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Influence of Canola Oil and Lysine Supplementation Diets on Growth Performance and Fatty Acid Composition of Meat in Broiler Chicks

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***Abstract*—**A study was conducted to evaluate the effects of diets containing different levels of lysine and canola oil on growth performance and fatty acid composition of meat of broilers chicks. 240-day old Ross broiler chicks were used in a 3×2 factorial arrangement with canola oil (1, 3, and 5%) and lysine (recommended, and 25% more than recommended by Ross broiler manual) in completely randomized design with four replicates and 10 birds per each. The experimental diets were iso-caloric and iso-nitrogenous. Feed intake and body weight gain were recorded at the end of starter (10 d), grower (24 d) and finisher (42 d) periods, and feed conversion ratio was calculated. The results showed that the weight gain of chickens fed diets containing 5% canola oil were greater than those of birds fed on other diets (P<0.05). The dietary lysine had significant effect on feed intake and diets with 25% more than recommended, increased feed intake significantly (P<0.05). The canola oil×lysine interaction effects on performance were not significant. Among all treatment birds, those fed diets containing 5% canola oil had the highest meristic acid and oleic acid content in their meat. Broilers fed diets containing 3 or 5% canola oil possessed the higher content of linolenic acid and lower content of arachidonic acid in their meat (P<0.05). The results of the present experiment indicated that the diets containing canola oil (5%) and lysine at 25% higher than requirement, improve the growth performance, carcass and breast yield of broiler, and increase the accumulation of Omega-3 fatty acids in breast meat.

***Keywords*—**Broiler, canola oil, lysine, fatty acid.

I. Introduction

THE idea of functional foods is a new frontier in nutritional sciences and its concept stretches the borders of nutrition. Classical nutrition focuses on meeting nutrient requirements and their significance regarding diseases due to deficiency, whereas functional food science emphasises on health-related and physiological effects of foods, helping to reduce the risk of chronic diseases. Thus, functional foods can be defined as those containing specific nutrients and (or) non-nutrients that provide a specific and beneficial physiological effect on health, performance and/or well-being extending beyond the provision of simple nutrients. In view of the above, polyunsaturated fatty acids (PUFAs, n-6 and n-3) are the most physiologically active or functional component of animal origin. Among them, n-3 PUFA is the most important fatty acid (FA). Clinical studies have shown that the dietary n-3 FAs may reduce the risk of several chronic diseases including cardiovascular disease and may have benefit in improvement of immune response and reduction of the serum cholesterol concentration [1]-[4].

Nowadays, chicken meat due to relatively low prices could play an important role in human diets in most countries. Moreover, from the economical and human health aspects, carcasses weight and composition of broiler chickens are receiving considerable attention in recent years. The FA composition of meat products (especially, n-3 PUFA) is an important parameter of the meat quality. Thus, there has been increased recent interest in manipulating the FA composition of meat. It has been already demonstrated that the poultry has a peculiar capability of incorporating n-3 FAs in the internal fat of meat and other tissues [5]-[8]. Crespo and Esteve-Garcia [28] reported that the meat quality, FAs composition, and concentration of several nutrients depend largely on diets which fed to birds. Several studies have shown that FA composition of broiler meat can be altered by changing in the FA content of diet [5], [9]. Previous reports have indicated that diets containing fish oil [10]-[12], canola oil [12], [13], fish powder [14], [15] full-fat oil seeds [16], and flaxseed influence the carcass FA composition. Canola oil has been recognized for its low saturated and high content of monounsaturated FAs. It is a good source of linolenic acid (C18:3), an unsaturated FAs, that can be converted to longer chain n-3 FAs [12].

Lysine is generally accepted as the second limiting amino acid following the methionine in corn-soybean based diets, and it is used as a reference amino acid in ideal amino acid system [17], [18]. Previous studies showed that higher lysine levels in diet resulted in better carcass and part yields [19]. Reference [20] reported a reduction in growth rate (45%), pectoral (60%) and Sartorius (40%) muscles and, higher protein degradation compared with protein synthesis in birds fed on lysine- deficient diets. Also, lower abdominal fat and higher breast and thigh yields were reported when broilers fed on diets high in lysine [19], [21].

Breast meat constitutes around 30% of total broiler meat and 50% of total edible protein and it is a valuable constituent of human food. At the present time, there is an emphasis on increasing breast meat production and decreasing the fat content of the broiler chicken carcass [22], [23]. In this regard, lysine is the most important amino acids that can affect the breast meat yield of modern broilers.

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We hypothesized that increased dietary n-3 PUFA due to canola oil supplementations may improve the growth rate and FCR and may change FAs composition of broiler meat. We were also interested at evaluating the effects of canola oil inclusion to broiler diets containing higher levels of lysine on n-3 FA deposition of meat and growth of broiler. Therefore, this study aimed at evaluating the effects of canola oil inclusion to broiler diets containing different levels of lysine on performance, carcass traits, and FAs composition of meat.

II. Materials and Methods

A. Birds Husbandry and Experimental Diets

A total of 240-day-old Ross 308 broiler chicks obtained from a local hatchery were randomly allocated in 24 cage pens (100 × 85 cm). Chickens were assigned to 1 of 6 dietary treatments (four pen replicates; 10 chicks per) and increased under environmentally controlled conditions taking after a standard temperature regimen that gradually dropped from 32 to 24 °C by 0.5 °C daily and a 23L: 1D lighting program. Every cage contained equivalent number of male and female birds. Feed intake and live BW were recorded weekly on a per cage basis, and feed consumption ratio (FCR) was then calculated.

Dietary treatments were allocated to cages as 3 × 2 factorial arrangements. The six experimental diets included a corn-soybean meal basal diet, the basal diet supplemented with three levels of canola oil (1, 3 and 5% diet), and two dietary lysine levels [recommended by Ross 308 manual (1.44, 1.29 and 1.16 for starter, grower and finisher periods, respectively) and 25% more than Ross recommendation (1.80, 1.61, and 1.45% for starter, grower and finisher periods, respectively)]. Diets were formulated to meet or exceed the nutritional recommendations (Table I; Ross 308 manual). Birds were fed with a starter diet from 0 to 10d followed by grower (11 to 24d) and finisher (25 to 42d) diets. Feed and water were provided ad-libitum.

B. Carcass Yields and Organ Weights

At day 42, two birds, including one from each sex, per treatment pen (n=8/treatment) were randomly selected, and were individually weighed, and euthanized by cervical dislocation. The abdominal cavity was opened, and the total gastrointestinal tract was immediately exposed. Entire intestinal tract, gizzard, liver, abdominal fat, legs and breast meat weights were measured as percentages of respective live BW. Weights of eviscerated carcasses, that the head, feet, abdominal fat pad and viscera were primarily removed and were also measured. Then, breast and thigh muscles of chickens were removed and were weighed individually and expressed as percentages of respective eviscerated carcasses. 16 samples per treatment of breast muscle were taken and thigh and were stored at -20 °C until analysis.

C. Analysis

Four mixed sample per tissue were used for N and crude fat determination. Intramuscular fat was extracted by following the procedure described by [24]. For FA determination, extracted lipids were esterified with a mixture of boron trifluoride, hexane, and methanol [25]. Methylated FAs were measured by gas chromatography, with Shimadzu GC-14A gas chromatograph (Kyoto, Japan), equipped with a ART.2560 fused silica capillary column (length 100 m; internal diameter 0.25 mm, film thickness 0.20 μm) and a flame-ionization detector.

D. Statistical Analysis

All data were subjected to ANOVA using the General Linear Models Procedure of SAS software [26]. Treatment means were analyzed by the Duncan's multiple-range test, and statistical differences declared which p Value was considered significant at $p < 0.05$. Lysine (L or H levels) diets had the better BW gain during the starter, grower, and overall rearing periods. Also, birds fed with 1% canola oil and low lysine diets, had the low live BW and higher FCR during finisher period. Highest BW gain and live BW at the end of the rearing period were belonging to birds fed with 5% canola oil + L level lysine. Moreover, highest BW gain was recorded at starter, grower, finisher, and overall rearing period in birds fed with 3, 3 or 5, 3 or 5 and 5% canola oil diets, respectively. High lysine diets positively affected BW gain and feed intake (during starter), and FCR (during grower period) when compared with low lysine diets.

III. Results

A. Birds' Performance and Carcass Characteristics

The effects of the body weight gain and feed conversion ratio (FCR), dietary treatments on feed intake are presented in Table II. Dietary effects on feed intake during starter, grower, and overall rearing period were not significant ($P>0.05$), but 3 or 5% canola oil and lysine (L or H level) diets interacted positively to significantly increase feed intake during the finisher period (24-42 d) in contrast to broilers fed diet containing 1% canola oil diet + L or H lysine content. In this study, 1% canola diet negatively affected feed intake when compared with 3 or 5% canola diets during the finisher and overall rearing periods.

Among all treatment birds, those fed with 3 or 5% canola oil + lysine (L or H levels) diets had the better BW gain during the starter, grower and overall rearing periods. Also, Birds fed 1% canola oil and low lysine diets, had the low live BW and higher FCR during finisher period.

There was no canola oil level × lysine level interactive effects on the carcass yield, and the relative weights of internal organs (total gut, abdominal fat and liver) and carcass components (Table III). Nevertheless, birds fed on 5% canola oil and high lysine diets, had heavier breast compared to the others treatments.

No significant effect of dietary lysine was observed on the internal organs, carcass yield, and carcass components. However, the percentage of the breast and abdominal fat tended to be higher and lower, respectively, in birds fed on high lysine diets.

The birds that received the diet containing 5% canola oil represent a higher percentage of breast and lower abdominal fat, than those fed on diets containing 1% canola oil (P<0.05).

TABLE I
INGREDIENT (%) AND NUTRIENT COMPOSITION OF EXPERIMENTAL DIETS (AS-FED)[1]

	Starter (0-10 d)						Grower (11-24 d)						Finisher (25-42)					
Canola oil (%)	1		3		5		1		3		5		1		3		5	
Lysine[1]	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Corn	58.5	60	53.8	53.6	47.5	47.7	61.2	61.6	55	55.3	48.9	49.1	69.1	69.3	63	63.1	56.8	56.9
Soybean meal	35.2	34	35.8	36.5	37.8	31.7	33	32.3	34.5	33.5	35.9	34.8	26.4	25.8	27.7	27.1	28.9	28.4
Canola oil	1	1	3	3	5	5	1	1	3	3	5	5	1	1	3	3	5	5
Oyster shell	1.25	1.2	1.2	1.26	1.25	1.25	1.2	1.35	1.2	1.25	1.24	1.25	1.6	1.8	1.4	1.4	2.8	2.8
DCP	1.8	1.9	1.9	1.92	1.93	1.95	1.95	1.9	1.9	1.91	1.91	1.95	1.1	1.1	1.2	1.2	1.9	2
Premix[2]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Salt	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
DL- Methionine	-	-	-	-	-	-	-	-	-	-	-	-	0.55	0.46	0.44	0.56	0.47	0.47
HCl-Lysine	0.34	0.38	0.32	0.4	0.35	0.4	0.38	0.4	0.31	0.39	0.4	0.39	0.2	0.4	0.14	0.4	0.1	0.37
Inert[3]	-	-	0.34	2.9	5.8	6	0.6	0.015	3.6	4.45	6.5	7.4	-	-	3.3	3.7	6.2	6.7
	Chemical composition																	
AMEn (kcal/kg)[4]	2900	2900	2900	2900	2900	2900	3000	3000	3000	3000	3000	3000	3100	3100	3100	3100	3100	3100
Crude Protein	21	21	21	21	21	21	20	20	20	20	20	20	18	18	18	18	18	18
Linoleic acid	1.38	1.35	1.49	1.44	1.59	1.53	1.30	1.36	1.38	1.32	1.44	1.41	1.24	1.20	1.31	1.24	1.43	1.36
Calcium	1.05	1.05	1.05	1.05	1.05	1.05	0.9	0.9	0.9	0.9	0.9	0.9	0.85	0.85	0.85	0.85	0.85	0.85
Lysine	1.43	1.78	1.43	1.78	1.43	1.78	1.24	1.55	1.24	1.55	1.24	1.55	1.09	1.36	1.09	1.36	1.09	1.36
Methionine	0.51	0.51	0.51	0.51	0.51	0.51	0.45	0.45	0.45	0.45	0.45	0.45	0.41	0.41	0.41	0.41	0.41	0.41
Met + Cys	1.07	1.07	1.07	1.07	1.07	1.07	0.95	0.95	0.95	0.95	0.95	0.95	0.86	0.86	0.86	0.86	0.86	0.86

[1] L: Dietary lysine levels recommended by Ross 308 manual, H: Dietary lysine levels 25%more than Ross recommendation.

[2]Mineral and Vitamin premix provided by Razak Co., Iran, and presented: vitamin A, 11,000.0 IU; vitamin D3, 2,000.0 IU; vitamin E, 18.0 IU; vitamin K, 4.0 mg; thiamine, 1.8 mg; vitamin B_{12}, 0.015 mg; riboflavin, 6.6 mg; calcium pantothenic acid, 12.0 mg; niacin, 30.0 mg; pyridoxine, 2.9 mg; folic acid, 1.0 mg; choline, 260.0 mg; zinc, 33.8 mg; iron, 100.0 mg; manganese, 64.5 mg; copper, 8.0 mg; iodine, 1.9 mg; selenium, 0.25 mg, per kilogram of diet

[4]Inert filler were used to catch 100% in diet formulations.

[5]AMEn: Nitrogen-corrected apparent metabolisable energy provide

TABLE II
EFFECT OF DIFFERENT LEVELS OF CANOLA OIL AND LYSINE IN DIETS (%) ON BROILER CHICKS PERFORMANCE (0-42 D OF AGE)[1]

Items		Body weight gain (g/bird)				Feed intake (g/bird)				Feed conversion				40-d LBW(g)[5]
		0-10 d	11-24d	25-42d	0-42d	0-10 d	11-24d	25-42d	0-42d	0-10 d	11-24d	25-42d	0-42d	
Canola oil (%) × Lys[2]														
1	L	13.12	42.6[b]	54.3[b]	41.7[d]	19.0	80.7	95.4[c]	76.3	1.45	1.89	1.77	1.83[a]	1776[c]
	H	13.9	42.8[b]	59.6[b]	44.1[c]	20.6	78.6	103.8[b]	72.2	1.48	1.84	1.74	1.62[b]	1922[b]
3	L	13.8	45.7[ab]	69.6[a]	49.3[b]	18.5	79.3	118.4[a]	82.4	1.34	1.75	1.70	1.67[b]	2213[a]
	H	15.6	50.7[a]	76.4[a]	49.3[b]	21.0	80.8	124.1[a]	84.9	1.34	1.60	1.63	1.72[b]	2224[a]
5	L	13.5	57.5[a]	75.5[a]	52.5[a]	20.0	80.5	122.9[a]	84.6	1.51	1.70	1.63	1.61[b]	2329[a]
	H	14.6	51.3[a]	70.1[a]	50.7[ab]	21.9	81.6	119.1[a]	86.1	1.50	1.60	1.71	1.69[b]	2186[a]
Pooled SEM		0.48	3.90	4.58	1.28	1.85	4.66	4.59	3.08	0.145	0.112	0.131	0.071	98.04
Main effects														
Canola oil (%)														
1		13.5[c]	42.3[b]	56.9[b]	42.9[c]	19.8	79.3	99.6[b]	74.2[b]	1.46	1.86[a]	1.75	1.73	1849[b]
3		14.7[a]	48.1[a]	72.9[a]	49.3[b]	19.8	80.9	121.3[a]	83.7[a]	1.34	1.67[b]	1.66	1.70	2218[a]
5		14.1[b]	49.2[a]	72.8[a]	51.6[a]	21.2	81.9	121.0[a]	85.3[a]	1.51	1.64[b]	1.66	1.65	2257[a]
Pooled SEM		0.24	1.95	2.29	0.64	0.93	2.33	2.30	1.54	0.730	0.056	0.066	0.035	49.02
Lys[2]														
L		13.5[b]	45.3	66.5	47.9	19.3[b]	80.2	112.2	81.1	1.43	1.78[a]	1.70	1.70	2106
H		14.7[a]	48.3	68.7	48.0	21.2[a]	80.3	115.7	81.0	1.44	1.68[b]	1.69	1.68	2111
Pooled SEM		0.34	2.76	3.24	0.91	1.31	3.29	3.25	2.18	0.102	0.079	0.093	0.050	69.30
		P Value												
Lys[2]		0.0001	0.0773	0.2440	0.7132	0.0256	0.9346	0.0830	0.9652	0.8994	0.0439	0.9153	0.5210	0.9054
Canola oil		0.0003	0.0064	0.0001	0.0001	0.2394	0.8277	0.0001	0.0001	0.0901	0.0017	0.3479	0.1040	0.0001
Canola oil × Lys[2]		0.1317	0.0439	0.0316	0.0130	0.8204	0.7110	0.0390	0.0939	0.9233	0.6996	0.5470	0.0015	0.0287

[a-c]Means within same column with different superscript letters are significantly different (P< 0.05).

[1]Data are means of 4 observations per diet.

[2]L: Dietary lysine levels recommended by Ross 308 manual, H: Dietary lysine levels 25%more than Ross recommendation.

[5]Live body weight

B. Chemical Composition and FAs Profile of Meat

The results for chemical composition and FAs profile of breast meat are presented in Table IV. The crude protein (CP) in breast was highest in birds fed on 5% canola oil and high lysine diet (P<0.05). In contrast, in birds receiving 1% canola oil and low lysine diet, the CP content of breast meat was lower when compared to birds fed the other diets (P<0.05). There were no interaction effects between canola oil and lysine on ether extract content of breast meat. However, the EE and CP in breast meat increased by increasing levels of dietary canola oil (P<0.05). On the other hand, high lysine diets significantly reduced EE and increased the CP in breast meat (P<0.05).

The results indicated that the amount of c18:1 was significantly higher in the birds that were fed by 5% canola oil (P < 0.05). The chickens which received diets containing 25% more than recommended had the highest amount of c18:3 and c20:3, but it was not significant. Those which received diets containing more than 4% lysine had the highest amount of c20 (p<0/05). Lysine levels had no significant effects on other measured FAs.

In the present experiment, the consumption of diets containing 5% canola oil increased the amount of oleic acid in meat significantly but did not have significant effects on other FAs measured.

The interaction effects of canola oil and lysine acid on the FA profile have been shown in Table IV. The results of the present experiment indicated that levels of canola oil and lysine acid had negative (opposite) effects on the amount of arachidonic acid. That is, increase in the amount of canola oil led to decrease in the amount of arachidonic acid, while increase in the amount of lysine levels in the diet enhanced the amount of arachidonic acid in chicken meat.

Interaction between dietary canola oil level and lysine shows best effect in canola oil=3% with lysine= 25% more than recommended level on weight gain in finisher. But, in total daily weight gain canola oil=5% with Lysine=recommended level had best effect.

IV. Discussion

In the present experiment, increase in the amount of canola oil in the diet was accompanied by increase in the amount of CP in chicken meat. Reference [23] indicated that there was no significant difference in the amount of CP of meat when levels of the diet were augmented. Reference [27] showed that with reduction in the proportion of essential FAs to unessential FAs, the amount of retained nitrogen in broiler chicks decreased. With an increase in the amount of lysine, the amount of CP increased too, a finding that is consistent with the results obtained by other researchers [28].

The results of the present experiment indicated that canola oil levels influenced the amount of meat fat and that higher amounts of canola oil in the diet were accompanied by higher amounts of meat fat. Reference [10] showed reported that addition of 2.5% fish oil to the diet, compared to 1.25% fish oil, led to an increase in the total amount of meat FAs in broiler chicks. Reference [5] showed reported no significant difference in the amount of reserved fat in leg and breast of broiler chicks as a result of addition of different plant oils (flax oil, olive oil, and sun flower oil).

In the current study, an increase in lysine levels in the diet resulted in a decrease in the amount of meat fat. Reference [29] carried out an experiment on three lysine levels, but contrary to the results of the current study, they did not find any significant difference in the amount of meat fat in male and female chickens as a result of increasing lysine levels.

Reference [28] indicated that increase in plant oils (olive oil, cotton seed oil, and sun flower oil) led to an increase in the amount of oleic acid of broiler chicks. Reference [28] showed that the use of olive oil in diets resulted in the reservation of more Omega-3 FAs in breast meat, tibia meat (leg meat) and abdominal fat compared to cotton seed oil, and sun flower oil. Reference [30] reported that the use of fish oil at 2% level, compared to other levels (0%, 1%, 3%, 4%, and 5%) leads to an increase in the amount of oleic acid in breast meat. Reference [13] indicated that the use of canola oil at 2% level in diets, compared to 0% and 4% levels, exerted significant changes on the amount of linoleic acid in breast meat. It did not, though, change the other FAs measured in significant ways. Reference [11] reported that the use of olive oil, compared to corn oil, cotton oil, fish oil, sun flower oil, and slaughterhouse waste oil, led to the reservation of more unsaturated FAs with a double bond in the meat of broiler chicks.

In the present experiment, the effect of lysine levels on the amount of arachidonic acid was statistically significant (P<0.05). To date, reports on the effects of lysine levels on the FA profile have not been documented. Although met supplementation at twice the NRC recommendation increased AA in birds with dietary n-6/n-3 PUFA ratio of 5.5, it decreased AA in birds with n-6/n-3 PUFA ratio of 1.5. Reference [31] has shown that supplementation of methionine increased n-6 PUFA in different tissues of rat and chicken. Reference [31] has also explained increasing of n-6 PUFA in different tissues of rat and chicken by role of methionine in increasing Δ6- and Δ5-desaturase activity. However, regarding the reduction of AA in birds fed with methionine supplemented is the preferred substrate [23], [32] with an n-6/n-3 PUFA ratio of 1.5 and twice. However, [22] showed that increase in the amount of lysine in the diet decreased the amount of carcass fat (abdominal fat) in a way that, when 56 years old, the chickens receiving 1.24% lysine in their diet put on 0.19-gram weight of daily fat more compared to those chickens receiving only 0.87% lysine in their diet.

The interaction effects of canola oil and lysine acid on the FA profile have been shown in Table IV. The results of the present experiment indicated that levels of canola oil and lysine acid had negative (opposite) effects on the amount of arachidonic acid. That is, increase in the amount of canola oil led to decrease in the amount of arachidonic acid while increase in the amount of lysine levels in the diet enhanced the amount of arachidonic acid in chicken meat. References [13], [32] demonstrated that increase in the amount of canola oil in the diet decreased the amount of arachidonic acid in meat, a finding which is consistent with the findings of the current study. It was found that, among five sources of polyunsaturated oils (soybean, canola, sunflower, linseed, and fish), only canola and fish oil reduced the content of fat in the thigh meat. In the breast meat, fat content was reduced by sunflower oil, whereas it was elevated by linseed oil. These observations could be explained by differences in FAs deposited preferentially in each type of meat. What is more, canola and fish oil fed to broilers reduced the content of saturated and polyunsaturated (mainly n-6) FAs in the thigh meat, with fish oil increasing the content of C22:6 in this cut. Consequently, the ratio of n-6 to n-3 was reduced in the thigh meat [4]. In contrast, the use of soybean oil increased saturated and PUFA (mainly n-6) content in the thigh meat. However, it has also been indicated that the above changes, in relative proportions of FAs in broiler carcass, may reduce the susceptibility of lipids to oxidation, thus increasing their oxidative stability [10]. Third, although the total sum of PUFAs remained unchanged, the content of essential individual n-6 (e.g. C20:4, C22:4) and n-3 (e.g. C22:5, C22:6) FAs was decreased. These negative effects were probably associated with inhibitory action of CLA isomers on Δ9-desaturase activity [16], thus explaining the observed low proportion of MUFAs (mainly C18:1n-9) in the modified carcass. In the same line, a decrease in concentrations of n-6 and n-3 FAs could have been caused by inhibition of Δ6-desaturase, involved in desaturation of linoleic and α-linolenic acid to their long-chain derivatives [11].

A more recent study by [30] demonstrated that the weight gain was higher in broilers fed with diets containing 1.5% and 3% fish oil compared with control group without fish oil and 6% fish oil. Therefore, the results of the current study together with [10], [11] suggest that the effect of n-3 PUFA enrichment is dose-dependent, in that low levels of dietary fish oil are more efficient than high levels in improving broiler growth rate and FCR. This phenomenon may be explained by the role of n-3 PUFA in reducing catabolic response induced by immune stimulation [14]. Reference [30] demonstrated that improvements in performance parameters may also be due to superior digestibility of unsaturated FA compared with the saturated type.

25% more than recommended level of lysine had better effect on final body weight, daily weight gain, and feed intake of broiler chickens in total rearing period (but it was not significant). A possible explanation for these results is that the modern broilers may have higher demands for essential amino acids, particularly lysine. The present commercial broilers are substantially different from the broilers in the last decades due to genetic selection [33]. Evidently, the average growth rate during 35d has increased from 30 g/d in 1950 to 51.5 g/d in 2009 [34]. Therefore, [35] recommendations for amino acid requirement may not meet the requirements of the present modern broilers. Moreover, broilers in current commercial systems are normally exposed to a combination of adverse environmental stress and disease that enhance their nutrient requirements [36].

TABLE III
EFFECT OF DIFFERENT LEVELS OF DIETARY CANOLA OIL AND LYSINE(%) ON CARCASS YIELD[1], RELATIVE WEIGHTS OF INTERNAL ORGANS[1] AND CARCASS COMPONENTS[2] (%) AT 42D

Items		Carcass yield	Total tract	Abdominal fat	Liver	Leg	Breast
Canola oil *Lys[3]							
1	R	70.71	11.57	2.56	2.53	29.53	31.99
	H	70.29	10.85	2.32	2.46	28.96	32.03
3	R	71.67	12.59	2.23	2.62	29.54	31.08
	H	69.89	12.40	2.11	2.38	30.55	33.09
5	R	69.39	12.34	1.86	2.56	31.22	33.50
	H	66.12	10.34	2.02	2.40	31.16	35.32
Pooled SEM		4.775	1.553	0.560	0.469	0.009	0.015
Main effects							
Canola oil (%)							
1		70.27	11.27	2.58^{a}	2.46	29.96	31.64^{b}
3		70.74	12.24	2.12^{b}	2.58	30.30	32.12^{b}
5		67.86	11.71	1.94^{b}	2.59	31.28	34.56^{a}
Pooled SEM		2.387	0.776	0.280	0.234	0.005	0.009
Lys							
L		70.59	12.17	2.21	2.57	30.10	32.19
H		68.77	11.20	2.15	2.41	30.22	33.48
Pooled SEM		3.376	1.098	0.396	0.332	0.007	0.012
				P Value			
Lys		0.1956	0.0712	0.5064	0.2707	0.1666	0.2250
Canola oil		0.1560	0.2260	0.0073	0.9521	0.1971	0.0040
Canola oil × Lys		0.7020	0.5010	0.4991	0.6037	0.3841	0.7043

[(a-c)] Means within same column with different superscript letters are significantly different *(P< 0.05)*.
[1]Weights are expressed as percentages of live BW.
[2]Weights are expressed as percentages of carcass weight.
[3]L: Dietary lysine levels recommended by Ross 308 manual, H: Dietary lysine levels 25% more than Ross recommendation.
[4]Data are means of 8 observations per diet.

Interaction between dietary canola oil level and lysine shows best effect in canola oil=3% with lysine= 25%more than recommended level on weight gain in finisher. But, in total daily weight gain canola oil=5% with lysine=recommended level had best effect.

Many reports [4], [6], [15], [30] have shown that while increases in dietary fat resulted in improvement in growth rate and efficiency of food conversion, carcass measurements indicate an increase in fat content and a decrease in lean contents.

The dietary lysine at 25% more than recommended, increased the percent of breast, but it is not significant. On balance, the data support the original hypothesis that essential amino acids at levels higher than those required for maximum growth rate will improve meat yield. This result is in agreement with a recent study, [23], in which it was reported that increasing lysine in the grower diet increased cooked breast meat yield. However, in another recent study, [29] found no difference in broiler meat yield when diets were supplemented with methionine and lysine. In this experiment effect of lysine level on leg/carcass percent in total period was not significant but birds fed diets with The dietary lysine at 25 %more than recommended, increased the percent of leg/carcass. Lysine levels in the pectoral muscle is higher than thigh muscle and Probably higher breast muscle growth due to more lysine level of food, is the subsequence of this [19]. Lysine is an essential amino acid in protein synthesis. This amino acid participates rarely in metabolic reactions and Are mainly protein structure of carcass of birds. Pectoral muscle comprises 30% of the total corpus and 60% of the total protein found in this muscle. This has led to more extensive research in this area in recent years [17].

TABLE IV
EFFECT OF DIFFERENT LEVELS OF DIETARY CANOLA OIL AND LYSINE ON CRUDE PROTEIN, ETHER EXTRACT AND FAS CONTENTS OF BREAST MEAT OF BROILER CHICKS[1]

Items		CP(%)[2]	EE(%)[3]	FA profile (%)					Total FA in meat (g)				
				C18:0	C18:1	C18:2	C18:3	C20:3	C18:0	C18:1	C18:2	C18:3	C20:3
Canola oil × Lys[4]													
1	R	72.43^{d}	3.58	5.18	30.78	14.65^{a}	1.88^{c}	5.01	1.12	6.69	3.17	0.4	1.22
	H	74.86^{cd}	6.25	5.30	30.28	11.47^{bc}	3.71^{b}	5.00	2.55	7.64	2.31	0.87	1.73
3	R	77.00^{c}	7.25	7.11	33.46	14.02^{a}	5.62^{a}	2.42	2.35	14.96	4.88	1.35	1.27
	H	83.80^{b}	8.00	6.49	31.42	12.98^{ab}	6.13^{a}	2.79	2.81	9.83	3.58	2.38	1.94
5	R	84.68^{b}	10.16	7.40	35.70	10.37^{c}	6.81^{a}	1.94	8.66	20.54	5.08	1.89	0.73
	H	93.81^{a}	11.83	5.97	35.18	10.84^{c}	6.31^{a}	1.97	2.05	30.83	10.84	1.81	1.76
Pooled SEM		1.51	0.020	0.962	1.880	1.070	0.793	1.037	5.253	6.797	3.108	1.578	1.279
Main effects													
Canola oil (%)													
1		73.59^{c}	5.13c	5.24^{b}	30.53^{b}	13.06^{a}	2.80^{b}	5.01^{a}	2.15	7.89^{c}	2.70^{b}	0.87^{b}	1.64
3		88.66^{a}	7.61^{b}	6.80^{a}	32.44^{b}	13.50^{a}	5.87^{a}	2.61^{b}	3.52	15.02^{b}	3.93^{ab}	2.45^{a}	1.50
5		83.15 ^{b}	10.94^{a}	6.69^{a}	35.44^{a}	10.61^{b}	6.56^{a}	1.96^{b}	5.44	27.70^{a}	6.99^{a}	2.14^{ab}	1.04
Pooled SEM		0.075	0.010	0.481	0.942	0.537	0.396	0.518	2.476	3.204	1.390	0.743	0.603
Lys													
L		78.03^{b}	8.69^{a}	6.57	33.32	13.02^{a}	4.77	3.13	4.88	17.08	4.98	1.57	1.14^{b}
H		84.16^{a}	7.00^{b}	5.92	32.29	11.77^{b}	5.38	3.25	3.18	18.90	6.49	1.95	2.29^{a}
Pooled SEM		1.07	0.014	0.680	1.332	0.759	0.560	0.733	3.915	5.066	2.198	1.052	0.852
P Value													
Lys		0.0001	0.0001	0.1283	0.2086	0.0196	0.0850	0.7657	0.8182	0.6235	0.1290	0.5686	0.0223
Canola oil		0.0001	0.0001	0.0118	0.0008	0.0003	> 0.0001	0.0002	0.3412	0.0001	0.0221	0.0458	0.4063
Canola oil × Lys		0.0055	0.0613	0.3071	0.6580	0.0170	0.0372	0.9233	0.2940	0.5045	0.2690	0.6644	0.9437

(a-c) Means within same column with different superscript letters are significantly different ($P < 0.05$).
[1]Data are means of 8 observations per diet.
[2]Crude proteins based on dry matter of meat
[3]Ether extract based on dry matter of meat
[4]L: Dietary lysine levels recommended by Ross 308 manual, H: Dietary lysine levels 25% more than Ross recommendation.

Many researchers have reported increased pectoral muscle on the effect of lysine [17], [23]. An increasing muscle mass with no increase in growth suggests a decrease in fat content and an anticipated improvement in feed efficiency. Since a breast meat response to lysine was demonstrated while a feed conversion response was not, it is apparent that feed conversion is a cruder measurement of response than meat yield. The response of breast meat yield to methionine and lysine suggests a possible economic benefit. The results indicate that an extra l5-20 g (about 1.3%) of breast meat per bird can be obtained by increasing dietary lysine by 25% over recommended level. This roughly corresponds to an extra 2-4 g of lysine intake per bird. Whether or not such a nutritional regime is economically feasible depends in part on the relative value of breast meat and the cost of the amino acids.

REFERENCES

[1] Haug A, Eich-Greatorex S, Bernhoft A, et al. Effect of dietary selenium and omega-3 fatty acids on muscle composition and quality in broilers. Lipids Health Dis 2007; 6: 29.

[2] Kris-Etherton P, Harris W, Appel L. Fish Consumption, Fish Oil, Omega-3 Fatty Acids, and Cardiovascular Disease. Circulation cited 2009; 106: 2747-2757.
[3] Leaf A, Kang JX .N-3 Fatty acids and cardiovascular disease. World Rev. Nutr1998; 83: 24-37.
[4] Lopez-Ferrer S, Baucells MD, Barroeta A, et al. N-3 enrichment of chicken meat using fish oil: alternative substitution with rapeseed and linseed oils. Poult Sci 1999; 78: 356-365.
[5] Craspo N, Esteve-Garcia E. Dietary fatty acid profile modifiers abdominal fat deposition in broiler chickens. Poult Sci 2001; 80: 71-78.
[6] Osek M, Janocha A, Klocek B, et al. Influence of feed mixtures containing different fats on production coefficients and meat quality of slaughter chicken. Poult Sci 2001; 22: 153-164.
[7] Saricicek BZ, Ocak N, Garipoglu AV. A study on utilizing fish oil in broiler diets. Poult. Sci 1997; 12: 33 – 42.
[8] Zollitsch W, Knaus W, Aichinger F, et al. Effects of different dietary fat sources on performance and carcass characteristics of broilers. Anim Feed Sci Technol, 1997; 63–73.
[9] Yau J, Denton JH, Bailey CA, et al. Customizing the fatty acid content of broiler tissues. Poult Sci1991; 70: 167-172.
[10] Bou R, Guardiola F, Tres A, et al. Effect of Dietary Fish Oil, R-Tocopheryl Acetate, and Zinc Supplementation on the Composition and Consumer Acceptability of Chicken Meat. Poult Sci 2004; 83, 282-292.
[11] Kehui O, Mingsheng X, Xinchen S, et al. Influence of oils on the Taihe Silky Fowl production perfor-mances and fatty acids composition of the meat. J Anim Physiol. Anim Nutr. 2011; 95:106–113.
[12] Lopez-Garcia E, Schulze MB, Manson JE, et al. Consumption of n-3 fatty acids is related to plasma biomarkers of inflammation and endothelial activation in women. J Nutr sci 2004; 134, 1806–1811.
[13] Salamatdoustnobar R, Nazeradl K, Ayazi A, et al. Beneficial effects of canola oil on serum biochemical parameters of Iranian native Turkeys. J Anim Vet. Adv2009; 8: 2206-2209.
[14] Azad K, Rahimi S, Karimi Torshizi Sh. Effect of dietary oil seeds on n-3 fatty acid enrichment, performance parameters and humoral immune response of broiler chickens. Iranian Journal of Veterinary Research 2009; Vol. 10, No. 2, Ser. No. 27.
[15] Lopez-Garcia E. Major dietary patterns are related to plasma concentrations of markers of inflammation and endothelial dysfunction American Journal of Clinical Nutrition 2004; 80: 1029-1035.
[16] Ajuyah A, Lee K, Hardin R, et al. Changes in the yield and in the fatty acid composition of whole carcass and selected meat portions of broiler chickens fed full-fat oil seeds. Poultry Sci 1991. 70:2304–2314.
[17] Mack S, Bercovici D, DeGroate G, et al. Ideal amino acid profile and dietary lysine specification for broiler chickens of 20 to 40 days of age. Brtish Poultry Science 1999; 40: 257–265.
[18] Samadi F, Liebert F. Threonine Requirement of Slow Growing Male Chickens Depending on Age and Dietary Efficiency of Threonine Utilization. Poult Sci 2007; 86: 1140-1148.
[19] Acar N, Moran E, Bilgili S. Live performance and carcass yield of male broiler from two commercial strain crosses receiving rations containing lysine below and above the established requirement between six to eight weeks of age .Poultry Science 1991; 70: 2315-2321.
[20] Tesseraud S, Peresson R, Lopes J, et al. Dietary lysine deficiency greatly affects muscle and liver protein turnover in growing chickens. Br. J. Nutr 1996; 75:853-865.
[21] Holsheimer J, Veerkamp C. Effect of dietary energy, protein and lysine contents on performance and yields of two strains of male broiler chicks. Poult Sci1992; 71: 872-879.
[22] Kerr B, Kidd M, Halpan K, et al. Lysine level increases live performance and breast yield in male broiler. J Appl Poult Res1999; 8: 381-390.
[23] Rezaei M, Nassiri Moghaddam H, Pour Reza J, et al. The Effects of Dietary Protein and Lysine Levels on Broiler Performance, Carcass Characteristics and N Excretion. Poultry Science2004; 3 (2): 148-152.
[24] Folch J, Less M, Sloane-Stanley G. A simple method for the isolation and purification of total lipids from animal tissues. Biol Chem1957; 226, 497-509.
[25] Morrison W, Smith M. Preparation of fatty acid methyl esters and dimethylacetals from lipid with boron fluoride-methanol. J. Lipid Res1964; 5:600–608.
[26] SAS Institute. SASâ User's Guide: Statistics. SAS Institute Inc., Cary, NC, 2005.
[27] Ayerza, R., W. Coates, and M. Lauria. 2002. Chia seed (Salvia hispanica L.) as an ω-3 fatty acid source for broilers: Influence on fatty acid composition, cholesterol and fat content of white and dark meats, growth performance and sensory characteristics. Poult. Sci. 81:826–837.
[28] Crespo N, Esteve-Garcia E. Nutrient and fatty acid deposition in broilers fed different dietary fatty acid profiles.Poult Sci2002; 81:1533–1542.
[29] Han Y, Baker H. Lysine requirements of fast-and slow-growing broiler chicks. Poult Sci1991; 70: 2108-2114.
[30] Lopez-Ferrer S, Baucells M, Barroeta A, et al. 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. Poult. Sci 2001; 80, 741-752.
[31] Waladkhani A, Clemens M, Bode J, et al.Effect of methionine on the fatty acid composition of cellular membranes in rats with chronic ethanol consumption and jejunoileal bypass. Alcohol Alcohol 1996. 31:463–469.
[32] Nwokolo, E.; SIM, J., 1989.Barley and full-fat canola seed in broiler diets. Poultry Science, v. 68, n. 10, p. 1374-1380.
[33] Thiruvenkadan A, Prabakaran R, Panneerselvam S. Broiler breeding strategies over the decades: An overview. World's Poult. Sci 2011. J. 67:309–336.
[34] Schmidt M, Gomes PC, Rostagno HS, et al. Exigência nutricional de lisina digestível para poedeiras semipesadas no segundo ciclo de produção. Revista Brasileira de Zootecnia 2009; 38 (10):1956-1961.
[35] National Research council. Nutrient Re- uirements of Poult 9th Rev Edition. Natl. Acad. pres, Washington, Dc 1994.
[36] Zarate AJ, Moran ET, Burnham DJ. Exceeding essential amino acid requirements and improving their balance as a means to minimize heat stress in broilers. Applied Poultry Research 2003; 12:33-44.