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Growth performance, carcass characteristics, fatty acid composition and sensory attributes of meat of broiler chickens fed diet incorporated with linseed oil

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ABSTRACT

Day-old broiler chicks (240) were randomly distributed to 4 dietary groups with 10 replicates in each and raised for 42 days under uniform management conditions to determine the effect of supplementing omega-3 (n-3) fatty acid (FA) rich linseed oil (LO) on performance, carcass characteristics, meat fatty acid profile and sensory attributes of meat. A corn-soybean based starter (0–3 wk) and finisher (4–6 wk) control diets were formulated using sunflower oil (SFO). Subsequently, 3 experimental diets were formulated by replacing SFO with LO at 33, 67 and 100% levels. All experimental birds were provided feed and water *ad lib*. Body weights, feed intake (FI) and feed conversion ratio (FCR) were measured at weekly intervals. At the end of the experiment, 6 birds from each treatment were selected randomly and slaughtered to study the carcass traits (dressed weight, liver, giblet, breast meat and abdominal fat yield), fatty acid profile and to assess the sensory characters of meat. Dietary replacement of SFO with LO at all the levels (33, 67 or 100%) had no adverse effect on performance (weight gains, FI and FCR) and carcass traits. However, dietary incorporation of LO at 67 or 100% had significantly lowered the abdominal fat content. A significant increase in poly-unsaturated FA (PUFA), n-3 FA and a significant decrease in n-6:n-3 were noticed in breast and thigh muscle due to dietary incorporation of LO in the diets, the effect being more pronounced at the highest level of supplementation. Sensory attributes of meat was also not affected due to dietary incorporation of LO in broilers. It is concluded that dietary incorporation of LO at 2 and 3% level during starter and finisher phases, respectively, could enrich the meat with n-3 FA without affecting the performance of broilers and sensory characters of meat.

Key words: Broiler chickens, Fatty acid composition, Linseed oil, Performance, Sensory attributes of meat

Attempts have been made to improve the omega-3 (n-3) poly-unsaturated fatty acid (PUFA) content in human diets in light of research relating to their effects such as cardio-protective, anti-cancer, enhancing immune health and growth and maturation of the central nervous system (Neuringer *et al.* 1998, Simopoulos 2000, Kromhout *et al.* 2011). The most important n-3 PUFA in human nutrition are eicosapentaenoic acid (20:5 n-3), docosahexaenoic acid (22:6 n-3, DHA) and α-linolenic acid (18: 3 n-3, LNA); in that LNA serves as a precursor for synthesis of EPA and DHA (Arterburn *et al.* 2006, Gebauer *et al.* 2006). Fatty acid (FA) composition of broiler meat can be altered by modifying the contents of the broiler's diet (Lopez-ferrer *et al.* 2001, Shin *et al.* 2011). Therefore, many studies were conducted to alter the FA composition of broiler meat to increase n-3 PUFA content (Zuidhof *et al.* 2009, Shin *et al.* 2011). The main sources of n-3 PUFA are marine, but their use is restricted due to sensory problems in the final product (Hargis and Van Elswyk 1993). Linseed oil (LO) (vegetable oil) is rich in α LNA and its inclusion in the diet of broiler chickens may increase n-3 FA, especially in the form of LNA. The study was therefore, conducted to examine the effect of dietary inclusion of linseed oil on performance, fatty acid composition and sensory attributes of meat in broiler chickens.

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MATERIALS AND METHODS

Day-old Krishibro broiler chicks (240) were wing banded and randomly distributed into 40 raised-floored stainless steel battery brooder pens with 6 chicks/pen. Uniform management and vaccination schedules were followed for all the birds. Control starter (0–3 wk) and finisher (4–6 wk) diets using sunflower oil (SFO) were formulated to contain 2,900 kcal ME/kg and 22% CP and 3,000 kcal ME/kg and 20% CP, respectively (Table 1). Subsequently 3 experimental diets were formulated in which SFO was replaced by linseed oil (LO) at 33, 67 and 100% levels. Each diet was fed at random to 10 replicates of 6 chicks each throughout the experimental period of 6 weeks.

Body weight of chicks (individual) and feed intake (replicate-wise) were recorded at weekly intervals. Feed conversion ratio (FCR) was calculated as the ratio between the feed consumed and weight gained. For carcass yield, 1

Table 1. Ingredient and nutrient composition of basal diets* (%)

Ingredient	Starter (0–3 wk)	Finisher (4–6 wk)
Maize	56.10	58.02
Soybean meal	36.34	34.70
Dicalcium phosphate	1.88	1.62
Stone grit	1.67	1.71
Salt	0.40	0.40
DL- methionine	0.21	0.20
Choline chloride 50%	0.10	0.06
Vegetable sunflower oil	2.00	3.00
Vitamin premix[1]	0.05	0.04
Mineral premix[2]	0.10	0.10
Toxin binder	0.10	0.10
Antibiotics	0.05	0.05
Nutrient composition*		
ME (kcal/kg)	2905	3008
Protein (%)	21.97	20.06
Lysine (%)	1.21	1.07
Methionine (%)	0.53	0.50
Av. phosphorous (%)	0.45	0.40
Calcium (%)	0.90	0.85

[1]Supplies per kg diet: Vitamin A, 16,500 IU; vitamin D_3, 3200 ICU; vitamin E, 12 mg; vitamin K, 2 mg; vitamin B_1, 1.2 mg; vitamin B_2 10 mg; vitamin B_6, 2.4 mg; vitamin B_{12}, 12 mg; niacin, 18 mg; pantothenic acid, 12 mg; [2]Mn, 90 mg; Zn, 72 mg; Fe, 60 mg; Cu, 10 mg; I, 1.2 mg.* Calculated values. *In experimental diets, sunflower oil was replaced with linseed oil at 33, 67 and 100% levels during starter and finisher phases.

point Hedonic scale (Peryam and Pilgrim 1957).

Data were subjected to statistical analysis under completely randomized design employing one-way analysis of variance (Snedecor and Cochran 1989). The means of different treatments were compared with Duncan's multiple range test (Duncan 1955). Significance was considered at $P < 0.05$ levels.

RESULTS AND DISCUSSION

The body weight gain, feed consumption as well as feed conversion ratio were not affected by dietary incorporation of LO up to 2 and 3% during starter (1–21 d) and finisher (22–42 d) phases, respectively (Table 2). Similar to the findings of this study, Olomu and Baracos (1991) did not find any difference on weight gain, feed consumption or feed efficiency by dietary incorporation of LO (1.5–4.5%) in the diet of broilers. Lopez-Ferrer *et al.* (2001b) also did not observe any effect on feed intake and feed consumption due to dietary incorporation of LO at 2 and 4% levels in the diet. However, the authors reported a higher weight gain in 4% LO diet compared to 2% LO or control diet containing tallow as a source of fat. They attributed the higher weight gain to higher feed intake, however, no such effect was observed in the present study.

The carcass parameters such as dressed weight, liver, giblet and breast meat yield were not affected due to dietary incorporation of LO in the diet (Table 3). However, the abdominal fat content reduced significantly by dietary

Table 2. Effect of dietary incorporation of linseed oil on performance of broiler chickens

Treatment	Body weight gain (g)		Feed consumption (g)		Feed conversion ratio	
	0–3 wk	0–6 wk	0–3 wk	0–6 wk	0–3 wk	0–6 wk
SFO (100%)	475	1470	665	2911	1.40	1.98
SFO (67%) + LO (37%)	498	1508	702	2910	1.41	1.93
SFO (33%) + LO (67%)	482	1490	714	2876	1.48	1.93
LO (100%)	494	1516	702	2972	1.42	1.96
SEM	4.16	10.67	8.96	16.24	0.015	0.018
P value	0.221	0.427	0.326	0.248	0.247	0.482

SFO, Sunflower oil; LO, linseed oil.

bird representing the mean body weight of each replicate (6 birds /treatment) was selected and sacrificed by cervical dislocation on 43 d of age. The data on weight of edible carcass, giblet (liver, heart and gizzard), breast meat and abdominal fat were recorded and all the data were expressed as percentage of the pre-slaughter weight. Approximately, 20 g of breast and thigh muscle samples were collected in a sealed polythene bag and preserved at –20°C for further laboratory analysis. The fatty acid profiles of SFO and LO, breast and thigh meat were analyzed commercially. On the same day (43[rd]), another 3 birds (nearing the mean body weight) from each treatment were slaughtered, breast and thighs were separated and frozen at –20°C for sensory evaluation. Pressure-cooked meat without salt was organoleptically evaluated by semi trained judges on a 7

Table 3. Effect of dietary incorporation of linseed oil on carcass characteristics (% live weight) of broiler chickens

Treatment	Dressed weight	Liver	Giblet	Breast	Abdominal fat
SFO (100%)	71.25	2.30	4.97	16.06	1.34[a]
SFO (67%) + LO (37%)	71.05	2.26	5.06	16.40	1.37[a]
SFO (33%) + LO (67%)	71.23	2.11	4.87	16.17	0.089[b]
LO (100%)	71.67	2.31	4.94	16.79	0.094[b]
SEM	0.551	0.054	0.084	0.171	0.094
P value	0.808	0.751	0.863	0.645	0.047

Mean with different superscript in a column differ significantly (P<0.05). SFO, sunflower oil; LO. linseed oil.

incorporation of LO in broilers. The relative abdominal fat content was significantly lower in the diet in which SFO was replaced at either 67 or 100% levels compared to other dietary groups. This was in agreement with the findings of Lopez-Ferrer *et al.* (2001b). Smink *et al.* (2010) reported higher β-oxidation and reduced *denovo* synthesis are the causes for the lower fat deposition in diets containing higher levels of PUFA. In the present study, the LO based diets had higher levels of PUFA than SFO based diet and this could be the reason that a lower abdominal fat content was observed.

The total saturated fatty acid (TSFA) and mono unsaturated fatty acid (MUFA) contents of breast and thigh (Table 4) meat decreased progressively with higher amounts of LO, as expected according to the fatty acid profiles of the diet. The total poly unsaturated fatty acid (TPUFA) contents increased linearly with the levels of LO in the diet. The total n-3 FA contents in breast and thigh meats were significantly higher in the LO based diet compared to SFO. In addition to that, total n-3 contents increased linearly with increase in level of dietary incorporation of LO in diets. However, no difference in n-6 FA content of meat was observed due to variation in the levels of LO in the diet. The ratio of n-6: n-3 FA decreased linearly by increasing replacement of SFO by LO in the diet. Amongst the treatment, significantly higher n-3 FA contents in breast and thigh meat and lowest ratio of n-6: n-3 FA was observed due to complete replacement of SFO with LO in the diet. Previous findings also showed lower TSFA and MUFA contents, and higher deposition of n-3 FA (especially linolenic acid) in chicken meat due to dietary incorporation of LO in the diet of broiler chickens (Lopez Ferrer *et al.* 2001b, Rahimi *et al.* 2011). This is important for the health of consumers as poultry meat with higher level of PUFA can be a health promoting substance to prevent various lifestyle diseases (Lopez Ferrer *et al.* 2001a, Grashorn 2007).

No significant (P>0.05) differences (Table 6) were found

Table 4. Fatty acid composition of breast muscle of chickens

Fatty acid	SFO (100%)	SFO (67%) + LO (37%)	SFO (33%) + LO (67%)	LO (100%)	SEM	P value
Total SFA	44.07^{a}	43.10^{b}	42.22^{c}	39.18^{d}	0.008	0.047
Total MUFA	38.72^{a}	36.43^{b}	34.27^{c}	33.98^{c}	0.006	0.038
Total PUFA	17.21^{d}	20.47^{c}	23.51^{b}	26.84^{a}	0.121	0.015
Total n6	15.14^{b}	16.48^{a}	16.55^{a}	16.39^{a}	0.009	0.004
Total n3	2.07^{d}	3.99^{c}	6.96^{b}	10.45^{a}	0.224	0.001
n6:n3	7.31^{a}	4.13^{b}	2.37^{c}	1.38^{d}	0.126	0.001

Mean with different superscript in a row differ significantly. SFO, sunflower oil; LO, linseed oil.

Table 5. Fatty acid composition of breast muscle of chickens

Fatty acid	SFO (100%)	SFO (67%) + LO (37%)	SFO (33%) + LO (67%)	LO (100%)	SEM	P value
Total SFA	42.78^{a}	41.64^{b}	40.12^{c}	38.54^{d}	0.007	0.049
Total MUFA	40.29^{a}	38.12^{b}	36.47^{c}	35.01^{d}	0.016	0.012
Total PUFA	16.93^{d}	20.24^{c}	23.41^{b}	26.45^{a}	0.224	0.001
Total n6	15.02^{b}	16.71^{a}	16.65^{a}	16.23^{a}	0.009	0.054
Total n3	1.91^{d}	3.53^{c}	6.76^{b}	10.22^{a}	0.216	0.001
n6:n3	7.86^{a}	4.73^{b}	2.46^{c}	1.58^{d}	0.128	0.001

Mean with different superscript in a row differ significantly. SFO, sunflower oil; LO, linseed oil.

Table 6. Effect of dietary incorporation of linseed oil on organoleptic evaluation of broiler meat

Treatment	Organoleptic evaluation				
	Appearance	Flavour	Juiciness	Texture	Overall acceptability
SFO (100%)	6.20	5.89	5.97	6.20	6.25
SFO (67%) + LO (37%)	6.24	6.20	6.05	6.25	6.00
SFO (33%) + LO (67%)	6.38	5.95	5.90	6.16	6.20
LO (100%)	6.44	5.89	5.98	6.20	6.40
SEM	0.265	0.224	0.128	0.124	0.114
P value	0.645	0.457	0.556	0.405	0.428

SFO, sunflower oil; LO, linseed oil.

on sensory attributes (appearance, flavour, juiciness, tenderness and overall acceptability) of chicken meat when pressure cooked meat without salt was subjected to organoleptic evaluation by semi trained taste panel on a 7 point Hedonic scale. Concomitant to the findings of our study, Lopez-Ferrer *et al.* (2001b) did not observe variation in meat quality parameters due to incorporation of 4% LO in the diet of broiler chickens. Similarly, studies conducted by Chekani-Azar *et al.* (2008) indicated that chicken diet supplemented with 3% of fish oil (another n-3 fatty acid source) had no abnormal flavour or odour.

In the present study, SFO was included at 2 and 3% level in the starter and finisher diet of broiler chickens, respectively. Considering the 33, 67 and 100% levels of replacement of SFO with LO, the LO contents in starter and finisher diets were 0.66, 1.34 and 2.00%, and 1, 2 and 3%, respectively. Though performance was not affected due to variation in the levels of LO in the diet, but omega 3 FA depositions were significantly higher in the diet containing 2 and 3% levels of LO in the diet during starter and finisher phases, respectively. Further, no abnormality was detected in the sensory attributes of meat due to addition of LO at the highest levels in the diet. It is therefore concluded that LO @ 2% and 3% in broiler chicken diet during starter and finisher phase respectively, can effectively increase poly unsaturated FA and n-3 FA in meat.

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