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Fatty Acid Deposition on Broiler Meat in Chickens Supplemented with Tuna Oil

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ABSTRACT

The aim of the present study was to evaluate the effect of feeding four levels of tuna oil on performance and fatty acid (FA) profiles of broiler chicken meat. 240 Ross broiler chickens were randomly assigned to 20 pens and divided into four treatments: 0%, 0.75%, 1%, and 1.25% of tuna oil. At 49 days, breast and legs-thighs muscles were processed for FA analysis. Concentrations of FA in legs and thighs meat were significantly higher when compared with breast meat. In both types of meats (breast and legs-thighs), the inclusion of 1.0% or 1.25% of tuna oil in the diet significantly increased ($P < 0.05$) the concentration of n-3 FA (especially docosahexaenoic and eicosapentaenoic acids). Fat in broiler breast contained a proportion of 29% saturated FA (SFA): 36% monosaturated FA (MFA): 35% polyunsaturated FA (PUFA); while legs and thighs meat had a proportion of 28% SFA: 38% MFA: 33% PUFA. The addition of tuna oil in the broiler diet significantly reduced the deposition of SFA, MFA, and PUFA in breast meat, while in legs and thighs these reductions were less noticeable. The significant reduction in the concentration of n-6 PUFA and the increment of n-3 PUFA were more evident in breast than in legs and thighs, and with the addition of 1% and 1.25% of tuna oil. The results of the present study suggest a difference in FA deposition attributable to supplementation with tuna oil. The addition of tuna oil could be recommendable to increase n-3 PUFA in both broiler chicken breast and legs-thighs meats, providing a healthier and functional chicken meat to consumer.

Keywords: n-3 Fatty Acids; Broilers; Tuna Oil; Breast Meat; Legs and Thighs Meat

1. Introduction

Dietary recommendations of n-3 polyunsaturated fatty acids (PUFA), including alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) on health, immunomodulation and reduction of several chronic diseases due to an increase inflammatory response is well documented [1-7]. Marine fish are important sources of n-3 PUFA [8-10]. In many countries, the consumption of marine products is very low; hence the benefit that could be derived from a diet rich in n-3 PUFA does not reach the majority of the population. On the other hand, fat in broiler white meat contains 33.5% of saturated, 30.5% unsaturated and 32% polyunsaturated fatty acids [11], which encouraging human consumption when these are compared with the low levels of PUFA and high levels of saturated fatty acids (SFA) in red meats [12]. Therefore, manipulating the ratio of these FA could make chicken meat even more attractive to consumers. Poultry diets greatly influence lipid profile of chicken meat, and so SFA, mono saturated fatty acids (MFA) or PUFA tends to resemble the profile of the feed [13,14]. The aim of the present study was to evaluate the performance and fatty acid (FA) profiles in breast and legs-thighs meats of broiler chicken fed four levels of tuna oil.

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2. Materials and Methods

2.1. Birds and Diets

A total of 240 day-old Ross x Ross broiler chickens were randomly assigned to 20 pens and divided into four treatments (0%, 0.75%, 1% and 1.25%). Treatments were assigned randomly and consisted of the incorporation tuna oil in commercial sorghum-soybean diets (**Table 1**). Starter or grower diets were calculated to meet the recommendations of the National Research Council (NRC) [15,16]. The final concentration of n-6 and n-3 PUFA in the experimental diets are shown in **Table 2**. Feed and water were provided ad libitum until the end of the experiment (49 days of age).

2.2. Analytical Methods

At 49 days, 10 birds (one from each replicate) were humanely killed. Breast, legs and thighs were taken from these birds and the bones and skin removed. Meat samples were macerated with a food processor and frozen at −20˚C until chemical analysis. Samples were processed according to the methods described by Folch for total lipid analysis [17]. Methyl esters of meat fatty acids were obtained and saponification was performed using boron trifluoride [18]. Fatty acids were quantified by gas chromatography using a DB-23 column (JW 122-2332 of 30 m × 0.25 mm internal diameter) on a Varian 3400 CX gas-liquid chromatograph, equipped with an autosampler and a flame ionization detector (Varian Associates, Inc., Sugar Land, TX). Nitrogen was the carrier gas at a flow rate of 30 mL/min. Temperatures were: column, 230˚C; injector, 150˚C; detector, 300˚C. Myristic acid (Sigma Chemical Co., St. Louis, MO.) was used as an internal standard for fatty acids. Retention times were compared with fatty acid methyl ester standards.

2.3. Statistical Analysis

Data from the productive parameters and meat chemical

Table 1. Composition of the diets for broiler chicken.

Item	Starter feed (0 - 21 days)				Grower feed (22 - 49 days)			
	0% Tuna oil	0.75% Tuna oil	1.0% Tuna oil	1.25% Tuna oil	0% Tuna oil	0.75% Tuna oil	1% Tuna oil	1.25% Tuna oil
Ingredient								
Sorghum (9% CP)	60.84	60.84	60.84	60.84	64.09	64.09	64.09	64.09
Soybean meal (48% CP)	31.74	31.74	31.74	31.74	29.19	29.19	29.19	29.19
Soybean Oil	3.00	2.25	2.00	1.75	3.00	2.25	2.00	1.75
Tuna oil	0.00	0.75	1.00	1.25	0.00	0.75	1.00	1.25
Calcium phosphate	2.24	2.24	2.24	2.24	1.60	1.60	1.60	1.6
Calcium carbonate	0.92	0.92	0.92	0.92	1.04	1.04	1.04	1.04
Vitamin premix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral premix[2]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Others	1.26	1.26	1.26	1.26	1.08	1.08	1.08	1.08
Total	100	100	100	100	100	100	100	100
Calculated Analysis								
ME, kcal/kg	3001	3007	3006	3005	3043	3040	3039	3038
CP, %	21.00	21.00	21.00	21.00	20.00	20.00	20.00	20.00
Lysine, %	1.17	1.17	1.17	1.17	5.02	5.02	5.02	5.02
Methionine + cysteine, %	0.84	0.84	0.84	0.84	1.00	1.00	1.00	1.00
Treonine, %	0.78	0.78	0.78	0.78	0.75	0.75	0.75	0.75
Arginine, %	1.21	1.21	1.21	1.21	0.70	0.70	0.70	0.70
Triptophan, %	0.27	0.27	0.27	0.27	1.138	1.138	1.138	1.138
Total calcium, %	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90
Available phosphorus %	0.45	0.45	0.45	0.45	0.35	0.35	0.35	0.35

[1]Vitamin premix supplied the following per kilogram of complete feed: vitamin A, 12,000 IU; vitamin D3, 2500 IU; vitamin E, 30 IU; vitamin K3, 2 mg; thiamine, 2.25 mg; riboflavin, 7.5 mg; pyridoxine, 3.5 mg; cobalamine, 0.02 mg; niacin, 45 mg; D-pantothenic acid, 12.5 mg; biotin, 0.125 mg; folic acid, 1.5 mg. [2]Mineral premix supplied the following as milligram/kilogram of complete feed: zinc, 50; copper, 12; iodine, 0.3; cobalt, 0.2; iron, 100; selenium 0.1; manganese, 110.

analysis were analyzed by analysis of variance using the General Linear Models (GLM) procedure. Significant differences (P < 0.05) were further separated using Tukey's multiple range test and commercial statistical analysis software (SAS Institute, 2002), with sex and treatment replicate as main effects [19].

3. Results and Discussion

3.1. Production Parameters

Body weight, body weight gain, and feed conversion ratio were not influenced by dietary treatment (**Table 3**). These data are in agreement with previous studies which incorporated different PUFA into broilers' diets and did not find significant differences in these performance parameters [14,20].

3.2. Total Lipid and Fatty Acid Composition

The comparison of the content of total lipids and FA between meats in broiler diets with different concentrations of tuna oil is summarized in **Table 4**. Content FA were significantly altered in both types of meat, showing a progressive increase in n-3 PUFA when tuna oil was added, however, the concentrations of total lipids and FA in legs and thighs meat were significantly higher when compared with breast meat (**Table 4**). Interestingly, in both types of meat, the inclusion of 1.0 or 1.25% of tuna oil in the diet significantly increased the concentration of n-3 PUFA (especially EPA and DHA). The concentration of EPA in legs and thighs was 300% higher than in breast and 100% higher for DHA in the same tissues.

Feeding additional tuna oil resulted in an increased accumulation of EPA, DHA, and total n-3 PUFA primarily at the expense of two omega-6 fatty acids, linoleic (18:2n-6) and arachidonic acid (20:4n-6) (data not shown). In the present study, fat in broiler breast contained a proportion of 29% SFA: 36 % MFA: 35% PUFA; while legs and thighs had a proportion of 28% SFA: 38% MFA: 33% PUFA.

These results agree with previous reports [14,18,21]. This profile is more beneficial for human consumption compared with the 40% SFA: 40% MFA: 20% PUFA presenting in beef meat [11]. The addition of tuna oil in the broiler diet significantly reduced the deposition of SFA, MFA, and PUFA in breast meat, while in legs and thighs these reductions were less noticeable (**Table 4**). On the other hand, the significant reduction in the concentration of n-6 PUFA and the increment of n-3 PUFA were more evident in breast than in legs and thighs, and

Table 2. Concentration of n-6 and n-3 polyunsaturated fatty acids (PUFA) in the experimental diets (mg/100g).

	Starter feed (0 - 21 days)				Grower feed (22 - 49 days)			
	0% Tuna oil	0.75% Tuna oil	1.0% Tuna oil	1.25 % Tuna oil	0% Tuna oil	0.75% Tuna oil	1% Tuna oil	1.25% Tuna oil
*C*18:2 *n*6 (*LA*)	904.31	646.71	476.88	499.69	466.11	469.69	515.55	570.55
*C*20:4 *n*6 (*AA*)	0.49	6.29	5.92	8.17	0.11	4.33	6.36	9.3
*C*18:3 *n*3 (*ALA*)	121.72	90.19	65.03	67.73	60.25	66.19	75.44	83.12
*C*20:5 *n*3 (*EPA*)	1.78	36.06	35.02	48.74	0.7	25.57	35.59	55.36
*C*22:5 *n*3 (*DPA*)	2.36	1.88	1.86	2.52	0.35	0.35	1.87	2.96
*C*22:6 *n*3 (*DHA*)	0.18	19.07	19.12	25.73	0.46	13.32	18.6	30.6
Total n-6	904.8	653	482.8	507.28	468.22	474.02	521.91	579.37
Total n-3	126.04	147.2	121.03	144.72	61.76	105.43	131.5	172.04

Table 3. Productive parameters of broilers fed different levels of tuna oil from 0 to 21 days and from 22 to 49 days of age.

Treatment	0 - 21 days of age			22 - 49 days of age		
Dietary tuna oil (%)	Body weight (g)	Feed consumption (g)	FCR	Body weight (g)	Feed consumption (g)	FCR
0	688.0 ± 1.51	868 ± 0.79	1.35 ± 0.03	2510 ± 0.07	3554 ± 0.04	1.96 ± 0.08
0.75	658.0 ± 1.03	855.0 ± 1.86	1.38 ± 0.01	2597 ± 0.03	3712 ± 0.07	1.92 ± 0.04
1.0	669.0 ± 0.48	857.4 ± 0.59	1.37 ± 0.01	2644 ± 0.04	3668 ± 0.09	1.88 ± 0.02
1.25	675.4 ± 0.79	888.4 ± 2.90	1.40 ± 0.02	2651 ± 0.05	3779 ± 0.07	1.91 ± 0.04

Means ± standar error. In each column there were no significant differences (P > 0.05).

Table 4. Lipids (g/100g) and fatty acids (mg/100g) in breast and legs-thighs meat of broiler fed different concentration of tuna oil.

Item	SFA	MFA	ALA (C18:3n3)	EPA (C20:5n3)	DHA (C22:6n3)	n-6 PUFA	n-3 PUFA	PUFA
Breast								
0% T. oil	232.2 ± 45.8^c	308.1 ± 59.9^e	18.97 ± 4.34^d	2.40 ± 0.37^f	5.62 ± 0.79^d	244.8 ± 45.8^c	26.9 ± 51.2^d	271.9 ± 5.47^d
0.75% T. oil	83.80 ± 3.04^d	99.35 ± 2.6^g	7.06 ± 0.27^e	4.21 ± 0.48^e	8.31 ± 0.93^d	81.5 ± 3.23^d	19.58 ± 4.5^e	100.9 ± 1.4^e
1.0% T. oil	99.27 ± 3.46^d	129.5 ± 15.2^f	6.68 ± 0.30^e	9.27 ± 1.13^d	17.98 ± 0.87^c	83.84 ± 2.72^d	33.93 ± 2.6^f	117.7 ± 1.7^e
1.25% T. oil	102.8 ± 5.39^d	117.3 ± 8.3^{fg}	6.33 ± 0.71^e	8.46 ± 0.75^d	21.54 ± 0.83^{bc}	79.90 ± 6.33^d	36.34 ± 6.9^f	116.2 ± 0.89^e
Legs and thighs								
0% T. oil	454 ± 47.9^{ab}	769.3 ± 48.4^a	63.81 ± 1.17^a	3.83 ± 0.27^e	6.23 ± 0.29^d	536.4 ± 69.5^a	73.8 ± 69.2^c	610.4 ± 0.91^a
0.75% T. oil	387.1 ± 30.3^b	520.9 ± 45.2^d	37.63 ± 4.25^c	17.00 ± 1.63^c	17.62 ± 1.60^c	380.4 ± 44.0^c	72.2 ± 48.3^c	452.7 ± 4.36^c
1.0% T. oil	416.4 ± 32.3^b	589.9 ± 45.3^c	43.41 ± 4.05^b	30.38 ± 2.60^b	27.5 ± 2.70^{ab}	439.2 ± 30.3^b	101.4 ± 39.3^b	540.6 ± 9.26^b
1.25% T. oil	512.1 ± 53.9^a	670.5 ± 82.6^b	46.20 ± 4.42^b	36.19 ± 5.90^a	33.2 ± 5.8^a	444.9 ± 79.0^b	115.8 ± 94.9^a	560.8 ± 16^{ab}

Data expressed as means ± standard error. Values within columns with different superscripts differ significantly ($P < 0.05$).

with the addition of 1% and 1.25% than 0.75% of tuna oil (**Table 4**). Similar results have been reported by other researchers [13,15,22]. The results of the present study suggest that tuna oil could be an attractive alternative to increase the concentrations of n-3 PUFA in broiler chicken meat.

REFERENCES

[1] K. M. Connor, J. P. SanGiovanni, C. Lofqvist, C. M. Aderman, J. Chen, A. Higuchi, S. Hong, E. A. Pravda, S. Majchrzak, D. Carper, A. Hellstrom, J. X. Kang, E. Y. Chew, N. Salem, C. N. Serhan Jr. and L. E. H. Smith, "Increased Dietary Intake of Omega-3-Polyunsaturated Fatty Acids Reduces Pathological Retinal Angiogenesis," *Nature Medicine*, Vol. 13, No. 7, 2007, pp. 868-873. doi:10.1038/nm1591

[2] W. E. Connor and S. L. Connor, "The Importance of Fish and Docosahexaenoic Acid in Alzheimer Disease," *The American Journal of Clinical Nutrition*, Vol. 85, No. 4, 2007, pp. 929-930.

[3] C. Vanek and W. E. Connor, "Do n-3 Fatty Acids Prevent Osteoporosis?" *The American Journal of Clinical Nutrition*, Vol. 85, No. 3, 2007, pp. 647-648.

[4] P. Simopoulos, "The Omega-6/Omega-3 Fatty Acid Ratio, Genetic Variation, and Cardiovascular Disease," *Asia Pacific Journal of Clinical Nutrition*, Vol. 17, Suppl. 1, 2008, pp. 131-134.

[5] P. Simopoulos, "Evolutionary Aspects of the Dietary Omega-6:Omega-3 Fatty Acid Ratio: Medical Implications," *World Review of Nutrition and Dietetics*, Vol. 100, 2009, pp. 1-21. doi:10.1159/000235706

[6] P. Simopoulos, "Omega-6/Omega-3 Essential Fatty Acids: Biological Effects," *World Review of Nutrition and Dietetics*, Vol. 100, 2009, pp. 1-16. doi:10.1159/000192755

[7] R. Uauy and A. D. Dangour, "Fat and Fatty Acid Requirements and Recommendations for Infants of 0 - 2 Years and Children of 2 - 18 Years," *Annals of Nutrition and Metabolism*, Vol. 55, 2009, pp. 76-96. doi:10.1159/000228997

[8] M. Betti, T. I. Perez, M. J. Zuidhof and R. A. Renema, "Omega-3-Enriched Broiler Meat: 3. Fatty Acid Distribution between Triacylglycerol and Phospholipid Classes," *Poultry Science*, Vol. 88, No. 8, 2009, pp. 1740-1754. doi:10.3382/ps.2008-00449

[9] C. Nishida and R. Uauy. "WHO Scientific Update on Health Consequences of Trans Fatty Acids: Introduction," *European Journal of Clinical Nutrition*, Vol. 63, Suppl. 2, 2009, pp. S1-S4. doi:10.1038/ejcn.2009.13

[10] P Simopoulos, "Commentary. Genetic Variants and Omega-6, Omega-3 Fatty Acids: Their Role in the Determination of Nutritional Requirements and Chronic Disease Risk," *Journal of Nutrigenetics and Nutrigenomics*, Vol. 2, No. 3, 2009, pp. 117-118. doi:10.1159/000235630

[11] W. M. Ratnayake, R. Hollywood, E. O'Grady and G. Pelletier, "Fatty Acids in Some Common Food Items in Canada," *Journal of the American College of Nutrition*, Vol. 12, No. 6, 1993, pp. 651-660.

[12] J. M. Bourre, "Effect of Increasing the Omega-3 Fatty Acid in the Diets of Animals on the Animal Products Consumed by Humans," *Medécine Sciences* (*Paris*), Vol. 21, No. 8-9, 2005, pp. 773-779. doi:10.1051/medsci/2005218-9773

[13] S. López-Ferrer, M. D. Baucells, A. C. Barroeta and M. A. Grashorn, "n-3 Enrichment of Chicken Meat. 1. Use of Very Long-Chain Fatty Acids in Chicken Diets and Their Influence on Meat Quality: Fish Oil," *Poultry Science*, Vol. 80, No. 6, 2001, pp. 741-752.

[14] P. R. Howe, J. A. Downing, B. F. Grenyer, E. M. Grigonis-Deane and W. L. Bryden, "Tuna Fishmeal as a Source

of DHA for n-3 PUFA Enrichment of Pork, Chicken, and Eggs," *Lipids*, Vol. 37, No. 11, 2002, pp. 1067-1076. doi:10.1007/s11745-002-1002-3

[15] H. W. Hulan, R. G. Ackman, W. M. Ratnayake and F. G. Proudfoot, "Omega-3 Fatty Acid Levels and General Performance of Commercial Broilers Fed Practical Levels of Redfish Meal," *Poultry Science*, Vol. 68, No. 1, 1989, pp. 153-162. doi:10.3382/ps.0680153

[16] National Research Council, "Nutrient Requirements of Poultry," 9th Revised Edition, National Academy Press, Washington DC, 1994.

[17] J. Folch, M. Lees and G. H. Sloane Stanley, "A Simple Method for the Isolation and Purification of Total Lipides from Animal Tissues," *The Journal of Biological Chemistry*, Vol. 226, No. 1, 1957, pp. 497-509.

[18] M. I. Castro González, S. Montano Benavides and F. Pérez-Gil Romo, "Fatty Acids in Sardine Canned in Tomato Sauce from Different Fishing Areas of the Mexican Pacific," *Archivos Latinoamericanos de Nutrición*, Vol. 51, No. 4, 2001, pp. 400-406.

[19] SAS Institute Inc, "SAS User's Guide: Statistics," SAS Institute Inc., Cary, 2002.

[20] E. T. Moran Jr., "Variations in Body Composition of Poultry," *The proceedings of the Nutrition Society*, Vol. 45, No. 1, 1986, pp. 101-109. doi:10.1079/PNS19860040

[21] D. Shin, S. H. Choi, G. Go, J. H. Park, C. Narciso-Gaytan, C. A. Morgan, S. B. Smith, M. X. Sanchez-Plata and C. A. Ruiz-Feria. "Effects of Dietary Combination of n-3 and n-9 Fatty Acids on the Deposition of Linoleic and Arachidonic Acid in Broiler Chicken Meats," *Poultry Science*, Vol. 91, No. 4, 2012, pp. 1009-1017. doi:10.3382/ps.2011-01836

[22] R. Gonzalez-Esquerra and S. Leeson, "Effects of Menhaden Oil and Flaxseed in Broiler Diets on Sensory Quality and Lipid Composition of Poultry Meat," *British Poultry Science*, Vol. 41, No. 4, 2000, pp. 481-488. doi:10.1080/713654967

