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Effect of Dietary Supplementation with Different Levels of Green Tea Powder and Fish Oil or their Combination on Carcass Characteristics in Broiler Chickens

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Abstract.- This study was aimed at assessing the effects of fish oil and green tea powder and their combination on carcass traits and intestinal measurements of broiler chickens reared for 42 d of age. Two hundred and seventy day-old male broiler chicks (Ross 308) were randomly assigned to one of nine dietary treatments with three replicates of 10 chicks based on a completely randomized design. The dietary groups comprised a control diet without feed additive; diets containing only 1.0 or 1.5% of green tea powder; diets containing 1.5% of fish oil combined with 0, 1.0 or 1.5% of green tea powder; diets containing 2.0% of fish oil combined with 0, 1.0 or 1.5% of green tea powder. The growth responses achieved by broilers from all dietary groups complied with the standards. Dietary inclusion of fish oil and green tea powder did not affect broilers' body weight and carcass yield as well as meat cuts compared with those fed the control diet. Feeding a combination of fish oil and green tea powder resulted in lower abdominal fat and neck percentages in birds as well as in higher heart and jejunum percentages. In conclusion, results from the current trial suggested that the dietary supplementation with a combination of fish oil and green tea powder may support carcass parameters in broilers. Further research is needed to assess the effects of these supplements as a feed resource for poultry production.

Keywords: Broiler, fish oil, green tea powder, intestine, carcass traits.

INTRODUCTION

Poultry meat is a popular and versatile and valuable food widely consumed compared to the other meats (Moumeni, 2001). Optimal feeding program can reduce costs and economize productions in order to offer higher quality products to consumers (Laudadio *et al*., 2002a; Poorghasemi *et al*., 2013). Moreover, due to concerns of bacterial resistance, the use of antibiotics as growth promoters is under scrutiny. In this context, herbal products have received increased attention, because as natural additives they have a high acceptability amongst consumers (Toghyani *et al*., 2010).

Natural feed additives can be incorporated into diet to improve the livestock production through improvement of feed properties, to enhance the animal productive performance as well as the derived food (Ebrahimi *et al*., 2014). Tea is one of the world's most highly consumed beverages and it has attracted much attention in recent years due to its numerous health benefits (Perumalla and Hettiarachchy, 2011). The polyphenolic compounds of green tea have been shown to improve body weight gain and feed efficiency in pigs (Hossain *et al*., 2012) and poultry (Khan, 2014). In poultry diets, green tea and its derivatives such as green tea extract, green tea leaves, green tea by-products, green tea polyphenols and green tea flowers are supplemented for improving performance (Khan, 2014).

Fish oil is one of the available energy sources used in the poultry diet and its supplementation has been reported to improve body weight gain and feed efficiency in the broilers (Mansoub, 2011) Moreover, the positive effect of supplementing fish oil to broilers diet on their performance has been already demonstrated and it was found that fish oil enhanced also poultry immune response. Thus, dietary fish oil and green tea powder may positively

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Table I.- Ingredients and nutrient analysis of diets fed to broiler chickens during the starter period (1-14 days of age).

Ingredient (g/kg as fed basis)	Dietary treatments								
	1	2	3	4	5	6	7	8	9
Corn	583.1	574.2	568.2	576.5	566.5	561.6	573.8	564.1	559.3
Soybean meal	377.7	374.2	373.7	378.9	376.3	375.0	379.6	376.8	375.4
Fish oil	-	-	-	15.0	15.0	15.0	20.0	20.0	20.0
Green tea powder	-	10.0	15.0	-	10.0	15.0	-	10.0	15
Soybean oil	12.6	15.0	16.5	3.0	5.6	6.8	-	2.5	3.7
DL-methionine	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
L-lysine	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Mineral mixture[1]	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Vitamin mixture[2]	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
$CaCO_3$	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Phytase enzyme	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Multi-enzyme	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Nutrient analysis									
ME (kcal/kg diet)	2,969	2,969	2,969	2,969	2,969	2,969	2,969	2,969	2,969
Crude protein (%)	22.13	22.10	22.13	22.12	22.13	22.13	22.13	22.13	22.13
Crude fiber (%)	3.34	3.46	3.52	3.34	3.46	3.53	3.34	3.47	3.53
Calcium (%)	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Tryptophan SID[3] (%)	0.42	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
Available phosphorus (%)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Linoleic acid (%)	1.76	1.85	1.91	1.32	1.42	1.46	1.18	1.27	1.32
Lysine SID (%)	1.33	1.31	1.31	1.33	1.32	1.31	1.33	1.32	1.31
Methionine SID (%)	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.56
Cysteine (%)	0.68	0.67	0.67	0.68	0.67	0.67	0.68	0.67	0.67
Sodium (%)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

[1] Calcium Pantothenate: 4 mg/g; Niacin: 15 mg/g; Vitamin B_6: 13 mg/g; Cu: 3 mg/g; Zn: 15 mg/g; Mn: 20 mg/g; Fe: 10 mg/g; K: 0.3 mg/g;
[2] Vitamin A: 5000 IU/g; Vitamin D_3: 500 IU/g; Vitamin E: 3 mg/g; Vitamin K_3: 1.5 mg/g; Vitamin B_2: 1 mg/g;
[3]SID: Standardized Ileal Digestible.

affect carcass traits and organ characteristics of modern broilers.

To the best of our knowledge, no data have yet been published on the simultaneous effects of these feed additives on the growth performance of broilers. Therefore, the current study was planned to evaluate the effects of fish oil and green tea powder and their combination in diet for broiler chickens.

MATERIALS AND METHODS

Two hundred and seventy day-old male broiler chicks (Ross 308) were randomly assigned to one of nine dietary treatments with three replicates of 10 chicks based on a completely randomized design, and reared for 42 days. A 3 × 3 factorial design was used in which corn-soybean meal based diets were supplemented with three different levels of fish oil (0, 1.5 and 2.0%, respectively) and green tea powder (0, 1.0 and 1.5%, respectively). Diets were formulated to meet broiler nutrients' requirements based on Ross 308 strain breeding manual. Feed and water were provided *ad libitum*.

All experimental starter, grower and finisher diets contained 2969, 3005 and 3050 of metabolizable energy (ME) kcal/kg diet and 22.1, 20.5 and 19.4% of crude protein (CP), respectively. The ingredient composition of the experimental diets and the respective calculated nutrient analysis are reported in Tables I-III. The dietary groups comprised a control diet without feed additive (treatment 1); diets containing only 1.0 or 1.5% of

Table II.- Ingredients and nutrient analysis of diets fed to broiler chickens during the grower period (15-28 days of age).

Ingredient (g/kg as fed basis)	Dietary treatments								
	1	2	3	4	5	6	7	8	9
Corn	628.1	618.6	613.6	621.4	611.5	606.8	615.7	609.4	604.6
Soybean meal	333.6	330.8	329.5	335.0	332.3	330.9	336.2	332.7	331.3
Fish oil	-	-	-	15.0	15.0	15.0	20.0	20.0	20.0
Green tea powder	-	10.0	15.0	-	10.0	15.0	-	10.0	15
Soybean oil	11.7	14	15.3	2.0	4.6	5.7	-	1.3	2.5
DL-methionine	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
L-lysine	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Mineral mixture[1]	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Vitamin mixture[2]	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
$CaCO_3$	10.0	10.0	10.0	10.0	10.0	10.0	10.5	10.0	10.0
Phytase enzyme	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Multi-enzyme	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	0.5	7.0	7.0	7.0	7.0	7.0	8.0	7.0	7.0
Nutrient analysis									
ME (kcal/kg diet)	3,005	3,005	3,005	3,005	3,005	3,005	3,005	3,005	3,005
Crude protein (%)	20.54	20.54	20.54	20.54	20.54	20.54	20.55	20.54	20.54
Crude fiber (%)	3.06	3.18	3.25	3.06	3.19	3.25	3.07	3.19	3.25
Calcium (%)	0.64	0.63	0.63	0.64	0.63	0.63	0.68	0.63	0.63
Tryptophan SID[3] (%)	0.40	0.39	0.39	0.40	0.39	0.39	0.40	0.39	0.39
Available phosphorus (%)	0.24	0.24	0.24	0.24	0.24	0.24	0.26	0.24	0.24
Linoleic acid (%)	1.79	1.87	1.92	1.34	1.44	1.48	1.24	1.28	1.33
Lysine SID (%)	1.21	1.20	1.19	1.21	1.20	1.20	1.21	1.20	1.20
Methionine SID (%)	0.54	0.53	0.53	0.54	0.53	0.53	0.54	0.53	0.53
Cysteine (%)	0.63	0.62	0.62	0.63	0.62	0.62	0.63	0.62	0.62
Sodium (%)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

[1] Calcium pantothenate: 4 mg/g; Niacin: 15 mg/g; Vitamin B_6: 13 mg/g; Cu: 3 mg/g; Zn: 15 mg/g; Mn: 20 mg/g; Fe: 10 mg/g; K: 0.3 mg/g;
[2] Vitamin A: 5000 IU/g; Vitamin D_3: 500 IU/g; Vitamin E: 3 mg/g; Vitamin K_3: 1.5 mg/g; Vitamin B_2: 1 mg/g;
[3]SID: Standardized Ileal Digestible.

green tea powder (treatments 2 and 3, respectively); diets containing 1.5% of fish oil combined with), 1.0 or 1.5% of green tea powder (treatments 4, 5 and 6, respectively); diets containing 2.0% of fish oil combined with 0, 1.0 or 1.5% of green tea powder (treatments 7, 8 and 9, respectively).

Before starting the trial, all pens, feeders and water bottles were cleaned with a disinfectant solution of 0.1% Despadak®. Furthermore, the whole facilities were also thoroughly cleaned. Rearing conditions such as temperature, relative humidity, cross-ventilation as well as lighting program, stocking density were followed according to standard conditions and the Ross 308 broiler management guide.

At the age of 42 days, after 4 h of fasting for complete evacuation of the gut, one bird from each replicate was selected. Care was taken to choose the most representative birds based on the body weight (BW) compared to the mean body weight in each group. These broilers were used for measuring carcass yield and distribution of meat as well as gastrointestinal tract characteristics.

Data were analyzed controlled for normality by Shapiro-Wilk test. The treatments were analyzed using univariate ANOVA and post hoc contrast testing with the Student-Newman-Keuls test. Moreover, the mixed linear model with the factors fish oil and tea powder levels and Scheffe´s contrast testing were used (SPSS, 1997). Results were reported as mean and standard error of the means (SEM). Significance implies $P<0.05$ unless otherwise stated.

Table III.- Ingredients and nutrient analysis of diets fed to broiler chickens during the finisher period (29-42 days of age).

Ingredient (g/kg as fed basis)	Dietary treatments								
	1	2	3	4	5	6	7	8	9
Corn	656.2	646.7	641.8	649.5	639.8	635.0	644.1	637.6	632.7
Soybean meal	302.7	299.7	298.4	303.9	301.1	299.7	305.0	301.5	300.2
Fish oil	-	-	-	15.0	15.0	15.0	20.0	20.0	20.0
Green tea powder	-	10.0	15.0	-	10.0	15.0	-	10.0	15.0
Soybean oil	14.5	17.0	18.2	5.0	7.5	8.7	2.8	4.3	5.5
DL-methionine	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
L-lysine	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Mineral mixture[1]	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Vitamin mixture[2]	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
$CaCO_3$	10.0	10.0	10.0	10.0	10.0	10.0	10.5	10.0	10.0
Phytase enzyme	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Multi-enzyme	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Dicalcium phosphate	7.0	7.0	7.0	7.0	7.0	7.0	8.0	7.0	7.0
Nutrient analysis									
ME (kcal/kg diet)	3,050	3,050	3,050	3,050	3,050	3,050	3,050	3,050	3,050
Crude protein (%)	19.39	19.39	19.39	19.39	19.39	19.39	19.39	19.39	19.39
Crude fiber (%)	2.86	2.99	3.05	2.86	2.99	3.05	2.87	2.99	3.05
Calcium (%)	0.63	0.62	0.62	0.63	0.62	0.62	0.67	0.62	0.62
Tryptophan SID[3] (%)	0.39	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Available phosphorus (%)	0.24	0.24	0.24	0.24	0.24	0.23	0.26	0.24	0.23
Linoleic acid (%)	1.95	2.04	2.09	1.51	1.61	1.65	1.40	1.46	1.50
Lysine SID (%)	1.12	1.11	1.11	1.13	1.12	1.11	1.13	1.12	1.11
Methionine SID (%)	0.52	0.52	0.51	0.52	0.52	0.51	0.52	0.52	0.51
Cysteine (%)	0.60	0.59	0.59	0.60	0.59	0.59	0.60	0.50	0.59
Sodium (%)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

[1] Calcium pantothenate: 4 mg/g; Niacin: 15 mg/g; Vitamin B_6: 13 mg/g; Cu: 3 mg/g; Zn: 15 mg/g; Mn: 20 mg/g; Fe: 10 mg/g; K: 0.3 mg/g;
[2] Vitamin A: 5000 IU/g; Vitamin D_3: 500 IU/g; Vitamin E: 3 mg/g; Vitamin K_3: 1.5 mg/g; Vitamin B_2: 1 mg/g;
[3]SID: Standardized Ileal Digestible.

RESULTS AND DISCUSSION

The effects of dietary fish oil and green tea powder and their combination on final BW, carcass characteristics and intestinal traits of broiler chickens are presented in Tables IV-VI. During the whole feeding period the final BW of broilers did not vary significantly ($P > 0.05$) among dietary groups. According to the data on Tables IV-VI, some carcass traits were significantly ($P < 0.05$) influenced by dietary treatments. The growth responses achieved by broilers from all dietary groups complied with the standards. However, feeding a combination of fish oil and green tea powder resulted in lower abdominal fat and neck percentages in birds as well as in higher heart and jejunum percentages. In this study, diet supplementation with fish oil and green tea powder, particularly combining the two ingredients, determined an improvement in abdominal fat deposition of broiler carcass. The favorable result on this of trait could be explained by the positive impact of these feed additives on the reduced passage rate of the digesta through the gastrointestinal trait, allowing for better nutrient absorption and utilization (Latshaw, 2008), resulting thus in a more efficient use of nutrients from diet.

In a previous study, Crespo and Esteve-Garcia (2000) stated that reduction of abdominal fat in broilers fed a diet supplemented with oils seems to be a consequence of higher lipid oxidation, although the higher synthesis of endogenous fatty

Table IV.- Performance traits (% on BW) of broiler chickens fed the experimental diets.

Treatment		BW (g at 42 days)	Carcass yield (%)	Breast yield (%)	Drumstick yield (%)	Abdominal fat (%)
Fish oil (% in diet)	0	2,529	80.3	27.1	31.1	1.61[b]
	1.5	2,442	83.6	26.2	30.2	1.73[b]
	2.0	2,625	82.4	27.1	30.1	1.62[b]
	SEM	72.39	5.26	0.87	0.66	0.10
Green tea powder (% in diet)	0	2,597	82.5	26.6	30.9	1.73[b]
	1.0	2,432	80.9	26.1	31.3	1.80[b]
	1.5	2,567	83.0	27.5	30.1	1.46[a]
	SEM	75,22	4.21	0.79	0.62	0.12
Fish oil (0)-Green tea (0)		2,621	82.6	26.5	32.0	1.63[b]
Fish oil (0)-Green tea (1.0)		2,383	79.2	26.0	30.4	2.19[c]
Fish oil (0)-Green tea (1.5)		2,584	79.1	28.7	30.8	1.11[a]
Fish oil (1.5)-Green tea (0)		2,527	83.8	26.5	29.9	1.61[b]
Fish oil (1.5)-Green tea (1.0)		2,366	79.9	25.7	31.8	1.60[b]
Fish oil (1.5)-Green tea (1.5)		2,433	87.2	26.5	28.7	1.99[b]
Fish oil (2.0)-Green tea (0)		2,643	81.0	27.6	30.7	1.97[b]
Fish oil (2.0)-Green tea (1.0)		2,547	83.6	26.7	31.7	1.60[b]
Fish oil (2.0)-Green tea (1.5)		2,685	82.7	27.2	30.6	1.30[a]
SEM		91.25	9.12	1.49	1.14	0.18

[*] Means within each column with no common superscript differ significantly at $P < 0.05$.

Table V.- Organs and cuts yield (% on BW) of broiler chickens fed the experimental diets.

Treatment		Gizzard yield (%)	Heart yield (%)	Neck yield (%)	Kidneys yield (%)	Pancreas yield (%)
Fish oil (% in diet)	0	2.67	0.58[b]	3.03[b]	0.68	0.29
	1.5	2.63	0.61[a]	3.24[b]	0.65	0.31
	2.0	2.32	0.50[b]	3.25[b]	0.62	0.28
	SEM	0.18	0.02	0.11	0.06	0.02
Green tea powder (% in diet)	0	2.38	0.56[b]	3.18[b]	0.64	0.27
	1.0	2.63	0.55[b]	3.19[b]	0.65	0.31
	1.5	2.61	0.58[a]	3.14[b]	0.66	0.31
	SEM	0.13	0.03	0.12	0.05	0.03
		2.63	0.59[a]	3.27[b]	0.71	0.29
Fish oil (0)-Green tea (0)		2.63	0.59[a]	3.27[b]	0.71	0.29
Fish oil (0)-Green tea (1.0)		2.99	0.55[b]	2.99[a]	0.66	0.30
Fish oil (0)-Green tea (1.5)		2.38	0.58[a]	2.84[a]	0.66	0.29
Fish oil (1.5)-Green tea (0)		2.28	0.61[a]	2.98[a]	0.62	0.27
Fish oil (1.5)-Green tea (1.0)		2.42	0.56[b]	3.40[b]	0.58	0.31
Fish oil (1.5)-Green tea (1.5)		3.17	0.64[a]	3.33[b]	0.75	0.35
Fish oil (2.0)-Green tea (0)		22.3	0.47[b]	3.30[b]	0.58	0.24
Fish oil (2.0)-Green tea (1.0)		2.47	0.53[b]	3.18[b]	0.71	0.31
Fish oil (2.0)-Green tea (1.5)		2.28	0.51[b]	3.27[b]	0.58	0.30
SEM		0.31	0.04	0.18	0.09	0.03

[*] Means within each column with no common superscript differ significantly at $P < 0.05$.

Table VI.- Intestinal traits yield (% on BW) of broiler chickens fed the experimental diets.

Treatment		Duodenum (%)	Jejunum (%)	Ileum (%)	Colon (%)	Cecum (%)
Fish oil (% in diet)	0	1.64	4.38[a]	0.51	0.13	0.34
	1.5	1.19	3.81[b]	0.54	0.12	0.32
	2.0	0.97	3.37[b]	0.60	0.11	0.31
	SEM	0.38	0.46	0.06	0.01	0.02
Green tea powder (% in diet)	0	1.50	3.35[b]	0.50	0.12	0.30
	1.0	1.10	3.72[b]	0.56	0.12	0.35
	1.5	1.22	4.49[a]	0.58	0.13	0.32
	SEM	0.37	0.41	0.05	0.01	0.03
Fish oil (0)-Green tea (0)		1.73	3.76[b]	0.42	0.13	0.31
Fish oil (0)-Green tea (1.0)		1.02	3.96[b]	0.56	0.13	0.43
Fish oil (0)-Green tea (1.5)		1.17	4.42[a]	0.55	0.14	0.27
Fish oil (1.5)-Green tea (0)		0.83	3.21[b]	0.43	0.13	0.31
Fish oil (1.5)-Green tea (1.0)		1.16	4.10[b]	0.59	0.13	0.32
Fish oil (1.5)-Green tea (1.5)		1.57	4.12[b]	0.58	0.12	0.32
Fish oil (2.0)-Green tea (0)		0.95	3.09[b]	0.66	0.10	0.26
Fish oil (2.0)-Green tea (1.0)		1.05	3.12[b]	0.53	0.10	0.29
Fish oil (2.0)-Green tea (1.5)		0.93	3.97[b]	0.60	0.12	0.37
SEM		0.53	0.69	0.09	0.01	0.04

[*] Means within each column with no common superscript differ significantly at $P < 0.05$.

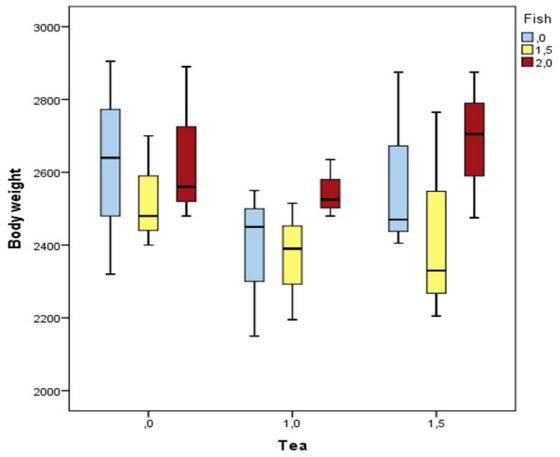

Fig. 1. Boxplot of body weight (g) in broilers fed diets supplemented with different levels (%) of fish oil and green tea powder.

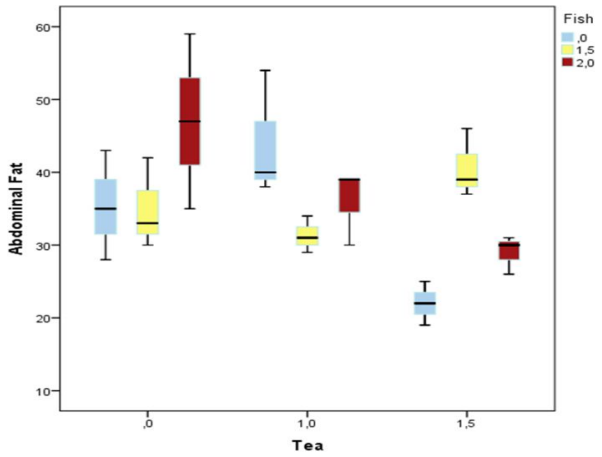

Fig. 2. Boxplot of abdominal fat weight in broilers fed diets supplemented with different levels (%) of fish oil and green tea powder.

acids. Among fat sources available for poultry feeding, it has been recognized that fish oil is an valuable combination of essential fatty acids, unsaturated fatty acids that can improve broiler growth traits, and also linolenic acid can be converted to longer chain ω-3 fatty acids that is an important factor in poultry feeding as health promoter (Bezard *et al*., 1994).

Data analyzed, except those related to the organs and gut traits were normally distributed. No treatment effect was found on body weight (Fig. 1), carcass yield, head yield, breast and drumstick yields, except abdominal fat weight (Fig. 2) that was significantly affected by treatment ($P < 0.05$). In

fact, adding 1.5% of green tea powder to the diet was found to significantly decrease ($P < 0.05$) the abdominal fat yield in broiler chickens, whereas supplementing fish oil appeared to increase the carcass abdominal fat, but this increase was not statistically significant ($P > 0.05$). However, there was a significant interaction ($P < 0.05$) on abdominal fat growth between 1.5% of green tea powder and 2% of fish oil in diet. The green tea powder could reduce the 47 g of abdominal fat induced by 2% of dietary fish oil to 27 g on average. The findings of the present study indicated that, the jejunum yield of broilers was significantly ($P < 0.05$) higher when the diet contained a combination of fish oil and green tea powder (Table VI). This increase in small intestine trait disagrees with the previous report of Ahmad *et al*. (2006) who reported that the length of intestinal tract was reduced in birds fed a diet supplemented with oil or fat.

In conclusion, results from the current trial suggested that the dietary supplementation with a combination of fish oil and green tea powder may support carcass parameters in broilers. In particular, it seems that that dietary green tea powder may possess some positive effect on abdominal fat deposition in broilers carcass. However, further research is needed to assess the effects of these supplements as a feed resource for poultry production.

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