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.

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 m² 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).
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 1. Composition and calculated analysis of the basal diet

| Ingredient (%) | SO | SA | FL | FI |
|----------------|----|----|----|----|
| Yellow corn    | 54.49 | 54.49 | 54.49 | 54.49 |
| Soybean meal-46| 10.00 | 10.00 | 10.00 | 10.00 |
| Fullfat soybean-36| 9.64 | 9.64 | 9.64 | 9.64 |
| Limestone (GRN)| 7.71 | 7.71 | 7.71 | 7.71 |
| Sunflower meal-36| 7.46 | 7.46 | 7.46 | 7.46 |
| Corn gluten meal-60| 3.86 | 3.86 | 3.86 | 3.86 |
| Meat-Bone-35    | 2.48 | 2.48 | 2.48 | 2.48 |
| DCP-18         | 1.57 | 1.57 | 1.57 | 1.57 |
| Soybean oil    | 2.00 | -  | -  | -  |
| Sunflower oil  | -  | 2.00 | -  | -  |
| Flax oil       | -  | -  | 2.00 | -  |
| Fish oil       | -  | -  | -  | 2.00 |
| Salt           | 0.24 | 0.24 | 0.24 | 0.24 |
| Vitamin premix1| 0.20 | 0.20 | 0.20 | 0.20 |
| Sodium bicarbonate| 0.10 | 0.10 | 0.10 | 0.10 |
| L-lysine       | 0.06 | 0.06 | 0.06 | 0.06 |
| Choline-60     | 0.05 | 0.05 | 0.05 | 0.05 |
| DL-methionine  | 0.04 | 0.04 | 0.04 | 0.04 |
| Total          | 100 | 100 | 100 | 100 |

SO (2% soybean oil), SA (2% sunflower oil), FL (2% flax oil) and FI (2% fish oil). 1Vitamin premix (per kg of diet): vitamin A, 16,000 IU; vitamin D3, 3,000 IU; vitamin E, 40 IU; vitamin K, 2.5 mg; vitamin B12, 2.5 mg; vitamin B1, 10 mg; nicotinamide, 50 mg; calcium D-pantothenate, 15 mg; vitamin B6, 6.25 mg; vitamin B12, 0.035 mg; folic acid, 15 mg; D-biotin, 0.045 mg; choline chloride, 150 mg. 2Mineral premix (mg/kg of diet): Mn, 80; Fe, 80; Zn, 60; Cu, 8; Co, 0.2; I, 0.5; Se, 0.15.
The addition of different oil sources in broiler breeder diets had significant effects on egg weight, albumin weight, yolk weight, egg shell weight, egg yolk index, shell strength, and yolk colour (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 strength, 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,
palmitic acid, palmitoleic fatty acids in egg yolk. Also, amounts of linoleic acid, linolenic acid, arachidonic 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.

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

| Numeric name | Common name | Diet oil source (Groups) | SED | P     |
|--------------|-------------|--------------------------|-----|-------|
| C14:0        | Myristic acid | SO 0.23b SA 0.22b FL 0.19c FI 0.26a | 0.002 | 0.0001 |
| C16:0        | Palmitic acid | SO 24.50b SA 25.47a FL 23.40c FI 24.49b | 0.053 | 0.0001 |
| C16:1        | Palmitoleic acid | SO 1.95a SA 1.72b FL 1.51c FI 1.58c | 0.016 | 0.0001 |
| C17:0        | Heptadecanoic acid | SO 0.10 SA 0.05 FL 0.09 FI 0.014 | - | - |
| C17:1        | cis-17-Heptadecenoic acid | SO 0.11 SA 0.11 FL - FI - | - | - |
| C18:0        | Stearic acid | SO 4.82a SA 4.36b FL 3.53c FI 3.10d | 0.039 | 0.0001 |
| C18:1n9      | Oleic acid | SO 41.79c SA 42.79a FL 42.37ab FI 41.93bc | 0.092 | 0.0006 |
| C18:2n6      | linoleic acid | SO 20.27ab SA 19.99b FL 20.25ab FI 20.65a | 0.080 | 0.0385 |
| C18:3n3      | linolenic acid | SO 0.94b SA 0.39d FL 3.41a FI 0.59c | 0.019 | 0.0001 |
| C20:0        | Arachidic acid | SO 0.05c SA 0.05bc FL 0.07a FI 0.06b | 0.001 | 0.0001 |
| C20:1cis-11  | Eicosenoic acid | SO 0.12a SA 0.11b FL 0.09c FI 0.08c | 0.002 | 0.0001 |
| C20:4n6      | Arachidonic acid | SO 0.18b SA 0.11c FL 0.17b FI 0.25a | 0.008 | 0.0001 |
| C20:5n3      | Eicosapentaenoic acid | SO - SA - FL - FI - | - | - |
| C22:1n9      | Erusic acid | SO - SA - FL - FI - | - | - |
| C22:2cis     | cis-113-16-Docosadienoic acid | SO 0.70b SA 0.80a FL 0.83a FI 0.85a | 0.015 | 0.0020 |
| C22:6n3      | Docosahexenoic acid | SO 1.07c SA 0.74d FL 1.78b FI 3.38a | 0.017 | 0.0001 |
| Total omega-3 fatty acids | SO 2.02c SA 1.14d FL 5.20a FI 4.00b | 0.023 | 0.0001 |
| Total omega-6 fatty acids | SO 20.45ab SA 20.11b FL 20.43ab FI 20.90a | 0.080 | 0.0074 |
| Total saturated fatty acids | SO 29.71b SA 30.17a FL 27.30d FI 28.06c | 0.058 | 0.0001 |
| Total mono unsaturated fatty acids | SO 43.97b SA 44.64a FL 43.97b FI 43.68b | 0.092 | 0.0014 |
| Total polyunsaturated fatty acids | SO 23.13b SA 22.05c FL 26.46a FI 25.76b | 0.090 | 0.0001 |

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