment

Feedstuffs, %	Broiler Starter Diet (0 - 21 days)			Broiler Grower Diet (22 - 42 days)		
	Control	HO_A	HO_B	Control	HO_A	HO_B
Wheat	22.25	22.25	22.25	23.00	23.00	23.00
Corn	33.00	33.00	33.00	38.00	38.00	38.00
Soybean meal (46% CP)	35.00	35.00	35.00	29.50	29.50	29.50
Hemp seed oil	-	1.5	3	-	1.5	3
Oil (soybean)	4.50	3.00	1.50	4.50	3.00	1.50
Fish meal (64% CP)	2.00	2.00	2.00	2.00	2.00	2.00
DL- methionine	0.15	0.15	0.15	0.15	0.15	0.15
L- lysine hydrochloride	0.20	0.20	0.20	0.20	0.20	0.20
DCP	1.40	1.40	1.40	1.25	1.25	1.25
Limestone	1.00	1.00	1.00	0.90	0.90	0.90
Sodium bicarbonate	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.20	0.20	0.20	0.20	0.20	0.20
Vitamin - mineral premix[1]	0.20	0.20	0.20	0.20	0.20	0.20
	Chemical analysis, DM%					
Dry matter	87.25	87.11	86.72	94.22	94.29	94.28
Crude protein	22.63	22.75	23.08	22.07	21.94	21.84
Crude fiber	4.86	3.52	4.23	4.53	4.35	4.26
Ether extract	6.15	6.24	7.67	8.27	8.99	9.12
Ash	5.21	5.27	5.08	5.92	5.94	5.95
Starch	38.04	38.04	36.96	35.87	35.33	35.87
Invert sugar	6.84	7.04	6.89	5.58	5.63	5.78
Calculated metabolizable energy (Kcal/kg)[2]	3073	3091	3173	3101	3135	3168

[1]Vitamin - mineral premix (2.5 kg/tons of feed). Each 2.5 kg contain: Vit. A, 15000000 IU; Vit. D_3, 3000000 IU; Vit. E, 100000 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 50000 mg; Niacin, 50000 mg; D-Biotin, 150 mg; Cal.D-Pantothenate, 15000 mg; Folic acid, 1500 mg; Apo Carotenoic acid, 2500 mg; Cu, 5000 mg; Fe, 60000 mg; Mn, 80000 mg; Co, 200 mg; I, 1000 mg; Zn, 60000 mg; Se, 150 mg.
[2]Formula used to calculate ME (TSE 1991; TS 9610), Kcal/kg = (37.07 × % CP) + (82 × % EE) + (39.89 × % Starch) + (31.1 × % Sugar)

Results

Based on the data obtained in the presented study, the average LW, LWG, FI, and FCR values of the control, HO_A and HO_B groups are given in Table 2.

When Table 2 is examined, it was determined that the mean total live weights of the control, HO_A and HO_B groups were 2637.90, 2647.81 and 2665.68 g, respectively, but there was no statistically significant difference ($P > 0.05$) between these groups at the end of the experiment. When the weekly LW values of the groups were examined, it was noted that there were statistically significant changes between the groups at the end of the first three weeks and the LW values in the HO_A and HO_B groups fed with hemp seed oil were higher than the control group ($P < 0.05$) but were similar in the last three weeks ($P > 0.05$). In addition, one chick death was recorded in the control group and two chicks in both experimental groups.

Table 2. Performance parameters of broiler fed different levels of hemp seed oil

Parameters	Treatment groups[1] (mean ± *SEM*[4])				
	Age (week)	Control (n = 36)	HO_A (n = 36)	HO_B (n = 36)	*P value*
	Initiation	41.70 ± 0.52	41.87 ± 0.31	41.67 ± 0.56	0.949
LW[2] (g)	3rd	824.19^{b} ± 10.99	851.38^{ab} ± 9.60	864.49^{a} ± 10.82	0.024
	6th	2637.90 ± 25.70	2647.81 ± 27.05	2665.68 ± 22.88	0.736
	1-3	781.41^{b} ± 10.59	808.85^{ab} ± 9.36	821.76^{a} ± 10.34	0.018
LWG[2] (g)	4-6	1813.87 ± 17.19	1790.26 ± 18.69	1789.71 ± 15.66	0.528
	1-6	2595.03 ± 25.28	2605.16 ± 26.83	2622.54 ± 22.39	0.734
	1-3	912.31 ± 10.60	935.14 ± 9.06	944.55 ± 10.06	0.139
FI[2] (g)	4-6	3131.94 ± 50.31	2945.64 ± 90.18	2955.80 ± 64.01	0.189
	1-6	4044.25 ± 57.18	3880.78 ± 99.05	3900.36 ± 71.51	0.336
	1-3	1.18 ± 0.02	1.16 ± 0.01	1.16 ± 0.01	0.651
FCR[2,3]	4-6	1.73^{a} ± 0.02	1.65^{b} ± 0.02	1.66^{b} ± 0.01	0.001
	1-6	1.56^{a} ± 0.02	1.50^{b} ± 0.02	1.49^{b} ± 0.01	0.001

[1]Control: The group was fed a basal diet without any additives. HO_A: The group fed with a 1.5% hemp seed oil-supplemented diet. HO_B: The group was fed with a 3% hemp seed oil-supplemented diet.
[2]LW: Live weight. LWG: Live weight gain. FI: Feed intake. FCR: Feed conversion ratio.
[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 ($P < 0.05$).

When the LWG of the groups was examined, it was noted that the average total LWG during the experiment was 2595.03, 2605.16 and 2622.54 g, respectively, for the control, HO_A and HO_B groups. When the weekly LWG was examined, it was noticed that there were no significant differences between the groups in total live weights gained at the end of the experiment ($P > 0.05$), except in the first three weeks of the experiment ($P < 0.05$). As with the LW results, the LWG was higher in the experimental groups (HO_A and HO_B) compared with the control group in the first three weeks of the experiment ($P < 0.05$). However, it is understood that the control group gained a developmental acceleration in the last weeks of the breeding process so that the total weight averages reached by the groups at the end of the process were similar ($P > 0.05$).

It was determined that the mean FI of the groups were 4044.25, 3880.78 and 3900.36 g, while the FCR values were 1.56, 1.50 and 1.49, respectively for the control, HO_A and HO_B groups, throughout the experiment. Based on these results, there were no statistically significant differences between the average amounts of feed consumed by the groups in all weeks of the experiment ($P > 0.05$), but there were significant differences between the FCR values of the groups, especially in the last weeks of experiment ($P < 0.05$). FCR values of HO_A and HO_B groups were better compared to the control group ($P<0.05$). The carcass parameters of the current study are shown in Table 3. When the carcass parameters were examined, there were statistically significant differences between the liver and bursa of Fabricius weights of the groups ($P < 0.05$). It was determined that the weight of the liver was significantly lower and the weight of the bursa of Fabricius was higher in the groups fed with hemp seed oil, especially in the HO_A group compared with the control group. In terms of other parameters, there were no significant differences between the groups ($P > 0.05$).

Table 3. Carcass parameters of broiler fed different levels of hemp seed oil

Parameters	Treatment groups[1] (mean ± *SEM*[3])			*P value*
	Control (n = 16)	HO_A (n = 16)	HO_B (n = 16)	
Live weight (g)	2675.58 ± 27.83	2634.62 ± 25.56	2669.27 ± 21.89	0.460
Carcass weight (g)	2077.17 ± 25.35	2047.00 ± 22.05	2067.60 ± 17.94	0.606
Dressing percentages, (LW/CW)[2]	77.61 ± 0.21	77.70 ± 0.39	77.46 ± 0.19	0.861
Liver weight (g)	46.21^a ± 1.78	41.00^b ± 1.15	43.24^{ab} ± 1.20	0.034
Percentage of Liver (g/100g LW)	1.73 ± 0.07	1.55 ± 0.04	1.62 ± 0.05	0.067
Heart weight (g)	9.61 ± 0.20	9.50 ± 0.20	10.19 ± 0.27	0.089
Percentage of heart (g/100g LW)	0.36 ± 0.01	0.36 ± 0.01	0.38 ± 0.01	0.077
Spleen weigh (g)	3.45 ± 0.34	2.89 ± 0.21	3.14 ± 0.24	0.303
Percentage of spleen, (g/100g LW)	0.13 ± 0.01	0.11 ± 0.01	0.12 ± 0.01	0.353
Pancreas weight (g)	4.61 ± 0.12	4.52 ± 0.13	4.69 ± 0.24	0.751
Percentage of pancreas (g/100g LW)	0.17 ± 0.004	0.17 ± 0.004	0.18 ± 0.009	0.822
Bursa of Fabricius weigh (g)	4.62 ± 0.30	5.49 ± 0.25	5.30 ± 0.29	0.069
Percentage of bursa of Fabricius (g/100g CA)	0.17^b ± 0.01	0.21^a ± 0.01	0.20^{ab} ± 0.01	0.041

[1]Control: The group was fed a basal diet without any additives. HO_A: The group was fed with a 1.5% hemp seed oil-supplemented diet. HO_B: The group was fed with 3% hemp seed 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 broiler fed different levels of hemp seed oil

Parameters	Treatment groups (mean ± *SEM*[3])			*P value*
	Control (n = 16)	HO_A (n = 16)	HO_B (n = 16)	
Glucose (mg/dL)	258.33 ± 5.26	258.86 ± 3.84	263.53 ± 4.05	0.690
Total protein (g/dL)	3.16^a ± 0.05	2.96^b ± 0.05	3.04^{ab} ± 0.07	0.044
Albumin (g/dL)	1.21 ± 0.02	1.13 ± 0.02	1.15 ± 0.04	0.156
Triglyceride (mg/dL)	27.67 ± 1.81	27.24 ± 1.68	25.20 ± 1.44	0.584
Total cholesterol (mg/dL)	122.39 ± 3.80	113.90 ± 1.65	118.93 ± 2.69	0.088
HDL-C[2] (mg/dL)	74.11^b ± 2.42	76.62^{ab} ± 1.51	81.47^a ± 1.82	0.043
none-HDL-C[2] (mg/dL)	48.28^a ± 2.28	37.29^b ± 1.30	37.47^b ± 2.43	< 0.001
LDL-C[2] (mg/dL)	42.74^a ± 2.29	31.84^b ± 1.05	32.43^b ± 2.27	< 0.001
TAC[2] (mmol Trolox Eq/L)	1.88^a ± 0.09	1.50^b ± 0.02	1.61^b ± 0.08	< 0.001
TOC[2] (μmol H_2O_2 Eq/L)	2.37^b ± 0.27	3.63^a ± 0.35	3.21^{ab} ± 0.37	0.026

[1]Control: The group was fed a basal diet without any additives. HO_A: The group fed with a 1.5% hemp seed oil-supplemented diet. HO_B: The group was fed with a 3% hemp seed oil-supplemented diet.
[2]HDL-C: High-density lipoprotein-cholesterol. LDL-C: Low-density lipoprotein-cholesterol. TOC: Total oxidant capacity. TAC: Total antioxidant capacity. None-HDL-C: None high-density lipoprotein-cholesterol. [3]*SEM*: Standard error of the mean.
[a, b]: There is a statistical difference between data with different letters in the same row ($P < 0.05$).

Serum biochemistry parameters are presented in Table 4. When serum biochemical parameters are evaluated, it is seen that there are statistically significant differences between the groups in total protein, LDL-C, HDL-C, none-HDL-C, TAC and TOC levels ($P < 0.05$). In the groups fed with hemp seed oil, the total protein, LDL-C, none-HDL-C and TAC values were significantly lower, the total cholesterol tended to be lower (the lowest in the HO_A group); HDL-C and TOC values were significantly higher than the control group. It was determined that there was no significant difference in the serum glucose, albumin, and triglyceride values of the treatment groups ($P > 0.05$).

Discussion

This experiment was carried out to evaluate the effects of hemp seed oil use (*Cannabis sativa* L.) on performance, carcass yield, internal organs weights, some blood parameters, and total oxidant and antioxidant status in broilers.

Performance parameters

Khan *et al.* (2010), in a study conducted with diets containing 5 - 10 - 20% hemp seeds, noted that the live weights of broilers fed with diets containing 10% and 20% hemp seeds significantly increased, whereas live weights of broilers fed with diets containing 5% hemp seeds decreased compared to the control group. They also reported that the feed intakes of broilers significantly increased in parallel with the increase in the rate of hemp seeds in the diet and feed efficiencies significantly improved in all experimental groups compared to the control group. On the other hand, Eriksson and Wall (2012), found that the use of 10% and 20% hemp seed meal in broiler diets did not cause a significant change in broiler performance. Similarly, Konca *et al.* (2014) reported that feeding diets containing 5 - 10 - 20% hemp seeds in Japanese quails did not create significant differences in live weight, feed intake and feed efficiency values among treatments. Mahmoudi *et al.* (2015) revealed that the addition of 2.5% hemp seeds to broiler basal diets significantly reduced feed efficiency and daily live weight gain values, and when this ratio was increased to 7.5%, only similar results were achieved with the control group, but there was no significant change in the feed efficiencies of the experimental groups. Stastnik *et al.* (2019), reported that the 15% addition of hemp seed meal containing 9.7% oil to broiler diets resulted in significantly lower live weights in the treatment group compared to the control group, but carcass yields were similar between groups. Skrivan *et al.* (2020), reported that the addition of 4% hemp seed into the broiler diet did not cause any changes in the live weight, feed intake and feed efficiency values of broilers. On the other hand, Jing *et al.* (2017) reported that adding hemp seed oil up to 6% to broiler diets did not make a significant difference in the live weight, live weight gain, feed intake and feed efficiency values of the groups; however, there were no negative effects on the performance data either.

As it can be seen in the literature presented above, it can be understood that generally full-fat hemp seed or meal was used in broiler studies, and broiler studies conducted with direct hemp seed oil are limited, and hemp seed oil use was mostly preferred in laying hen studies (Gakhar *et al.*, 2012; Stastnik *et al.*, 2015; Neijat *et al.*, 2016). When the studies using full-fat hemp seed or meal are examined, it is seen that the results vary. However, studies have shown that performance data are adversely affected in cases where the percentage of full-fat hemp seed addition in broiler diets is below 5%, and positive increases are provided by increasing this ratio above 10%; In the use of hemp seed meal, it is possible to conclude that serious performance changes do not occur even when the percentage of hemp seed meal in diet is increased up to 20%.

In this study, there were significant weekly changes in the LW and LWG values, but the total body weight and live weight gain values were statistically similar at the end of the experiment among the groups. FI values were statistically similar at all stages of the experiment. However, hemp seed oil addition to the basal diet significantly improved feed efficiencies, especially in the last weeks of the study. It is thought that the synergistic effects of the unique fatty acid composition of hemp seed oil in the body may cause this improvement.

Carcass parameters

In the literature, Konca *et al.* (2014) noted that the addition of 5 - 10 - 20% hemp seed into Japanese quail's diets did not make a significant difference on carcass and visceral organ weights. Similarly, Mahmoudi *et al.* (2015) reported that the addition of 25 - 75 g/kg of hemp seed into broiler basal diets did not create significant differences in the relative weights of the spleen and bursa of Fabricius among treatment groups. When the studies in the literature are examined, it is seen that the data on the effects of hemp seed oil use on broiler carcass parameters are quite limited.

In the present study, it was determined that the data related to the liver weights was lower and the data related to bursa of Fabricius weight was higher in broilers fed with hemp seed oil compared to broilers in the control group. It is thought that the decreases in liver parameters may have led to decreases in liver fattening rates, which is a desirable index for body health, with the effect of high polyunsaturated fatty acids in hemp seed oil. The increase in the bursa of Fabricius parameters, on the other hand, suggests the possibility that the positive reflections of hemp seed oil may have mediated functional increases in this lymphoepithelial organ in poultry and, in parallel, some developments in the immunological parameters of this organ. It is thought that understanding whether these situations are a real positive development in terms of organ or body health will only gain meaning by making histopathological and biochemical evaluations on these organ systems in similar study designs.

Serum biochemical parameters

Konca *et al.* (2014) stated that feeding Japanese quails with diets containing up to 20% full-fat hemp seed seeds did not significantly change serum triglyceride, total cholesterol and HDL-C values, but the LDL-C levels of the experimental groups were lower than the control group. Neijat *et al.* (2014), reported that up to 30% hemp seed or up to 9% hemp seed oil use in laying hen diets had no negative effects on serum total cholesterol, glucose, total protein, albumin and even globulin, creatine kinase, AST, GGT, uric acid values of laying hens. On the other hand, Mahmoudi *et al.* (2015) found that the addition of 25, 50 and 75 g/kg hemp seed to broiler basal diets caused statistically significant decreases in serum total cholesterol, triglyceride, LDL-C and VLDL-C levels in experimental groups and increases in HDL-C levels in parallel with the increases of hemp seed levels in diets. Also, Bazdidi *et al.* (2016) reported that groups fed with diets containing 2-4% hemp seed oil or 5-10-15-20% hemp seed had generally similar plasma total protein, total cholesterol, triglyceride, HDL-C, LDL-C and AST levels compared to the control group fed without additives, but the experimental group fed 6% hemp seed oil had significantly lower plasma total cholesterol, triglyceride, LDL-C and AST levels and higher HDL-C levels compared to all other groups. In another study, Vispute *et al.* (2019) reported that the addition of 0.3% hemp seed to the basal diet did not change the serum total protein value but significantly reduced total cholesterol, triglyceride and LDL-C levels in broilers. It is noticed that the trials with hemp seed oil mostly focus on laying hens, and the literature data on the effects of hemp seed oil on broiler serum biochemical parameters are still very few and insufficient. In the current study, the addition of hemp seed oil into the basal diet had no effects on total cholesterol and triglyceride values, while it increased the HDL-C levels and decreased the LDL-C and none-HDL-C values, which are in agreement with the studies mentioned above. Hence, it is possible to say that these changes are very positive important improvements in terms of living health.

When the effects of hemp seed oil on oxidative parameters are examined, Konca *et al.* (2014) reported that Japanese quails-fed diets containing hemp seed up to 20% showed increases in liver antioxidant parameters (especially glutathione peroxidase activity) compared to the control group. Mierlita (2019) found that the concentration of malondialdehyde (MDA), an indicator of lipidic peroxidation in egg yolk, was lower in the eggs of those fed with full-fat hemp seed meal compared to those fed with hemp seed meal and that the addition of full-fat hemp seed was more effective than hemp meal in maintaining the oxidative stability of egg lipids in laying hens. Contrary to the studies presented above, in the presented study, it was determined that serum TAC values were lower (lowest in HO_A) and TOC values were higher (highest in HO_A) in broiler fed diets containing hemp seed oil compared with broiler-fed control diet. Based on the data, it is thought that the antioxidant activity of hemp seed oil is weak and if it is used above 1.5%, it can seriously increase metabolic oxidative stress in broilers.

In conclusion, the current data indicated that up to 3% hemp seed oil addition into broiler diets can have remarkable effects on feed conversion ratio, carcass and serum biochemical parameters in broilers, which can provide very important gains in terms of health, especially with its improving effects on serum lipid profile. However, the fact that the antioxidant character of hemp seed oil is weak and can be one of the important negative features of hemp seed oil. In this respect, diets containing hemp seed oil may need to be strengthened with antioxidant supplements. Thus, the addition of hemp seed oil up to 3% into broiler diets can be beneficiary.

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