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The Effects of Different Fat Sources on Carcass Yields and Meat Fatty Acid Profile of Broilers

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Abstract: The aim of this research was to investigated the effects of different fat sources (soybean oil (SO), canola oil (CO), acid oil (AO) and calcium-palm fatty acid (Ca-PFA)) on broiler carcass yield, small intestine length, abdominal and gizzard fat content and composition of meat fatty acid. In the experiment, 240 day-old Ross-308 broiler chicks were used. The chicks were randomly allocated into four dietary treatments with six replicate pens per treatment (5 female and 5 male in each cage). All experimental diets were formulated to contain the same level of metabolisable energy and crude protein. The results showed that carcass ratio of CO groups were detected highest value than the other group (P<0.001). Supplemental fat sources changed meat fatty acid content especially miristic (P<0.001), palmitic (P<0.001), oleic (P<0.001), linoleic (P<0.001) and linolenic acid (P<0.05). When the addition of the Ca-PFA in the broiler diets small intestine length was the longer than other groups (P<0.001). On the other hand, carcass parts yield and abdominal and gizzard fat did not show differences among the groups. However, the female broilers had more abdominal fat and meat oleic acid than the males (P<0.05).

Keywords: Acid oil, broiler, canola oil, carcass yields, fatty acids

Farklı Yağ Kaynaklarının Etlik Piliçlerde Karkas Oranı ve Etin Yağ Asitleri Profili Üzerine Etkileri

Öz: Bu araştırma, farklı yağ kaynaklarının (soya yağı, kanola yağı, asit yağ ve palm yağ asitlerinin kalsiyum tuzu) etlik piliçlerde karkas oranı, ince bağırsak uzunluğu, abdominal yağ ve taşlık yağ miktarı ile ette yağ asitleri profili üzerine etkilerinin belirlenmesi amacıyla planlanmıştır. Denemede günlük yaşta 240 adet Ross 308 civciv kullanılmıştır. Civcivler 4 grupta 6 tekerrürlü ve her tekerrürde 10 civciv (5 dişi ve 5 erkek) olacak şekilde gruplara rastgele dağıtılmışlardır. Araştırmada kullanılan rasyonlar enerji ve protein bakımından birbirine benzer şekilde düzenlenmiştir. Deneme sonunda en yüksek karkas randımanı kanola yağı tüketen gruplarda tespit edilmiştir (P<0.001). Rasyona katılan yağ kaynakları etin özellikle miristik (P<0.001), palmitik (P<0.001), oleik (P<0.001), linoleik (P<0.001) ve linolenik asit (P<0.05) miktarlarını değiştirmiştir. Palm yağ asitlerinin kalsiyum tuzu ile beslenen etlik piliçlerde ince bağırsak uzunluğu diğer gruplara göre daha yüksek bulunmuştur (P<0.001). Diğer taraftan karkas parça oranları ile abdominal ve taşlık yağ oranları gruplarda birbirine benzer gerçekleşmiştir. Dişi hayvanların erkeklere göre daha fazla abdominal yağ ile ette oleik asit miktarına sahip olduğu tespit edilmiştir (P<0.05).

Anahtar Kelimeler: Asit yağ, etlik piliç, kanola yağı, karkas randımanı, yağ asitleri

1. Introduction

Chicken meat plays an important role in human diet and is highly appreciated by consumers at present constitute a notable part of our feeding regime (in 2015, 21.06 kg per person and year (BESD-BİR, 2015) more than half of the

total meat consumption in Turkey). In the last 10-15 years, consumption of chicken has increased due to its price and satisfying nutritional value, such as its high easily digestible protein, low fat content, important source of essential fatty acids, B groups vitamins and some important minerals, optimal saturated and unsaturated fatty acid ratio. Human demand for healthy, safely and quality food products has become to concern manipulating the nutritive value of animal products like meat and eggs (Jóźwik et al., 2016). In livestock, meat fatty acid composition can be altered by the diet, more simply in poultry (Wood and Enser, 1997). Oils and fats are generally used in poultry ratios to producing maximum energy and having some essential fatty acids. Oil/fat addition in broiler feeds changes carcass fat content because in chickens, the feed fatty acid (FA) composition impacts to the FA composition of fat storages (Barroeta, 2007). FA composition of poultry meat is a notable component both nutritional value and shelf life. In this regard, polyunsaturated fatty acids (PUFA) is one of the most important FA groups. Vegetable oils like sunflower, soybean, canola, cottonseed, and corn oil are rich in PUFA**.** Dietary n-3 FA has been revealed to help in the prevention of certain diseases, particularly cardiovascular disorders (Leaf and Kang, 1998). The FA composition of poultry meat can be modified by altering the ingredients of the broiler's diet (Yau et al., 1991). Thus, many researches are conducted to the manipulation of the FA composition of broilers with using different oil and fat sources. However, there are limited reports about the effect of feding dry fat on meat FA composition and fat deposition in poultry. The purpose of the research was to determine the effect of diets containing calcium-palm fatty acid (Ca-PFA) with acid oil, soybean oil and canola oil on the meat FA profile, carcass and parts yield and fat deposition of chickens 42 d of age.

2. Materials and Methods

2.1.Animals, feeds and experimental design

The study was conducted at the experimental broiler unit of the University of Ankara, Agriculture Faculty Department of Animal Science. Day-old mixed sex total of 240 broiler chicks (Ross 308) obtained from a local producer were used in experiment. Animals were randomly divided into 4 main diet groups which were divided into 6 replicates each containing 10 chicks (5 females and 5 males). All chickens were received 24-h light schedule during the experiment. Mash feed and fresh water were supplied *ad libitum*.

All experimental diets were prepared to contain same metabolisable energy and crude protein. The diets were formulated following the recommendations of the Ross 308 catalogue (2007). All groups were fed diets that included 3025 kcal ME kg^{-1} and 23% CP, 3150 kcal ME kg^{-1} and 21% CP, 3200 kcal ME kg^{-1} and 19% CP at the 0-2^{nd}, 3-4^{th} and 5-6^{th} weeks, respectively. The four diets contained four types of added fat (acid oil (AO), soybean oil (SO), canola oil (CO) and Ca-PFA). The chemical structure of Ca-PFA (Norel&Nature) used in this study was: metabolisable energy, 6800 kcal/kg, 96.5% dry matter, 12.5% ash, 9% Ca and 84% crude fat. The feedstuffs were analyzed for crude protein by the Kjeldahl method according to the AOAC (1995) and were calculated for calcium, available phosphorus, methionine, methionine+sistein, lysine by using NRC (1994).

Table 1. Ingredients and chemical composition of experimental diets
Çizelge 1*. Deneme rasyonlarının hammadde içerikleri ve kimyasal bileşimi*

	Starter 1-2. weeks				Grower 3-4. weeks				Finisher 5-6. weeks			
Ingredients, %	**AO**	**CO**	**SO**	**Ca-PFA**	**AO**	**CO**	**SO**	**Ca-PFA**	**AO**	**CO**	**SO**	**Ca-PFA**
Corn	51.4	50.44	50.44	53.38	56.22	55.65	55.65	57.97	57.61	59.61	59.61	58.9
CGM, 60%	2.00	2.00	2.00	5.00	2.00	2.00	2.00	5.50	3.00	3.00	3.00	4.00
SBM, 44%	34.60	37.80	37.80	28.87	29.00	31.95	31.95	21.50	28.70	28.50	28.50	27.45
FM, 65%	4.00	2.00	2.00	5.00	4.00	2.00	2.00	6.00	-	-	-	-
AO	4.50	-	-	-	5.80	-	-	-	7.20	-	-	-
CO	-	4.00	-	-	-	5.00	-	-	-	5.40	-	-
SO	-	-	4.00	-	-	-	5.00	-	-	-	5.40	-
Ca-PFA	-	-	-	5.00	-	-	-	7.00	-	-	-	7.00
Limestone	1.30	1.29	1.29	0.50	1.00	1.00	1.00	0.20	1.05	1.08	1.08	0.20
DCP	1.40	1.67	1.67	1.44	1.23	1.60	1.60	1.00	1.67	1.61	1.61	1.67
DL-Met	0.20	0.20	0.20	0.15	0.15	0.20	0.20	0.18	0.15	0.15	0.15	0.12
L-Lysine	-	-	-	0.06	-	-	-	0.05	0.02	0.05	0.05	0.06
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vit-Min Pr.*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100	100	100	100	100	100
Calculated Analysis												
ME, kcal/kg	3025	3025	3025	3024	3150	3150	3150	3158	3202	3209	3209	3203
CP,%	23.13	23.16	23.16	23.20	21.05	21.00	21.00	21.20	19.03	19.10	19.10	19.19
Ca,%	1.05	1.05	1.05	1.05	0.90	0.90	0.90	0.90	0.85	0.85	0.85	0.85
Avail-P,%	0.50	0.50	0.50	0.50	0.45	0.45	0.45	0.45	0.42	0.42	0.42	0.42
Meth,%	0.50	0.50	0.50	0.50	0.45	0.45	0.45	0.45	0.40	0.40	0.40	0.40
Met+Sis	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.80	0.80	0.80	0.80
Lysine,%	1.30	1.30	1.30	1.30	1.15	1.15	1.15	1.15	1.00	1.00	1.00	1.00

CGM: Corn gluten meal, SBM: Soybean meal, FM: Fish meal, AO: Acid oil, CO: Canola oil, SO: Soybean oil, Ca-PFA: Calcium salts of palm fatty acids *Vit-Min Premix provided per 2.5 kg of diets: 15 000 000 IU Vitamin A, 3000 000 IU Vitamin D3, 100 000 mg Vitamin E, 5 000 mg Vitamin K3, 3 000 mg Vitamin B1, 6 000 mg Vitamin B6, 20 mg B12, 50 000 mg Niacin, 80 000 mg Mn, 15.000 mg Calcium D- pantothenate, 200 mg Co, 130 mg Biotin, 1500 mg Folic acid, 5 000 mg Cu, 60 000 mg Fe, 1 000 mg I, 60 000 mg Zn, 150 mg Se

Metabolisable energy content of feeds were determined by equation for recommendations of the TSI (1991). The chemical composition and nutritional value of experimental rations were given Table 1 and, FA profile (AOCS, 1997) and metabolisable energy content of AO, CO, SO and Ca-PFA were presented in Table 2.

2.2. Sample collection

At the end of the trial, 4 female and 4 male chickens from each group (n = 8 per treatment) were slaughtered to find the weight of carcass and carcass parts, abdominal fat and gizzard fat, total length of small intestine and meat fatty acid composition. FA profile of poultry meat found by gas chromatography after taken white (breast) and black (thigh+drumstick) meat samples from same area (skin free) each of the carcass. Abdominal fat pads and gizzard fats were removed from the abdominal cavity and gizzard respectively and weighed by precision scale.

Table 2. Fatty acids composition and ME content of Ca-PFA and oil sources
Çizelge 2. *Ca-PFA ve yağ kaynaklarının yağ asiti içerikleri ve ME değerleri*

Fatty acids	AO	CO	SO	Ca-PFA
C14:0	0.08	0.06	0.07	1.50
C14:1	-	-	0.04	-
C16:0	7.53	5.57	11.50	44.00
C16:1	0.12	0.35	0.22	-
C18:0	3.26	0.76	1.59	5.00
C18:1	32.85	56.23	27.56	40.00
C18:2	53.68	30.39	52.64	9.50
C18:3	1.21	5.88	6.07	-
C20:0	0.26	0.76	0.31	-
Saturated	11.13	7.15	13.47	50.50
Monounsaturated	32.97	56.58	27.82	40.00
Polyunsaturated	54.89	36.27	58.71	9.50
ME, kcal kg^{-1}	7350	8800	8800	5000 (initial phase) 6800 (broilers and layers)

AO: Acid oil, CO: Canola oil, SO: Soybean oil, Ca-PFA: Calcium salts of palm fatty acids

2.3.Fatty acid analysis in meat

In the research, to determine the FA composition of each fat&oils and meat samples were extracted and purified according to the method defined by Bligh and Dyer (1959) and FAs were esterified to methyl esters (AOCS, 1997). The fatty acid methyl esters were analyzed by Shimadzu GC-2010 gas chromatograph equipped with DB-23 capillary column and flame ionization detector. The carrier gas was helium; at a flow rate of 1.0 mL min^{-1}. The temperatures of injector and detector were 230 °C and 240 °C, respectively. Results are demonstrated as percent of total fatty acid methyl esters.

2.4.Statistically analysis

All data were analyzed by the General Linear Models (GLM) by using the SPSS version 15.0. The differences between treatments were thought significant when $P<0.05$, and when significant main effects were observed, the differences between groups were detected using Duncan's multiple range test procedure (Duncan, 1955).

3. Results and Discussion

The results of carcass performance and relative intestine length of broilers are presented in Table 3. The different dietary fat supplementation in the broiler diets had effect ($P<0.001$) on the carcass yield of chickens. The carcass percentage of CO showed a significantly higher than the other groups ($P<0.001$). Zollitsch et al. (1997) declared that similar results were obtained by vegetable oils. In the current study, there were a significant decrement in carcass yield in the group of Ca-PFA and AO ($P<0.001$). Researchers explained that this result by saturated fatty acids in broiler diets could cause a lower metabolizability of fat and decreased growth performance (Zollitsch et al., 1997). Similarly Pekel et al. (2013) reported that carcass yield of chickens fed neutralized sunflower soapstock diets was lower than that for birds fed the SO diets. But, in the another research, dietary inclusions of Ca-PFA up to 15% did not affect carcass yield and carcass composition in broiler (Dewi et al., 2011).

There were no significant difference among treatment groups in thigh and drumstick, breast, wing, back and neck, gizzard, gizzard fat and abdominal fat ratio for treatments ($P>0.05$). Similarly, in some researches, the fat level and type did not affect on thighs and breasts weights (Zollitsch et al., 1997; Crespo and Esteve-Garcia, 2001). In another study researchers found similar carcass and carcass part yields of chickens fed sunflower, soybean, canola, corn, poultry fat or lard (Andreotti et al., 2001). The total carcass lipids is highly correlated with abdominal fat. The

abdominal fat is used as a main characteristic showing excessive fat deposition in the broiler carcass (Chambers, 1990). In some researches, increased PUFA is caused a decline of abdominal fat deposition in chickens (Sanz et al., 1999; 2000; Crespo and Esteve-Garcia, 2001; Wongsuthavas et al., 2008). In this study, the means presented the percentage of abdominal and gizzard fat of broilers did not show the differences among the treatments (Table 3).

This result supported the Pinchasov and Nir's (1992) research data, they did not find any effect on dietary fat source on abdominal fat deposition in broiler chickens. However, some studies have reported opposite results. Vila and Esteve-Garcia (1996), Sanz et al. (1999) and Poorghasemi et al. (2013) revealed that more abdominal fat in broilers fed tallow than in those fed vegetable oil. Sanz et al. (2000), showed that dietary fats' metabolic use and fat accumulation in broiler chickens were affected the saturation degree of fats. Similarly, Abdelrahman (2013) observed that dry fat increased abdominal fat ratio in broiler. On the other hand, abdominal fat deposition could affected by birds' genetic merit. Keren-Zvi et al. (1990), found that soybean oil supplementation in a broiler line reduced fat deposition of carcass, whereas there were no dietary effects in the low abdominal fat line. Dewi et al. (2011) reported that the supplementation of Ca-PFA in the ratio until 15% was not affected the saturated fatty acid however it increased unsaturated fatty acid, omega-3 fatty acids and decreased fat deposition in broiler. In our study, the weight of abdominal fat pad was higher in female broilers than in male ($P < 0.05$) just as the result of Sanz et al.'s (1999) study. As it can be seen from Table 3, the small intestine length was influenced by the dietary fat supplementation ($P<0.01$). The lowest small intestine length was in CO, whereas the highest was in treatment Ca-PFA. Similarly, Ahmad et al. (2006) and Poorghasemi et al. (2013) reported that different fat&oil sources could affect small intestine length in broiler. It is not clear about the reason of small intestine lenght too long in the group of Ca-PFA, and it needs the efforts of other animal researches. The FA percentages of the poultry meat are presented in Table 4.

FA analyses of broiler carcass demostrated that the FA composition of dietary fats and oils altered the meat fatty acid profile ($P<0.001$). This result confirms the Scaife et al. (1994), Lopez-Ferrer et al. (2000), Crespo and Garcia (2002) who recorded that the FA composition of poultry body fat is directly affected the fatty acid profile of feed consumption by animal. However, Alao and Balnave (1984) determined that broilers have indicated the same body fat deposition in animals receiving different compositions of FAs. In the present research, the most abundant FA in the broiler meat was oleic acid. Similarly, Ajuyah et al. (1991) and Hrdinka et al. (1996) found that the oleic acid was the main FA in meat of birds in their study.

The group of Ca-PFA had the highest content of miristic acid (C14:0) and palmitic acid (C16:0) in meat ($P<0.001$). The maximum oleic acid (C18:1) percentage of meat was seen in the groups of Ca-PFA and CO ($P<0.001$) and females broiler ($P<0.05$). The highest meat linoleic acid (C18:2) content was determined in AO and SO groups ($P<0.001$). The use of SO indicated an increment on the points of linoleic acid on the broiler meat (Phetteplace and Watkins 1989; Cascabulho 2000). The lowest content of meat linolenic acid (C18:3) were in AO and Ca-PFA, whereas the highest was in SO ($P<0.05$). Onthe other hand, miristoleic acid (C14:1), palmitoleic acid (C16:1), stearic acid (C18:0) and arachidic acid (C20:0) remained constant in broilers fed Ca-PFA, AO, SO, CO.

Table 3. Effects of Ca-PFA and other some oil sources on carcass and parts yield and small intestine length of broilers

Tablo 3. *Etlik piliçlerde Ca-PFA ve diğer yağ kaynaklarının karkas oranı, karkas parça oranları ve ince bağırsak uzunluğu üzerine etkileri*

Item	AO	CO	SO	Ca-PFA	♀	♂	P values		
% Slaughtered weight							Group	Gender	GroupxGender
Eviscerated ratio	65.45±0.529^{B}	68.26±0.595^{A}	67.50±0.574^{AB}	65.41±0.414^{B}	66.69±0.393	66.62±0.565	0.001	0.906	0.200
Chilled carcass	65.34±0.519^{B}	68.04±0.612^{A}	67.24±0.613^{AB}	65.25±0.395^{B}	66.43±0.394	66.50±0.558	0.002	0.895	0.165
Thigh+drumstick	19.54±0.902	20.09±0.429	20.05±0.588	20.11±0.383	19.43±0.437	20.46±0.358	0.888	0.094	0.423
Breast	18.51±0.564	19.40±0.668	17.61±0.667	18.34±0.304	18.74±0.290	18.19±0.513	0.215	0.353	0.544
Wing	7.06±0.245	7.00±0.148	6.94±0.266	6.92±0.079	7.06±0.077	6.90±0.186	0.970	0.446	0.736
Back and neck	19.61±0.701	21.52±0.390	20.26±0.775	19.53±0.468	20.82±0.448	19.65±0.465	0.095	0.058	0.918
Gizzard weight	2.37±0.134	2.06±0.118	2.17±0.117	2.12±0.089	2.23±0.074	2.13±0.092	0.298	0.372	0.560
Gizzard fat	0.70±0.095	0.72±0.097	0.54±0.098	0.63±0.050	0.73±0.070	0.58±0.046	0.483	0.123	0.769
Abdominal fat	1.83±0.211	2.08±0.252	1.73±0.167	1.69±0.123	2.05±0.153^{b}	1.61±0.092^{a}	0.361	0.014	0.079
Intestine length	11.01±0.240^{B}	9.27±0.146^{C}	10.52±0.198^{B}	12.41±0.343^{A}	10.86±0.319	10.75±0.349	0.000	0.631	0.197

AO: Acid oil, CO: Canola oil, SO: Soybean oil, Ca-PFA: Calcium salts of palm fatty acids; ^{AB}Values in the same row without a common superscript letter are significantly different (P < 0.001); ^{ab}Values in the same row without a common superscript letter are significantly different (P < 0.05)

Table 4. Effects of Ca-PFA and other some oil sources on broiler meat fatty acid profile

Tablo 4. *Ca-PFA ve diğer yağ kaynaklarının piliç eti yağ asiti kompozisyonu üzerine etkileri*

Fatty acids	AO	CO	SO	Ca-PFA	♀	♂	P Values		
			Group				Gender		GroupxGender
C14:0	0.364±0.017^{B}	0.464±0.059^{B}	0.352±0.0344^{B}	0.711±0.019^{A}	0.446±0.042	0.498±0.046	0.000	0.128	0.064
C14:1	0.119±0.017	0.198±0.050	0.122±0.021	0.189±0.017	0.138±0.015	0.175±0.027	0.104	0.201	0.128
C16:0	17.978±0.729^{B}	17.42±0.981^{B}	18.183±0.702^{B}	23.554±0.684^{A}	19.506±0.834	19.056±0.831	0.000	0.593	0.900
C16:1	6.186±0.660	7.331±0.530	5.848±0.916	7.707±0.466	7.322±0.397	6.214±0.543	0.181	0.112	0.851
C18:0	3.839±0.669	4.010±1.130	4.198±0.741	3.257±0.171	3.395±0.247	4.255±0.683	0.833	0.266	0.432
C18:1	36.998±0.688^{B}	45.510±1.810^{A}	34.630±1.490^{B}	45.950±1.050^{A}	42.360±1.530^{a}	39.180±1.540^{b}	0.000	0.017	0.596
C18:2	32.800±1.690^{A}	22.080±1.090^{B}	31.940±1.840^{A}	16.870±1.000^{B}	24.530±2.030	27.320±1.900	0.000	0.067	0.964
C18:3	0.912±0.075^{b}	2.567±0.334^{ab}	3.630±1.350^{a}	1.077±0.314^{b}	1.532±0.202	2.562±0.754	0.031	0.150	0.319
C20:0	0.810±0.145	0.427±0.086	1.089±0.395	0.679±0.301	0.767±0.218	0.736±0.155	0.319	0.902	0.090

AO: Acid oil, CO: Canola oil, SO: Soybean oil, Ca-PFA: Calcium salts of palm fatty acids, C14:0: Miristic acid, C14:1:Miristoleic acid, C16:0: Palmitic acid, C16:1:Palmitoleic acid, C18:0: Stearic acid, C18:1: Oleic acid, C18:2: Linoleic acid, C18:3: Linolenic acid, C20:0: Arachidic acid ^{AB}Values in the same row without a common superscript letter are significantly different (P < 0.001) ^{ab}Values in the same row without a common superscript letter are significantly different (P < 0.05)

4. Conclusions

In this study, different fat sources effected carcass ratio of broiler. The most abundant FA in the broiler meat was oleic acid for all oil sources. We found consistent parallels between dietary FA and meat fatty acids in broilers. We concluded that the alteration of chicken meat fatty acid profile by dietary fat is certainly possible. According to the results, we can manipulate broiler meat fatty acid composition to more healthy and customized diets for human.

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