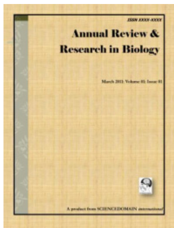

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Performance and Essential Fatty Acids Content of Dark Meat as Affected by Supplementing the Broiler Diet with Different Levels of Flaxseeds

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Research Article

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ABSTRACT

In recent years attention was focused on the relationship between, increased human consumption of Omega 3 fatty acids such as, $C_{20:5}$ (EPA), $C_{22:6}$ (DHA) & $C_{22:5}$ (DPA) and lowered incidence of human coronary heart disease. These fatty acids are mainly present in fish products which could result in fishy flavor in eggs of birds, fed such ingredients. Flaxseeds were found to be a good source for linolenic acid, an important poly-unsaturated fatty acid which is a precursor for the omega 3 fatty acids. This experiment was conducted to study the effect of feeding different levels of flaxseeds on performance and essential fatty acids content of broiler dark meat. Five levels of roasted or unroasted flaxseeds: 0, 5, 10, 15 and 20 % dry weight were fed to 400 broiler chickens in 4 replicates (10 birds/battery pen). Feed was given ad-libitum. Results of this experiment showed a relatively higher consumption of feed, lower body weight, higher feed conversion when flax seed level in the diet was increased beyond 5%. However, feeding 15 % flaxseed increased the omega3 fatty acid (linolenic acid, DHA, EPA and DPA) sharply in the fat of dark meat (thigh) which make this meat healthier to human. It is suggested that roasting can improve the quality of flax seeds and these seeds can be incorporated in the broiler diet if the producer is willing to sacrifice some performance. In turn he will get a premium price for his products.

Keywords: DHA, EPA, DPA, linolenic acid, flaxseed, broilers, dark meat;

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1. INTRODUCTION

Earlier studies have demonstrated the importance of Omega 3 fatty acids to human health (Burr and Burr, 1930; Holman et al., 1982; Owren et al., 1964; Holman et al., 1982; Owren et al., 1964; Singer et al., 1986; Cunnane et al., 1989; Farrell, 1995).

Fish products are high in n-3 fatty acids such as Eicosapentaenoic acid (EPA), 20:5, n-3 and Decosahexaenoic acid (DHA), 22:6, n-3 but because fish may not be readily available everywhere and the unacceptable fishy taint in meat and eggs of poultry fed fish products, other sources for n-3 fatty acids are needed (Novak and Scheideler, 2001).

Studies by Caston and Leeson (1990) and Jiang et al. (1991) provided evidence that brown-seeded flax (*Linum usitatissimum* L.) is one of the most concentrated sources of unsaturated fatty acid available in natural feedstuffs for poultry. Common varieties of flaxseeds have very high concentration of polyunsaturated fatty acids, especially α-linolenic acid (Genser, 1994).

Despite the beneficial effect of using flaxseed in chicken diet there has been some concern about the toxicity problem associated with flaxseeds which could be the result of anti-nutritional factors contained with full-fat flaxseed. Aymond and Van Elswyk (1995) reported a decrease in egg production in hens consuming 15 % flaxseed. Scheideler et al. (1995) showed that egg production was depressed with the addition of 10% flaxseed to the diet. Studies on broilers have demonstrated that effect. Components such as cyanogenic glycosides (linustatin, neolinustatin and linamarin) produce prussic acid and thiocyanate ions that can be very detrimental to the animal (Oomah et al., 1992). These compounds can be removed from flaxseeds by boiling in water, drying and wet autoclaving or by acid treatments, followed by autoclaving (Mazza and Oomah, 1995).

When comparing broilers with mammals, the omega3 fatty acid content of the skeletal muscle in birds is lower and that of n3 PUFA is higher (Hulbert et al., 2002) and when birds fed typical diets, the concentration of omega3 fatty acids in their edible tissues are relatively low. Therefore, broilers were fed diets fortified with flax seeds as an attempt to enrich the muscle tissues with more of the omega3 fatty acids.

This study was conducted in an attempt to study the effect of supplementing the broiler diet with roasted or unroasted full-fat flaxseeds on performance and fatty acid components of the chicken dark meat.

2. MATERIALS AND METHODS

Samples of ground flaxseeds were subjected to proximate chemical analysis according to the method of American Association of Cereal Chemists (AACC, 1994) .Fatty acid composition of the flaxseeds and chicken products were determined by gas liquid chromatography. Cholesterol in eggs and fatty acids in flaxseeds and yolks were determined by Gas Chromotographic method using direct saponification (AOAC official method 994.10, 2000). Lipid in test materials was saponified at high temperature with ethanolic KOH solution. Unsaponifiable fraction containing cholesterol and other sterols was extracted with toluene. Sterols were derivatized to trimethylsilyl (TMS) ethers and then quantified by Gas Choromotography.

Flax seeds were subjected to heat treatment using large try and exposed to direct heat from gas stove for 10 minutes during which the seeds were turned several times till color was changed to dark brown. The highest roasting temperature reached was 120 °C.

Four hundred chicks were randomly distributed intermingled in to 40 battery pens, each contained 10 chicks.

Five levels of roasted or unroasted flaxseeds replaced part of the grain in the ration at the rate of; 0, 5, 10, 15 and 20 % of the diet (Table 1). These dietary treatments were assigned to the pens in such a way that each dietary treatment was assigned to 4 replicates. Feed was given on a training basis for 10 days to acclimate the birds on the new ingredient. Feed was then given ad-libitum for the rest of the period.

Table 1. The composition of Broiler diet

Feedstuff composition	**Flax seed content**				
	0 %	**5 %**	**10 %**	**15 %**	**20 %**
Yellow Corn, %	61.00	56.20	52.00	48.00	45.00
SBM, 44 %	29.50	27.50	25.30	23.20	21.10
Wheat Bran , %	0.00	1.50	3.00	4.00	4.30
Fish meal, 60 % CP	3.08	3.00	3.00	3.00	3.00
Limestone, %	1.38	1.00	1.00	1.05	1.14
MVMIX[1]	0.20	0.20	0.20	0.20	0.20
DL Methionine,%	0.25	0.20	0.20	0.25	0.25
Dicalcium Phosphate, %	0.77	1.44	1.40	1.50	1.50
Salt, %	0.30	0.30	0.30	0.30	0.30
Veg. Oil, %	3.42	3.56	3.52	3.44	3.07
Antioxidant, %	0.10	0.10	0.10	0.10	0.14
Flaxseeds, %	0.00	5.00	10.00	15.00	20.00
Calculated Composition					
Crude Protein, %	20.00	20.00	20.00	20.00	20.00
Metabolizable Energy, Kcal/Kg	3100	3100	3100	3100	3100
Calcium, %	1.00	1.02	1.02	1.06	1.10
Available Phosphorus, %	0.43	0.54	0.54	0.55	0.55
Riboflavin, mg/kg	1.77	1.95	2.14	2.31	2.46
Niacin, mg/kg	26.05	29.04	32.17	34.47	35.72
Pantothenic Acid, mg/kg	7.68	7.82	7.96	7.98	7.83
Choline, mg/kg	1365	1454	1544	1633	1722
Methionine, %	0.58	0.54	0.54	0.58	0.59
Meth. + Cystine, %	0.88	0.84	0.85	0.89	0.91
Lysine, %	1.16	1.14	1.12	1.10	1.08
Tryptphan, %	0.30	0.30	0.29	0.29	0.29
Linoleic Acid, %	3.04	3.19	3.25	3.30	3.20

[1]*The multi vitamin-minerals premix provide the following per Kg of diet: 7000 IU, vit A; 1500 ICU, vit D3; 30 IU, vit E; 50 mg, vit C; 2.3 mg, vit K; 1.8 mg, vit B1; 5.5 mg, vit B2; 2.3 mg, vit B6; 0.011 mg, vit B12; 27.6, mg Niacin; 0.92 mg, Folic acid; 6.9 mg, PA; 0.092 mg, Biotin; 50 mg, Antioxidant (BHT); 8 mg, copper; 0.35 mg, Iodine; 0.26 mg, Iron; 0.44 mg, Manganese; 0.18 mg, Selenium; 44 mg, Zinc.*

Birds were weighed individually every week and weight gain was determined according to that. Feed was added as necessary and weekly and cumulative feed intake was determined from feed left as opposed to feed given. Weekly mortality was calculated based on number of birds died in specific day of the week.

At the end of the experiment, four birds, two males and two females from each treatment were slaughtered for dressing analysis. The experiment lasted for 42 days.

Samples from thigh meat were subjected to fatty acid analysis to determine the amount of these acids, deposited in the meat.

Statistical Analysis

A 2 X 5 factorial design was used to conduct the experiment. Data were subjected to the ANOVA using SAS General Linear Model procedure (SAS Institute, 1989). Means of the treatments were compared by Duncan Multiple Range Test (Duncan, 1955).

3. RESULTS AND DISCUSSION

3.1 PRODUCTION TRAITS

Interaction between type of heat treatment and level of flax seeds on broiler performance during the 6 weeks of the experiments was not significant ($P<0.05$) and not of any magnitude to the results of this study except for cumulative feed intake which was significant in weeks 2 to 6 (Table 2). In both treatments, roasted or unroasted, the effect of increasing flax in diets resulted in a significant increase in feed consumption. The effect was more explicable when 15 and 20 % flaxseed was added. Najib and Al-Yousef (2010) observed a lower feed intake when higher level of flaxseeds was added (20 %) to the layer diet. This result was reflected on cumulative feed conversion in weeks 5 and 6. Higher value of feed conversion in both treatments was observed when 15 and 20 % flax was added (Table 2). It is known that when there is a higher consumption with little or no gain the feed conversion deteriorates.

The increase in consumption with higher level of flax whether roasted or unroasted could be due to the lower utilization of flax by the chicken which in turn the bird tried to eat more to compensate for the lower utilization.

The effect of toxicity has probably harmed the final body of the birds since lower weights were observed with increasing level of flax from 10 to 20 %. Components such as cyanogenic glycosides (linustatin, neolinustatin and linamarin; Oomah et al., 1992) may possibily be present in the seeds and can produce prussic acid and thiocyanate ions that can be very detrimental to the animal. This was not true with 5 % flax since higher body weight was observed. The highest body weight and weight gain was achieved when 5 % flax was added in weeks 5 and 6 of the experiment (Table 3).

Roasting the flax did not significantly affect any of the treatments in the weeks of the experiment. It is possible that roasting time was not enough to remove the toxicity effect or roasting may not work similar to boiling. Cyanogenic compounds can be removed from flaxseeds by boiling in water, drying and wet autoclaving or by acid treatments, followed by autoclaving (Mazza and Oomah, 1995). Roasting method was used in this experiment after failing to boil the flax without becoming sticky and adhere to each other.

Table 2. Effect of interaction between level of flax seed and heat treatment on cumulative feed intake and conversion of broilers birds[1]

Traits	Level X Form	Weeks in experiment					
		1	2	3	4	5	6
Cumulative Feed intake, mg	RO 0	156.7±3.05	543.3±6.34	1228.6±17.0	2242.6±59.9	3568.6±126.3	4961.6±168.3
	RO 5	157.6±6.14	796.1±34.0	1672.9±42.9	2819.7±64.8	4206.7±68.03	4580.7±701.4
	RO 10	158.3±6.47	831.8±20.1	1770.3±54.2	2995.6±120	4384.7±98.85	4384.7±98.85
	RO 15	157.2±13.8	821.7±19.8	1795.2±56.3	3056.4±90.7	4382.7±115.3	4382.7±115.3
	RO 20	161.8±2.79	830.4±16.0	1858.2±56.9	3273.4±62.8	4707.9±85.35	4707.9±85.35
	UR 0	158.8±11.7	824.1±22.1	1872.9±42.2	3324.9±70.2	4796.7±26.66	4796.7±26.66
	UR 5	160.0±6.66	812.8±44.2	1708.5±105	2874.2±178	4196.1±155.4	4196.1±155.4
	UR 10	159.3±4.28	818.2±36.8	1743.1±70.2	3012.8±146	4400.2±140.4	4400.2±140.4
	UR 15	167.7±6.16	1228.6±17.0	2242.6±59.9	3568.6±126	4961.6±168.3	4961.6±168.3
	UR 20	158.5±5.75	1470.8±42.0	2485.8±55.9	3818.2±116	5226.5±183.0	5226.5±183.0
	P =	0.4717	0.0001	0.0001	0.0001	0.0001	0.0020
Cumulative Feed Conversion, kg feed/kg live weight	RO 0	0.99±0.07	1.34±0.03	1.38±0.02	1.53±0.06	1.61±0.04	1.80±0.08
	RO 5	0.94±0.02	1.32±0.02	1.40±0.01	1.61±0.10	1.61±0.05	1.79±0.10
	RO 10	0.92±0.01	1.29±0.04	1.48±0.12	1.62±0.05	1.70±0.04	1.85±0.06
	RO 15	0.97±0.01	1.37±0.03	1.58±0.02	1.85±0.10	1.96±0.05	2.10±0.09
	RO 20	0.95±0.02	1.38±0.08	1.56±0.03	1.89±0.05	2.09±0.04	2.22±0.10
	UR 0	0.97±0.06	1.36±0.03	1.40±0.01	1.55±0.02	1.58±0.08	1.73±0.10
	UR 5	0.95±0.08	1.32±0.02	1.46±0.06	1.63±0.05	1.70±0.10	1.87±0.17
	UR 10	0.94±0.03	1.35±0.02	1.55±0.14	1.80±0.05	1.78±0.08	1.91±0.09
	UR 15	0.96±0.05	1.38±0.04	1.53±0.05	1.80±0.04	1.79±0.09	2.00±0.03
	UR 20	0.94±0.05	1.35±0.08	1.61±0.05	1.94±0.09	2.10±0.04	2.24±0.03
	P =	0.8954	0.4300	0.3412	0.0354	0.0049	0.2048

[1] ± SD; RO: roasted flax; UR: unroasted flax; P: Probability level

3.2 FATTY ACIDS CONTENT OF THE EGG

The omega 3 fatty acids content of the thigh meat, such as α-linolenic acid, DHA, DPA and EPA were significantly affected by the interaction between heat treatment and level of the flax and between level of flax and sex of the bird (Table 4). There was a gradual increase of the α-linolenic acid content of fat muscle reaching its peak when 15 % roasted flaxseed was added then decreased sharply at the 20 % level. Unroasted flax did not show similar effect. DHA, DPA and EPA followed similar trend as α-linolenic acid did with the 15 % roasted flax.

Table 3. Performance of broilers fed different levels of flax seeds[1]

Traits	Flax level, %	Weeks in experiment					
		1	2	3	4	5	6
Daily Feed intake, gm	Among levels of Flax						
	0	22.53[a]	55.03[a]	91.68[b]	126.61[d]	165.18[d]	193.49[b]
	5	22.68[a]	55.19[a]	95.23[ab]	133.10[c]	178.21[c]	198.33[b]
	10	22.69[a]	55.12[a]	96.42[a]	141.96[b]	184.80[c]	194.23[b]
	15	23.29[a]	55.50[a]	95.95[a]	145.91[b]	196.27[b]	203.06[b]
	20	22.87[a]	55.30[a]	96.67[a]	152.30[a]	210.22[a]	213.62[a]
	P=	0.7566	0.7403	0.0671	0.0001	0.0001	0.0010
	Between type of treatment						
	RO	22.61[a]	55.08[a]	94.59[a]	139.01[a]	4250.1[a]	200.25[a]
	UR	22.98[a]	55.37[a]	95.79[a]	140.95[a]	4716.2[b]	200.84[a]
	P =	0.2853	0.2198	0.3088	0.2699	0.3772	0.8435
Body weight, gm	Among levels of Flax%						
	0	160.85[a]	402.6[a]	852.6[a]	1345.6[a]	2047.1[a]	2696.4[a]
	5	168.69[a]	412.9[a]	847.7[a]	1334.0[a]	2063.2[a]	2713.4[a]
	10	170.61[a]	412.2[a]	808.8[b]	1294.0[a]	2016.0[ab]	2588.5[b]
	15	168.82[a]	401.4[a]	787.3[b]	1230.2[b]	1934.1[b]	2458.9[c]
	20	169.19[a]	401.6[a]	772.2[b]	1194.0[b]	1797.1[c]	2407.5[c]
	P=	0.0914	0.1289	0.0002	0.0001	0.0001	0.0001
	Between type of treatments						
	RO	166.1[a]	406.48[a]	817.4[a]	1288.4[a]	1960.7[a]	2574.1[a]
	UR	169.1a	405.82[a]	810.0[a]	1270.7[a]	1982.4[a]	2571.8[a]
	P =	0.2106	0.8621	0.5310	0.3113	0.4755	0.3301
Body Weight gain, gm	Among levels of Flax%						
	0	118.41[b]	241.7[a]	450.06[a]	492.99[a]	701.5[a]	649.25[a]
	5	126.39[a]	244.2[a]	434.78[a]	486.35[a]	729.2[a]	650.13[a]
	10	128.18[a]	241.6[a]	396.60[b]	485.21[a]	722.0[a]	572.50[ab]
	15	126.32[a]	232.6[a]	385.85[b]	442.96[ab]	703.9[a]	524.75[b]
	20	126.80[a]	232.4[a]	370.56[b]	421.81[b]	603.1[b]	610.43[ab]
	P =	0.0869	0.1756	0.0005	0.0513	0.0314	0.0175
	Between type of treatments						
	RO	123.7[a]	240.34[a]	410.9[a]	471.04[a]	672.2[a]	613.4[a]
	UR	126.8	236.70[a]	404.2[a]	460.69[a]	711.6[a]	589.4[a]
	P =	0.1923	0.3489	0.5639	0.5541	0.1413	0.3523

[1] Means that are not carrying the same superscripts are significantly different, P<0.05
P = Probability level

Table 4. The Effect of interaction between heat treatment method and level of Flax seed in the diet on some essential Fatty Acids profile of broiler thigh meat[1]

Source of variation	Linoleic acid	α-Linolenic acid	DPA	DHA	EPA
TRT X LVL					
RO 0	12.47±6.21	0.91±0.64	0.08±0.08	0.11±0.09	0.10±0.09
RO 5	6.76±0.33	0.39±0.24	0.10±0.16	0.06±0.06	0.02±0.02
RO 10	16.42±0.8	1.74±0.28	0.19±0.11	0.19±0.14	0.11±0.10
RO 15	19.06±1.47	2.58±0.39	0.26±0.04	0.34±0.04	0.26±0.03
RO 20	13.30±4.34	0.75±0.20	0.11±0.08	0.08±0.03	0.06±0.02
UR 0	12.47±6.21	0.91±0.63	0.08±0.08	0.11±0.10	0.10±0.09
UR 5	9.80±2.74	0.28±0.14	0.04±0.05	0.08±0.04	0.05±0.06
UR 10	11.01±1.52	0.62±0.16	0.07±0.03	0.09±0.03	0.08±0.04
UR 15	7.67±2.69	0.56±0.48	0.02±0.02	0.06±0.03	0.08±0.06
UR 20	9.95±3.77	1.23±0.80	0.07±0.10	0.10±0.06	0.07±0.08
P =	< 0.0001	< 0.0001	0.0119	0.0001	0.0107
SEX x LVL					
F 0	17.84±0.11	1.46±0.05	0.15±0.00	0.18±0.01	0.18±0.01
F 5	7.13±0.52	0.32±0.29	0.02±0.01	0.09±0.04	0.03±0.01
F 10	13.39±4.26	1.14±0.45	0.18±0.12	0.19±0.14	0.13±0.08
F 15	11.69±7.16	1.28±1.15	0.12±0.13	0.18±0.15	0.14±0.11
F 20	8.62±1.1	0.80±0.12	0.05±0.03	0.09±0.05	0.08±0.08
M 0	7.10±0.41	0.36±0.23	0.01±0.00	0.04±0.03	0.03±0.02
M 5	9.44±3.16	0.32±0.09	0.13±0.15	0.05±0.05	0.04±0.06
M 10	14.04±2.03	1.23±0.86	0.08±0.04	0.09±0.03	0.06±0.06
M 15	15.04±6.10	2.30±1.04	0.16±0.15	0.22±0.17	0.23±0.09
M 20	14.62±3.90	1.33±0.10	0.12±0.10	0.10±0.05	0.05±0.03
P =	< 0.0001	0.0002	0.0027	0.0121	0.0069

[1]= % of fat , DPA = Docosapentonoic acid, DHA = Docosahexonoic acid, EPA = Eicosapentonoic acid, RO = roasted , UR = unroasted, F = female, M = male, TRT = treatments, LVL = level, P = Probability level

Rymer and Givens (2005) in a review article reported that the concentration of α-linlenic acid (ALA) in the edible tissues of poultry is readily increased by increasing the concentration of ALA in the birds' diet particularly, meat with skin and dark meat, to a greater extent than white meat. The concentration of EPA in both white and dark meat was also increased when the birds diet was supplemented with EPA, they further added.

Table 5. The Effect of interaction between heat treatment method and level of Flax seed in the diet on Fatty Acids profile and cholesterol of broiler thigh meat[1]

Source of variation	Palm	Stearic	Pal oli	Oleic	Cholest
TRT x LVL					
RO 0	28.32±2.71	8.42±0.42	4.02±0.36	42.42±5.02	0.74±0.23
RO 5	29.57±0.75	10.44±1.37	4.78±0.53	45.05±1.02	0.88±0.19
RO 10	24.72±0.20	8.88±0.25	3.94±0.29	40.57±1.70	1.15±0.21
RO 15	24.02±1.58	8.17±0.61	3.59±0.39	38.42±0.70	1.22±0.56
RO 20	27.70±1.96	10.94±2.88	3.48±0.33	39.35±0.60	1.48±0.86
UR 0	28.32±2.71	8.42±0.42	4.02±0.36	42.42±5.02	0.74±0.23
UR 5	29.78±1.00	9.25±0.68	4.78±0.47	42.95±1.48	0.79±0.47
UR 10	27.82±1.06	8.75±0.44	4.64±0.64	43.73±1.13	0.80±0.01
UR 15	32.65±2.81	11.18±2.36	3.99±0.72	40.64±1.63	0.88±0.18
UR 20	28.84±2.08	11.26±1.62	4.00±0.47	41.04±1.75	0.98±0.01
P =	< 0.0001	0.0003	0.4393	0.0006	0.7594
SEX x LVL					
F 0	26.02±0.00	8.75±0.19	3.72±0.01	38.10±0.29	0.90±0.00
F 5	29.91±0.90	10.69±1.07	4.72±0.60	44.18±0.42	0.60±0.20
F 10	26.56±2.29	8.77±0.49	4.56±0.60	41.66±2.92	0.90±0.14
F 15	30.10±5.64	10.78±2.76	3.64±0.32	38.82±1.31	0.78±0.05
F 20	29.38±1.04	12.97±0.80	3.50±0.35	40.82±1.50	0.94±0.08
M 0	30.62±0.74	8.10±0.18	4.33±0.12	46.74±0.85	0.58±0.00
M 5	29.44±0.81	9.01±0.50	4.84±0.59	43.82±2.43	1.06±0.08
M 10	25.99±4.03	8.86±0.14	4.03±0.52	42.64±1.28	1.04±0.36
M 15	26.58±4.47	8.57±1.06	3.94±0.79	40.25±1.83	1.31±0.44
M 20	27.16±2.17	9.22±0.99	3.98±0.48	39.57±1.45	1.54±0.78
P =	< 0.0001	0.0007	0.1323	0.0001	0.3372

*1 = % of fat , Oleic = Oleic Acid , Pal-Oli = Palmioliec , Palm = Palmitic, Cholest = Cholesterol , ** significant, P<0.001. NS = Not significant , P>0.05, P = probability level*

The effect of linseed oil on fatty acid composition in broiler chickens has been studied at 56 days of age by Phetteplace and Watkins (1989) and for shorter periods by Olomu and Baracos (1991). Linseed oil fed at from 1.5% to 5% increased the incorporation of omega-3 fatty acids into chicken muscle lipids with the longer chain fatty acids influenced less than linolenic acid. While there was an increase in the omega-3 fatty acids, there was a slight decrease in the long chain omega-6 fatty acids. This may be due to competition of fatty acids resulting in decreased activity of the delta-6-desaturase enzyme. This observation agreed with the results of this experiment. Linoleic acid (C18:2) responded negatively to the unroasted flax seed while 15 % of the roasted increased its content in the fat (Fig 6). Oleic acid (monounsaturated fatty acid), on the otherhand was lower at the 15 % flax in both roasted or unroasted (Table 5).

Male broilers deposited more linolenic acid, linoleic acid, DHA and EPA in the fat than females did at the 15 % level of flax (Table 4). However the results did not show any trend. Rymer and Givens (2005) in their review reported conflicting results between no differences between males and females to a slightly of higher deposition of PUFA by male birds. This could be due to the reflection of the physiological immaturity of broilers at the slaughtered age.

The effect of interaction between flax seeds level and roasting and between level of flax and sex of the birds on saturated fatty acid, palmitic and stearic acids were significant ($P<0.05$) (Table 5). Both fatty acids increased as level of unroasted fatty acids increased to 15 %, while the opposite occurred with the roasted ones. This could be a reflection to the increase of most poly unsaturated fatty acid at the 15 % roasted flax. Male and female responded similarly to the increasing levels of roasted or unroasted flax seeds. Not much increase in their contribution to the dark meat fat. The cholesterol, on the other hand did not show a significant response to any of the treatments used although there was a slight non significant increase of the cholesterol in the dark meat of birds fed higher level of flax. Thigh male has slightly more cholesterol than female (Table 5).

Table 6.The effect of flax seed level and sex of the birds on dressing parameters

Source of Variation	**Traits**		
	Dressing %	**Fat %**	**Giblets %**
Flax level, %	NS	NS	NS
0	80.31[a]	1.857[a]	6.535[a]
5	79.96[a]	1.588[ab]	6.251[a]
10	79.03[a]	1.204[b]	5.972[a]
15	79.74[a]	1.620[ab]	6.548[a]
20	79.60[a]	1.311[ab]	6.342[a]
P =	0.8728	0.0875	0.2855
Sex	NS	**	*
Male	79.10[a]	1.266[a]	6.088[a]
Female	80.35[a]	1.766[b]	6.571[b]
P =	0.1214	0.0027	0.0121
Treatments	NS	NS	NS
Roasted	79.99[a]	1.524[a]	6.314[a]
Un Roasted	79.48[a]	1.507[a]	6.346[a]
P =	0.4820	0.9144	0.8656

[1]Means Within columns carrying different superscripts are significantly different, $P<0.05$.
***NS** = Not significant, $P>0.05$. ** Significant at 1 % level of probability, **LVL** = 0, 5, 10, 15 and 20 % of Flax seeds, P = Probability level*

There was no significant interaction between level of the seeds and sex of the birds or between roasting and sex of the birds or between heat treatment and level of the flax. The only notable difference (>5 % and < 10%) was in the fat level of the dressed bird (Table 6). Increasing level of flax in the diet decreased fat level in dressed bird especially at the 20 % flax. Female birds accumulated more fat than males.

4. CONCLUSION

It is concluded that feeding 15 % roasted flaxseeds to the broiler diet has increased the omega3 fatty acids ((linolenic acid, DHA, EPA and DPA) of broiler thigh meat which makes these products healthier to human. However, the performance was negatively affected. Therefore, if the producer can get a premium price for his broiler meat then lower performance can be justified.

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