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Effect of omega-3 and omega-6 fatty acid inclusion in broiler breeder's diet on laying performance, egg quality, and yolk fatty acids composition

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ABSTRACT

The present study was conducted to evaluate the effect of different dietary oil sources (omega-3 and omega-6 fatty acid) in female broiler breeders' diets on laying performance, egg quality and yolk fatty acids composition. Ross-308 breeders (220; 25 weeks old) were used in this experiment for 6 weeks. Birds were placed in a complete randomized design with 4 dietary treatments (containing 2% soybean oil, 2% sunflower oil, 2% flaxseed oil, and 2% fish oil) and 5 replications containing 1 male + 10 females in each pen having a similar body weight (3,424 g) and egg production (86%). Results indicated that different sources of dietary oil had no significant effect on body weight gain, feed conversion ratio, and egg production but had a significant effect on egg weight. Also feeding the diets containing 2% of different fatty acids had a significant effect on some egg quality parameters and egg yolk fatty acids composition. It was concluded that inclusion of 2% flaxseed oil can improve laying performance, egg quality, and egg yolk fatty acids composition parameters in broiler breeders.

Key words: Broiler breeders, Fatty acids composition, Omega-3, Omega-6, Performance

Improvements in quality of poultry products developed rapidly (Cahaner *et al*. 2001). In breeders' nutrition, different dietary oils are commonly used as energy sources. It had been reported that for increasing energy density in the diet and obtaining high performance in animals, different fat sources must be used in poultry diets (Lopez-Ferrer *et al*. 2001). Value-added omega-3 fatty acid enriched egg products have been ordered by consumers from US egg producers that acquire 10% of the market share for the shell egg and egg product retail market (USDA 2016). Egg and meat can be easily enriched with omega-3 PUFA by dietary modification (such as fish oil, linseed oil or whole linseed and canola oil) of the laying hens (Lopes *et al*. 2013). Laying hen needs 2 weeks to adapt to an omega-3 fatty acid enriched diet and change the dietary omega-3 fatty acid incorporation into developing ovarian follicles (Nain *et al*. 2012). In broiler breeders, egg quality parameters such as egg size, egg shape, egg shell and importantly yolk fatty acids composition have an important effect on incubation (Papas *et al*. 2006). It was reported that supplementation of broiler breeder's diets with eicosapentaenoic acid and docosahexaenoic acid resulted in incorporation of these long chain omega-3 fatty acid in yolk (Koppenol *et al*. 2014). Also these fatty acids have beneficial roles in human health such as coronary heart disease, diabetes, hypertension, some types of cancer, and neuronal development (Simopoulos 2000). The present study aimed to investigate the effects of broiler breeders' diets containing 2% different omega-3 and omega-6 fatty acid sources on laying performance, egg quality, and yolk fatty acids composition.

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MATERIALS AND METHODS

Throughout the experimental study, standard breeder (female) diet based on corn and soya was used (NRC 1994). Ingredients and nutritional composition of the diet is given in Table 1.

Ross-308 [220 (200 female and 20 male); 25 weeks old] were used in this experiment. During pre-feeding period (25 and 26th weeks), all breeders were fed with a standard breeder diet. After this pre-feeding period, all birds were allocated according to body weight and also egg production in a completely randomized design into 4 treatments (containing 2% soybean oil, 2% sunflower oil, 2% flaxseed oil, and 2% fish oil) groups with 5 replicate pens (10 females and 1 male in each pen) sized 2 × 1.5 × 2 m^2 in the breeder unit, where 20 subgroup pens were available for the trial that lasted 6 weeks. Extra 5 males were raised separately to replace sexually inactive or dead males. Each pen of the breeder unit had 5 nests bedded wood shaving, sizing 25 × 43 × 35 cm each, with a tubular feeder for female and one male feeder. Each pen was provided with an automated water-bowl for providing fresh and clean drinking water *ad lib*. Animals were placed on wood shaving litter with 7–8 cm height. The trial with the experimental diets lasted 6 weeks (2 weeks for accustomisation + 4 weeks for testing)

Table 1. Composition and calculated analysis of the basal diet

Ingredient (%)	Dietary treatments				Nutrient composition (%)	
	SO	SA	FL	FI		
Yellow corn	54.49	54.49	54.49	54.49	Dry matter	88.52
Soybean meal-46	10.00	10.00	10.00	10.00	Crude protein (N × 6.25)	19.00
Fullfat soybean-36	9.64	9.64	9.64	9.64	Crude fibre	3.58
Limestone (GRN)	7.71	7.71	7.71	7.71	Crude fat	3.71
Sunflower meal-36	7.46	7.46	7.46	7.46	Crude ash	13.35
Corn gluten meal-60	3.86	3.86	3.86	3.86	Starch	34.99
Meat-Bone-35	2.48	2.48	2.48	2.48	ME (poultry; kcal/kg)	2680
DCP-18	1.57	1.57	1.57	1.57	Ca	3.65
Soybean oil	2.00	-	-	-	Total P	0.78
Sunflower oil	-	2.00	-	-	Ava-P	0.50
Flax oil	-	-	2.00	-	Sodium	0.16
Fish oil	-	-	-	2.00	Lysine	0.87
Salt	0.24	0.24	0.24	0.24	Methionine	0.37
Vitamin premix[1]	0.20	0.20	0.20	0.20	Methionine + Cystine	0.70
Mineral premix[2]	0.10	0.10	0.10	0.10	Tryptophan	0.20
Sodium bicarbonate	0.10	0.10	0.10	0.10	Threonine	0.70
L-lysine	0.06	0.06	0.06	0.06	Arginine	1.20
Choline-60	0.05	0.05	0.05	0.05	Isoleucine	0.76
DL-methionine	0.04	0.04	0.04	0.04	Valine	0.89
Total		100				

SO (2% soybean oil), SA (2% sunflower oil), FL (2% flax oil) and FI (2% fish oil). [1]Vitamin premix (per kg of diet): vitamin A, 16,000 IU; vitamin D_3, 3,000 IU; vitamin E, 40 IU; vitamin K_3, 2.5 mg; vitamin B_1, 2.5 mg; vitamin B_2, 10 mg; nicotinamide, 50 mg; calcium D-pantothenate, 15 mg; vitamin B_6, 6.25 mg; vitamin B_{12}, 0.035 mg; folic acid, 15 mg; D-biotin, 0.045 mg; choline chloride, 150 mg. [2]Mineral premix (mg/kg of diet): Mn, 80; Fe, 80; Zn, 60; Cu, 8; Co, 0.2; I, 0.5; Se, 0.15.

while the broiler breeders were 27 to 32 weeks of age and the lighting and feeds (female: 163 g/day, male: 130 g/day) were supplied according to the recommendation of Ross Breeding Company (Ross 2011). The environmental temperature (18–22°C) and humidity (55–60% RH) were maintained within the animal comfort zone using foggers and tunnel ventilation. During this experiment, body weight gain, feed intake, feed conversion ratio, egg production, and hen-day egg production were recorded weekly. At 31 and 32nd weeks of age, eggs (five eggs from each replication) obtained from the third and sixth days of week were analyzed for egg quality and fatty acids composition according to Brant *et al*. (1951) and Boehringer Mannheim Biochemica (1995). The data obtained from this study were analyzed using t-test procedure of SAS (SAS 2005). Also, the results of this study are presented as means per bird with standard errors of the difference between means (SED) with P values, except for feed intake as feeds were given to the birds in equal amounts according to the recommendation of the Breeding Company.

RESULTS AND DISCUSSION

There was no significant differences in body weight at the last day of experiment (P>0.05) (Table 2). Throughout the experiment, the birds were given feed according to Breeder Company recommendation (female 163 g/day, male 130 g/day). Feeding the birds according to the Breeder's recommendation kept the animal performance as breeders target in terms of body weight and because of it there was no significant difference (P>0.05) in feed intake and total feed intake. Inclusion of different oil sources in broiler breeders' diet did not significantly affect the feed conversion ratio and egg production (P>0.05) but there was significant difference in egg weight parameters (P<0.05). Also, eggs obtained from the group which received 2% SA oil were heavier than those of other groups.

The results of this experiment were in agreement with the results of other studies. It was reported that adding different level and sources of omega-3 and omega-6 fatty acids in broiler breeders and quails' diet had no significant effect on body weight, feed intake, and feed conversion ratio (Aghdamshahriyar *et al*. 2008, Al-Daraji *et al*. 2010). It had been reported that supplementation of layer diets with different levels of omega-3 polyunsaturated fatty acids had no significant effect on egg production (Ebeid *et al*. 2008) but significant effect on egg weight in broiler breeders (Aghdamshahriyar *et al*. 2008, Al-Daraji *et al*. 2010). On the contrary, Aghdamshahriyar *et al*. (2008) reported that omega-3 fatty acids had no effect on egg weight and laying performance. It seems that beneficial effect of sunflower oil on egg weight may be due to the linoleic acid found in sunflower oil. Also it was reported that high linoleic acid content in vegetable oil can increase egg production in layer hens (Shafey *et al.* 1992). Egg production was numerically higher in groups which received vegetable oils in their diets in present study also.

There was no significant difference in egg shape index, albumin size (mm), albumin index, yolk width (mm), Haugh

Table 2. Effects of different oil sources on live weight and feed intake in broiler breeders

Parameter	Diet oil source (Groups)				SED	P
	SO	SA	FL	FI		
Initial body weight (g/hen)	3438	3441	3395	3424	21.02	0.865
Last body weight (g/hen)	3641	3622	3604	3635	23.67	0.952
Body weight (g)	199	181	209	207.	23.67	0.952
Feed intake (g/hen/day)	163	163	163	163	-	-
Total feed intake (g/hen/28 day)	4564	4564	4564	4564	-	-
Egg production (g/hen/28 day)	1391	1466	1438	1350	20.21	0.229
Feed conversion ratio (g feed/g egg)	3.31	3.13	3.19	3.42	0.05	0.212
Egg production (number/hen/28 day)	23.82	24.07	24.23	23.22	0.28	0.620
Egg production (%)	85.07	85.96	86.54	82.93	1.01	0.620
Egg production (g/hen/day)	49.69	52.35	51.35	48.21	0.72	0.229
Egg weight (g/egg)	59.06^{ab}	61.02^{a}	59.02^{ab}	57.59^{b}	0.35	0.028

SO (2% soybean oil), SA (2% sunflower oil), FL (2% flax oil) and FI (2% fish oil). ^{a,b}Means bearing with different superscript in the same row are significantly different (P<0.05). The amount of food given/animal/day was 163 g; because of which statistical analysis was not performed in all groups.

unit, and shell thickness (mm) parameters (P>0.05) (Table 3). However, the addition of different oil sources in broiler breeder diets had significant effects on egg weight, albumin weight (g), yolk weight (g), egg shell weight (g), yolk height (mm), yolk index, shell strength (kg/cm²), and yolk colour (b) (P<0.05). These results were in agreement with those obtained by other researchers. (An *et al.* (2010), Ansari Pirsaraei *et al.* (2011), Al-Daraji *et al.* 2010) reported that adding of different omega-3 and omega-6 fatty acids source in broiler breeders and layer quails' diets have a significant effect on egg weight, egg yolk weight, egg shell weight, egg albumen and egg yolk weights, yolk index, and egg yolk colour. However, these results were in disagreement with other studies. Eseceli *et al.* (2003) reported that dietary oil sources in diets does not have a significant effect on egg yolk and egg albumin weight while Grobas *et al.* (2001), Güçlü *et al.* (2008), Al-Daraji *et al.* (2010) reported significant effects on Haugh Unit, shell thickness, egg yolk weights. Linoleic acid is one of the essential fatty acids in poultry nutrition which is available in some plants such as sunflower oil that results in egg weight increase (Güçlü *et al.* 2008). According to Wu *et al.* (2005), energy metabolism of fish oil can affect the biochemical mechanism and it can lead to changes in egg weights and its component parts. Also, dietary energy can affect estrogen synthesis and metabolism which have impact on egg yolk weight which results in egg weight change. Diets which are rich in omega-3 PUFA led to smaller yolks because of a reduction in plasma estradiol (Whitehead *et al.* 1993).

Broiler breeders diets containing different oil sources could affect egg yolk fatty acids composition (Table 4). Inclusion of 2% FL oil in the diets of broiler breeders yielded significantly (P<0.05) lower content of myristic acid,

Table 3. Effects of different oil sources on egg quality in broiler breeders

Parameter	Diet oil source (Groups)				SED	P
	SO	SA	FL	FI		
Egg weight (g/number)	58.27^{b}	59.54^{a}	59.06^{ab}	58.29^{b}	0.15	0.011
Albumin weight (g)	35.00^{b}	35.88^{a}	35.97^{a}	35.12^{b}	0.12	0.006
Yolk weight (g)	17.01^{ab}	17.34^{a}	16.92^{b}	17.05^{ab}	0.06	0.151
Egg shell weight (g)	6.25^{ab}	6.30^{a}	6.17^{ab}	6.11^{b}	0.07	0.029
Egg shape index (%)	79.43	80.15	80.35	79.14	0.22	0.169
Albumin width (mm)	68.21	69.59	69.00	69.35	0.24	0.212
Albumin length (mm)	78.13	79.20	79.80	78.45	0.29	0.212
Albumin height (mm)	7.47	7.48	7.56	7.34	0.05	0.582
Albumin index	10.23	10.09	10.18	9.95	0.09	0.763
Yolk width (mm)	41.29	41.45	41.72	41.44	0.09	0.399
Yolk height (mm)	19.16^{c}	19.78^{a}	19.69^{ab}	19.38^{bc}	0.07	0.001
Yolk index	46.42^{b}	47.74^{a}	47.21^{ab}	46.79^{b}	0.15	0.029
Haugh unit	86.78	86.43	87.08	85.99	0.33	0.696
Shell strength (kg/cm²)	4.23^{ab}	4.36^{a}	4.03^{b}	4.08^{ab}	0.05	0.108
Shell thickness (mm)	340.9	341.1	337.8	333.2	1.31	0.123
Yolk colour						
l (Lightness)	58.32	58.55	58.43	58.43	0.11	0.928
a (Redness)	12.94	12.92	12.44	13.13	0.14	0.399
b (Yellowness)	62.83^{a}	60.18^{b}	60.31^{b}	61.39^{ab}	0.28	0.004

SO (2% soybean oil), SA (2% sunflower oil), FL (2% flax oil) and FI (2% fish oil). ^{a,b}Means bearing with different superscript in the same row are significantly different (P<0.05).

Table 4. Effects of different oil sources on fatty acids composition of egg yolk

Numeric name	Common name	Diet oil source (Groups)				SED	P
		SO	SA	FL	FI		
C14:0	Myristic acid	0.23[b]	0.22[b]	0.19[c]	0.26[a]	0.002	0.0001
C16:0	Palmitic acid	24.50[b]	25.47[a]	23.40[c]	24.49[b]	0.053	0.0001
C16:1	Palmitoleic acid	1.95[a]	1.72[b]	1.51[c]	1.58[c]	0.016	0.0001
C17:0	Heptadecanoic acid	0.10	0.05	0.09	0.014	-	-
C17:1	cis-17-Heptadecenoic acid	0.11	0.11	-	-	-	-
C18:0	Stearic acid	4.82[a]	4.36[b]	3.53[c]	3.10[d]	0.039	0.0001
C18:1n9	Oleic acid	41.79[c]	42.79[a]	42.37[ab]	41.93[bc]	0.092	0.0006
C18:2n6	linoleic acid	20.27[ab]	19.99[b]	20.25[ab]	20.65[a]	0.080	0.0385
C18:3n3	linolenic acid	0.94[b]	0.39[d]	3.41[a]	0.59[c]	0.019	0.0001
C20:0	Arashidic acid	0.05[c]	0.05[bc]	0.07[a]	0.06[b]	0.001	0.0001
C20:1cis-11	Eicosenoic acid	0.12[a]	0.11[b]	0.09[c]	0.08[c]	0.002	0.0001
C20:4n6	Arachidonic acid	0.18[b]	0.11[c]	0.17[b]	0.25[a]	0.008	0.0001
C20:5n3	Eicosapentaenoic acid	-	-	-	0.03	-	-
C22:1n9	Erusic acid	-	-	-	-	-	-
C22:2cis	cis-113-16-Docosadienoic acid	0.70[b]	0.80[a]	0.83[a]	0.85[a]	0.015	0.0020
C22:6n3	Docosahexenoic acid	1.07[c]	0.74[d]	1.78[b]	3.38[a]	0.017	0.0001
Total omega–3 fatty acids		2.02[c]	1.14[d]	5.20[a]	4.00[b]	0.023	0.0001
Total omega–6 fatty acids		20.45[ab]	20.11[b]	20.43[ab]	20.90[a]	0.080	0.0074
Total saturated fatty acids		29.71[b]	30.17[a]	27.30[d]	28.06[c]	0.058	0.0001
Total mono unsaturated fatty acids		43.97[b]	44.64[a]	43.97[b]	43.68[b]	0.092	0.0014
Total polyunsaturated fatty acids		23.17[c]	22.05[d]	26.46[a]	25.76[b]	0.090	0.0001

SO (2% soybean oil), SA (2% sunflower oil), FL (2% flax oil) and FI (2% fish oil). [a,b]Means bearing with different superscript in the same row are significantly different (P<0.05).

palmitic acid, palmitoleic fatty acids in egg yolk. Also amounts of linoleic acid, linolenic acid, arashidonic acid, and docosahexenoic fatty acid contents were lower in group fed diets containing 2% SA oil than the other groups (P<0.05). Total omega-3 and omega-6 fatty acids content was significantly (P<0.05) higher for the egg yolks obtained from the hens fed with 2% FL and 2% FI oil respectively while lower total omega-3 and omega-6 fatty acids was seen in the group that received 2% SA oil. Total saturated fatty acid and mono unsaturated fatty acid content was significantly (P<0.05) lower in groups fed diet containing 2% FL and 2% FI oil respectively and the higher content of these fatty acids content was seen in the group that received diet containing 2% SA oil. Total polyunsaturated fatty acid content in the yolks of the group which received 2% SA oil was significantly (P<0.05) lower than the other groups. It was reported that inclusions of dietary fatty acids in broiler breeder's diet have significant effect on egg yolk fatty acids composition (Yalcin and Unal 2010). Ehr *et al.* (2017) indicated that, feeding laying hens with diet containing different levels of flaxseed oil ground flaxseed caused a change in egg yolk fatty acid content. Haechang *et al.* (2014) demonstrated that adding of omega-3 fatty acid sources in brown laying hens' diet have a significant effect on egg yolk fatty acids composition.

The results with respect to body weight changes of the hen during the trial showed that birds attained almost 199 g of weight in all groups without a significant difference (P>0.05).

Hence, it can be concluded that feeding broiler breeders with diets with different oil sources have a significant effect on egg weight, egg quality, and egg yolk fatty acids composition.

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