Asian Journal of Chemistry Vol. 22, No. 5 (2010), 3785-3792

Fatty Acid Compositions of Some Feed Raw Materials in Poultry Diets

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In this study, total fat content and fatty acid composition of 5 feed raw materials in animal source and 10 feed raw materials in vegetables source were determined by gas chromatography. Polyunsaturated fatty acids (PUFA) were found to be higher than saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA) in all samples except for rendering oil, tallow and meat bone samples. Palmitic acid was the major saturated fatty acid (7.65-20.31 % of total fatty acids) in all samples except for rendering oil and tallow. Oleic acid was identified as the major monounsaturated fatty acid (14.39- 40.00 % of total fatty acids) in all samples. Linoleic acid was the most abundant polyunsaturated fatty acid (2.53-60.80 % of total fatty acids) in all samples except for fish oil and fish meal. It was shown that the fatty acid composition, ω3/ω6 fatty acids ratio and SFA/PUFA ratio between the raw feed materials in poultry diets were varied.

Key Words: Feed, Fatty acid composition, Poultry, Diets.

INTRODUCTION

Lipids are regarded as the most important energy source in animal tissues, generally stored as triacylglycerols, in depot organs or adipose tissue[1]. Fat is a generic term and is commonly included in poultry diets to increase the energy and reduce dustiness of feed[2]. Feed composition plays an important role in feed intake, growth and the development of bird abdominal fat and breast muscle, including its fatty acid composition[3-5].

Fatty acid composition of the broiler carcass lipids is generally a reflection of the fatty acid profile of the diet[6]. The increase in the ω-3 PUFA content (C20:5ω-3, EPA, C22:5ω-3, DPA and especially C22:6ω-3 DHA) in poultry products is achieved by the supplementation of fish oil and other oils originating from sea organisms[7,8]. ω-3 PUFA have been shown to have positive effects on cardiovascular diseases[9].

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There is limited research on fatty acid composition of feed raw materials in poultry diets. Therefore, the aim of this study is to determine the total fatty acid composition, ω3/ω6 fatty acids ratio and SFA/PUFA ratio of some animal and plant source raw feed materials in poultry diets.

EXPERIMENTAL

105 Samples of different edible vegetable oils and animal fats obtained from the feed companies. Feed raw materials in animal source were categorized as rendering oil (n = 7), tallow (n = 7), fish oil (n = 7), fish meal (n = 7), meat-bone meal (n = 7) and the feed raw materials in vegetables source were categorized as bran (n = 7), wheat (n = 7), corn (n = 7), soy-bean meal (n = 7), sunflower-meal (n = 7), soybean (n = 7), corn oil (n = 7), sunflower oil (n = 7), soy-bean oil (n = 7) and acid oil (n = 7). These samples were frozen and stored at -27 ºC until analyzed.

Fatty acid analysis: Fat extraction was carried out according to the AOAC[10]. Fat (crude) was determined gravimetrically on 2 or 4 g portions of each feed composite or reference material by AOAC method 922.06[10]. Samples were *trans* esterified with BF_3-methanol[11].

The fatty acid methyl esters (FAMEs) were analyzed on a HP (Hewlett Packard) Agilent 6890N model gas chromatograph (GC), equipped with a flame ionization detector (FID) and fitted with a DB-23 capillary column (60 m, 0.25 mm i.d. and 0.25 μm). Injector and dedector temperatures were 270 and 280 ºC, respectively. Column temperature program was 190 ºC for 35 min then increasing at 30 ºC/min up to 220 ºC where it was maintained for 5 min. The total run time was 41 min. Carrier gas was helium (2 mL/min) and split ratio was 30:1. 1 mL of the fatty acid methyl esters was transferred to a GC vial and 1 μL was injected into the GC by an autosampler (HP 7683, HP Company, Wilmington, DE). Each reported result is the average value of three GC analyses. The results are offered as mean ± SD.

Identification of fatty acids was carried out comparing sample fatty acid methyl ester peak relative retantion times with those obtained for Alltech standards. Results were expressed as relative percentages. All solvents and reagents were analytical grade.

Statistical analysis: For analyzing the statistical data variance analysis with contrasts and regression analysis was applied using software Statistica for Windows version 5.1 and SAS System for Windows version 6.12.

RESULTS AND DISCUSSION

The feeds included in this study were non-dairy products and contained fatty acids of 8-24 carbon chain lengths. The total lipid content determined in the feed raw materials in poultry diets are given in Table-1. For this feed raw materials total lipid contents in soybean were determined higher than other samples.

Fatty acid composition of total 15 feed raw materials in poultry diets is shown in Table-2. In the present study, palmitic acid was the major saturated fatty acid

(7.65- 20.31 % of total fatty acids) in all samples except for rendering oil and tallow (Table-1) but tallow oil provided the highest amount of C16:0 (26.01 %) followed by the rendering oil (20.46 %). Similar results were obtained by Dugo *et al.*[12] with 28.11 % for tallow.

TABLE-1
TOTAL FAT CONTENTS OF SOME FEED RAW MATERIALS IN POULTRY DIETS

Samples	Contents of total fat (%)
Soybean	19.7
Soybean meal	2.7
Sunflower meal	1.9
Fish meal	11.6
Meat bone meal	15.5
Bran	3.9
Wheat	2.1
Corn	4.2

Oleic acid was identified as the major monounsaturated fatty acid (14.39- 40.00 % of total fatty acids) in all samples (Table-2). Similar results were obtained by Abu-Ghazaleh *et al.*[13] for soybean meal (15.94 g/100 g of fatty acids), Benedito-Palos *et al.*[14] for fish oil (12.5 %), Duran-Montge *et al.*[15] for tallow (31.0 %) and sunflower oil (27.3 %), Bonafaccia *et al.*[16] for common buckwheat (37.0 g/100 g total fatty acids), Mondello *et al.*[17] for soya oil (21.05/21.31 %, conventional/fast analysis) and corn oil (26.30/26.93 %, conventional/fast analysis), Marini *et al.*[18] for rice bran oils (36.0, 41.7 and 42.9 % in Thailand, Italy and Switzerland, respectively).

Linoleic acid (LA) was the most abundant polyunsaturated fatty acid (2.53-60.80 %) in all samples except for fish oil and fish meal. Rora *et al.*[19] found smilar results for soybean oil (43.6 %), Marini *et al.*[18] found similar results for rice bran oils (32.4, 34.9 and 37.9 %, in Thailand, Italy and Switzerland, respectively), Dugo *et al.*[12] for tallow (2.01 %), Mondello *et al.*[17] for corn oil (60.26/59.90 %, conventional/fast analysis), Aguilera *et al.*[20] for sunflower oil (55.92 g/100 g), Dunford and Zhang[21] for wheat germ oil (55.20-56.8 %), Abu-Ghazaleh *et al.*[13] for soybean meal (44.44 g/100 g of fatty acids), Mondello *et al.*[17] for soya oil (58.74/57.73 %, conventional/fast analysis).

The highest value of the SFA to PUFA ratio was in tallow. The SFA/PUFA value in tallow was around 14.49. The highest total saturated fatty acid content (63.33 %) was found in tallow. Similar results obtained by Yilmaz and Daglioglu[22] for beef tallow (59.4 %).

Consumption of ω-3 fatty acids may prevent the devolepment of coronary heart disease[23]. In the present study, fish oil and fish meal contained the highest levels of ω-3 fatty acids. These concentrations found were 36.78 and 30.47 % for fish oil and fish meal, respectively. In the present trial, the values for ω-6/ω-3 ratio were higher than 4, except for fish oil and fish meal that showed a value of 0.1 and 0.16, respectively. In meat bone, this ratio was near to 4.

TABLE-2
FATTY ACID COMPOSITION OF SOME FEED RAW MATERIALS IN POULTRY DIETS

Fatty acids	Rend. oil (n = 7)	Tallow (n = 7)	Fish oil (n = 7)	Fish meal (n = 7)	Meat bone (n = 7)	Bran (n = 7)	Wheat (n = 7)	Corn (n = 7)
C 8:0	-	0.01±0.00	0.32±0.12	0.01±0.01	-	-	0.01±0.01	0.01±0.00
C 9:0	-	0.05±0.00	0.10±0.03	-	-	-	-	-
C 10:0	0.03±0.01	0.07±0.01**	0.06±0.02	0.02±0.01	0.02±0.01	-	-	-
C 11:0	-	0.02±0.01	0.04±0.02	0.02±0.02	-	-	-	-
C 12:0	0.06±0.01	0.03±0.01	0.08±0.02	0.10±0.01	0.09±0.01	-	-	0.01±0.00
C 13:0	0.10±0.03	0.14±0.01	0.18±0.13	0.15±0.02	0.14±0.14	0.10±0.03	0.07±0.03	0.09±0.03
C 14:0	2.39±0.19	2.79±0.11	6.05±0.17	6.06±0.10	2.05±0.10	0.20±0.01	0.18±0.02	0.07±0.01
C 15:0	0.50±0.05	0.70±0.06	0.76±0.03	0.67±0.10	0.51±0.06	0.10±0.02	0.10±0.02	0.03±0.01
C 16:0	20.46±1.47	26.01±0.34	16.43±0.45	19.19±1.00	20.31±0.72	15.86±0.12	16.22±0.11	12.45±0.32
C 17:0	1.54±0.22	1.48±0.03	1.26±0.14	3.01±0.27	1.04±0.06	0.09±0.02	0.11±0.02	0.08±0.02
C 18:0	21.05±1.27	31.33±0.75	4.54±0.44	4.90±0.30	16.89±1.19	1.51±0.03	1.43±0.04	2.11±0.09
C 19:0	0.37±0.04	0.14±0.03	0.31±0.03	1.03±0.07	0.45±0.07	-	0.01±0.01	0.01±0.00
C 20:0	0.32±0.05	0.40±0.06	0.66±0.09	0.36±0.06	0.23±0.03	0.31±0.03	0.27±0.03	0.27±0.07
C 21:0	0.04±0.01	0.08±0.01	0.35±0.18	0.18±0.01	0.03±0.01	-	-	-
C 22:0	0.05±0.01	0.05±0.00	0.67±0.12	-	0.23±0.08	0.35±0.03	0.21±0.03	0.00±0.00
C 24:0	0.18±0.05	0.03±0.00	0.29±0.10	0.40±0.26	0.35±0.08	0.69±0.23	0.83±0.14	0.03±0.02
ΣSFA***	47.09	63.33	32.10	36.10	42.34	19.21	19.44	15.16
C 14:1 ω5	0.82±0.07	1.09±0.03	0.61±0.06	0.41±0.03	0.86±0.02	-	-	-
C 15:1 ω5	0.33±0.04	0.49±0.03	0.23±0.05	0.21±0.01	0.32±0.02	-	0.01±0.01	0.01±0.00
C 16:1 ω7	2.08±0.23	1.46±0.08	6.81±0.12	6.46±0.25	3.30±0.20	0.23±0.02	0.37±0.03	0.18±0.01
C 17:1 ω8	0.43±0.05	0.65±0.02	0.40±0.15	1.70±0.27	0.87±0.05	-	0.03±0.02	-
C 18:1 ω7	-	-	0.09±0.03	-	-	-	-	-
C 18:1 ω9	33.34±0.12	27.71±0.93	15.60±1.25	14.39±2.03	40.00±1.99	21.30±0.64	20.33±1.17	27.00±0.89
C 20:1 ω9	0.26±0.01	0.21±0.01	0.86±0.21	2.05±0.21	0.85±0.11	1.00±0.05	1.09±0.05	0.15±0.04
C 22:1 ω9	0.04±0.01	-	1.17±0.41	1.70±0.52	0.16±0.04	0.23±0.04	0.29±0.09	-
C 24:1 ω9	0.19±0.09	0.03±0.00	0.35±0.10	0.60±0.22	0.84±0.20	0.15±0.05	0.48±0.12	-
Σ MUFA***	37.49	31.64	26.12	27.52	47.20	22.91	22.60	27.34

C 16:2 ω4	0.85±0.06	1.25±0.09	0.36±0.07	0.70±0.05	1.01±0.11	-	-	-
C 18:2 ω6	12.12±3.44	2.53±0.20	1.63±0.08	2.47±0.17	5.24±0.99	52.50±0.63	52.09±1.16	56.24±0.69
C 18:3 ω3	0.47±0.05	0.43±0.05	1.82±0.23	1.97±0.26	0.93±0.14	4.42±0.13	4.12±0.16	1.27±0.02
C 20:2 ω6	0.07±0.01	0.03±0.00	0.13±0.03	0.27±0.02	1.24±0.50	0.01±0.01	0.04±0.02	-
C 20:4 ω6	0.05±0.02	0.05±0.00	1.13±0.02	1.06±0.09	0.07±0.02	-	-	-
C 20:5 ω3	0.20±0.08	-	12.87±0.69	11.58±1.55	0.07±0.04	-	-	-
C 22:2 ω6	0.01±0.01	-	0.38±0.03	0.03±0.03	0.08±0.04	-	-	-
C 22:3 ω3	0.05±0.02	0.04±0.01	0.32±0.13	0.67±0.12	0.44±0.06	0.13±0.06	0.61±0.13	-
C 22:4 ω6	0.59±0.20	0.01±0.01	0.41±0.07	1.17±0.18	0.75±0.21	0.27±0.09	0.98±0.42	-
C 22:5 ω3	0.57±0.05	0.03±0.00	4.43±0.82	1.70±0.25	0.42±0.09	0.42±0.16	0.04±0.04	-
C 22:6 ω3	0.01±0.01	-	17.34±0.70	14.55±1.35	-	-	0.09±0.09	0.01±0.01
Σ PUFA***	14.99	4.37	40.82	36.17	10.25	57.75	57.97	57.52
C 16:1t	0.04±0.02	0.25±0.02	0.80±0.16	-	-	0.14±0.01	-	0.01±0.01
C 18:2t	0.35±0.06	0.39±0.09	0.16±0.04	0.22±0.04	0.23±0.15	-	-	-
Σ TFA***	0.39	0.64	0.96	0.22	0.23	0.14	-	0.01
ω3	1.30	0.50	36.78	30.47	1.86	4.97	4.86	1.28
ω6	12.84	2.62	3.68	5.0	7.38	52.78	53.11	56.24
ω3/ω6	0.1	0.19	9.99	6.09	0.25	0.09	0.09	0.02
ω6/ω3	9.88	5.24	0.10	0.16	3.97	10.62	10.93	43.94
SFA/PUFA	3.14	14.49	0.79	1	4.13	0.33	0.34	0.26

Fatty acids	Soybean meal (n = 7)	Sunflower meal (n=7)	Soybean (n = 7)	Corn oil (n = 7)	Sunflower oil (n = 7)	Soybean oil (n = 7)	Acid oil (n = 7)
C 8:0	0.01±0.01	0.08±0.08	-	-	-	-	-
C 9:0	0.05±0.03	-	-	-	-	-	-
C 10:0	0.01±0.01	-	-	-	-	-	-
C 11:0	0.01±0.01	0.07±0.07	-	-	-	-	-
C 12:0	0.01±0.01	0.01±0.00	-	-	-	0.02±0.02	0.37±0.19
C 13:0	0.22±0.03	0.29±0.05	0.03±0.02	-	-	-	0.03±0.03
C 14:0	0.19±0.03	0.13±0.01	0.10±0.01	-	0.16±0.09	0.20±0.09	0.38±0.15
C 15:0	0.08±0.01	0.07±0.01	0.01±0.01	-	-	-	0.07±0.03
C 16:0	14.02±0.27	7.65±0.14	10.94±0.22	10.01±0.22	9.06±2.28	14.03±2.63	11.05±1.56
C 17:0	0.18±0.02	0.11±0.02	0.08±0.02	0.05±0.01	0.01±0.01	0.06±0.02	0.18±0.04
C 18:0	5.34±0.24	4.56±0.06	5.47±0.30	2.40±0.10	3.80±0.26	4.70±0.19	4.90±0.41
C 19:0	0.02±0.01	0.01±0.00	-	0.11±0.11	0.11±0.08	0.13±0.09	0.14±0.05

C 20:0	0.36±0.01	0.46±0.02	0.32±0.08	0.39±0.07	0.28±0.02	0.30±0.05	0.50±0.04
C 21:0	-	-	-	-	-	-	0.02±0.01
C 22:0	0.37±0.06	0.77±0.13	0.30±0.11	0.16±0.06	0.73±0.12	0.35±0.07	0.70±0.08
C 24:0	0.24±0.02	0.37±0.01	0.12±0.04	0.19±0.08	0.43±0.07	0.17±0.04	0.45±0.10
Σ SFA	21.11	14.58	17.37	13.31	14.58	19.96	18.79
C 14:1 ω5	0.01±0.01	-	-	-	-	-	0.02±0.01
C 15:1 ω5	0.03±0.01	0.02±0.01	0.02±0.01	-	-	-	0.01±0.01
C 16:1 ω7	0.14±0.02	0.13±0.00	0.10±0.02	0.12±0.01	-	0.13±0.03	0.02±0.02
C 17:1 ω8	0.05±0.02	0.02±0.01	-	-	-	-	0.09±0.02
C 18:1 ω7	-	-	-	-	-	-	-
C 18:1 ω9	19.24±0.69	23.76±0.70	22.19±0.20	29.01±0.50	28.72±1.88	31.78±2.09	32.89±3.97
C 20:1 ω9	0.16±0.03	0.13±0.03	0.12±0.04	0.24±0.04	0.17±0.04	0.16±0.03	0.49±0.14
C 22:1 ω9	-	0.13±0.07	-	-	0.19±0.06	0.09±0.09	0.16±0.01
C 24:1 ω9	-	-	-	0.03±0.03	0.10±0.08	-	0.16±0.09
Σ MUFA	19.63	24.19	22.43	29.40	29.18	32.16	33.84
C 16:2 ω4	0.02±0.02	-	-	-	0.02±0.02	-	0.03±0.02
C 18:2 ω6	51.47±0.55	60.80±0.67	52.49±0.22	56.46±0.66	55.63±0.61	40.64±4.82	42.79±3.68
C 18:3 ω3	7.64±0.28	0.35±0.04	7.69±0.08	0.80±0.04	0.18±0.03	7.24±1.73	3.05±1.56
C 20:2 ω6	-	-	-	-	0.01±0.01	-	0.12±0.02
C 20:4 ω6	-	-	-	-	-	-	0.01±0.01
C 20:5 ω3	-	-	-	-	0.03±0.02	-	0.07±0.02
C 22:2 ω6	-	-	-	-	-	-	-
C 22:3 ω3	-	-	-	-	-	-	0.19±0.06
C 22:4 ω6	-	-	-	-	0.08±0.05	-	0.18±0.04
C 22:5 ω3	-	-	-	-	0.03±0.03	-	0.09±0.06
C 22:6 ω3	-	-	-	-	-	-	0.11±0.03
Σ PUFA	59.13	61.15	60.18	57.26	55.98	47.88	46.64
C 16:1-t	0.13±0.02	0.10±0.02	0.01±0.01	0.03±0.02	0.23±0.08	-	0.35±0.09
C 18:2-t	0.00±0.00	-	-		-	-	0.34±0.05
Σ TFA	0.13	0.10	0.01	0.03	0.23	-	0.69
ω3	7.64	0.35	7.69	0.80	0.24	7.24	3.51
ω6	51.47	60.80	52.49	56.46	55.72	40.64	43.10
ω3/ω6	0.15	0.01	0.15	0.01	-	0.18	0.08
ω6/ω3	6.74	173.71	6.83	70.58	232.16	5.61	12.28
SFA/PUFA	0.36	0.24	0.29	0.23	0.26	0.42	0.40

*Values reported are mean ± SD. **Average of three lots analyzed. *** SFA: Saturated fatty acid, MUFA: Monounsaturated fatty acid, PUFA: Polyunsaturated fatty acid, TFA: Trans fatty acid.

In the present study, the most abundant fatty acids in fish oil were docosahexaenoic (C22:6ω6), palmitic acid (C16:0), oleic acid (C18:1ω9) and eicosapentaenoic (C20:5 ω3), palmitoleic acid, (C16:1ω7), miristic acid (C14:0), stearic acid (C18:0) and docosapentaenoic acid (C22:5ω3), at 17.34, 16.43, 15.60, 12.87, 6.81, 6.05, 4.54 and 4.43 %, respectively. These 8 fatty acids represented about the 84 % of total fatty acids. Similar results were observed by Guler *et al.*[24] for 22:6ω3 (DHA), 16:0, 18:1 ω9, 16:1 ω7, 20:5 ω3 (EPA) and 18:0 in zander.

In the present, study corn and corn oil contains 56.24 and 56.46 % of the linoleic acid (C18:2 ω6), respectively. Similar result was observed by Opapeju *et al.*[25] (54.61-57.73 %) for two corn hybrids. In present study, in soybean, linoleic acid was major fatty acid with 52.49 %. Similarly, Rora *et al.*[19] was observed this results with 43.6 % for soybean oil. Bonofacia *et al.*[16] investigated composition of common and tartary buckwheat. In this study, 16:0, 18:1, 18:2 and 20:1 were major fatty acids in common buckwheat. In this study, saturated fatty acids were 20.5 % and unsaturated fatty acids were 79.3 % in common buckwheat. Similarly, in present study in wheat, saturated fatty acids and unsaturated fatty acids were 19.44 and 80.57 %, respectively.

Balevi *et al.*[26] investigated the use of oil industry by-products in broiler diets. In this study, the authors found that myristic acid, palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid were 0.01, 10.18, 7.34, 30.38, 50.37 and 0.35 % in crude sunflower oil, respectively. Similarly, in present study, in sunflower oil, myristic acid, palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid were 0.16, 9.06, 3.80, 28.72, 55.63 and 0.18%, respectively.

Coskun *et al.*[27] investigated the effect of fat supplementation of by-products of fat industry into diets of layers on the fatty acid composition of yolk and egg yield. In this study, the authors found that myristic acid, palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid were 0.02, 4.00, 0.84, 25.84, 58.37 and 4.15 % in acid oil, respectively. In present study, in acid oil, myristic acid, palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid were 0.38, 11.05, 4.90, 32.89, 42.79 and 3.05 %, respectively.

In conclusion, it was determined that fatty acid compositions of feed raw materials varied between different feed samples. Further researches are needed to determine fatty acid composition of poultry products fed this feed.

ACKNOWLEDGEMENT

This study was financed by Selcuk University Scientific Research Foundation (BAP) under Project FBE 2003/173.

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(*Received*: 23 July 2009; *Accepted*: 20 January 2010) AJC-8336