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Effect of Canola Oil on Cholesterol and Fatty Acid Composition of Egg-yolk of Laying Hens

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Abstract: This experiment was conducted to determine the effect of a dietary Calcium Soap of Fatty Acids (CSFA) and canola oil on cholesterol and omega-3 fatty acids content of the egg. A total of 120 Hy-line white layer (24-week old) were randomly divided into four experimental treatments with six replicates (5 hens per cage) and arranged in a completely randomized design. The experimental period lasted eight weeks and during this period, the birds had free access to feed and water. Experimental diets consisted of: 1) basal diet; 2) basal diet with 1% calcium soap of fatty acids; 3) basal diet with 3% canola oil and 4) basal diet with 5% canola oil. Egg weight, egg-yolk and egg white weights, yolk and egg cholesterol concentrations, linolenic and docosahexaenoic acids (DHA) content of the yolk were measured. Egg and egg white weights were not significantly different ($p>0.05$) among treatments. Adding 3% canola oil and 1% CSFA had no significant effect on egg-yolk weight, but addition of 5% canola oil showed significant effect on egg-yolk weight ($p<0.05$). CSFA had no significant effect on egg and yolk cholesterol, linolenic acid and omega-3 concentrations ($p>0.05$). Canola oil at 3 and 5% increased the percentage of linolenic acid by 2.7 to 4.73 folds to give levels of 3.43 and 6.02 percent of total fatty acids, respectively. Canola oil increased DHA content of the egg ($p<0.05$). By adding 3 and 5% canola oil, the percentage of DHA increased by 8.73 and 9.8 folds compared with the control diet, respectively. Canola oil at 3 and 5% increased percentage of total omega-3 fatty acids by 3.3 and 4.75 folds (4.72 vs 6.80%) as compared with the control diet (1.43%). Based on the results it seems that adding 5% canola oil to the laying hen diet based on corn and soybean meal, can increase omega-3 fatty acids content of egg-yolk which may have beneficial roles on human health.

Key words: Egg, canola oil, linolenic acid, omega-3 fatty acid, cholesterol

Introduction

Oils have commonly been used as energy sources in the diets for laying hens. Studies have shown that type of dietary lipids of the laying hen, can drastically alter the lipid profile of the egg-yolk (Balnave, 1970; Yang *et al.*, 2000; Grobas *et al.*, 2001). Canola oil has been recognized as rich plant source of linolenic acid (C18:3). Linolenic acid can be converted to longer chain omega-3 fatty acids, such as eicosapentaenoic acid (EPA, C20:5), docosapentaenoic acid (DPA, C22:5) and docosahexaenoic acid (DHA, C22:6) in poultry through elongation and desaturation pathway, thus enriching the egg yolk with omega-3 fatty acids (Sim, 1990; Yang *et al.*, 2000). Omega-3 fatty acids have many health benefits including the ability to decrease cardiovascular disease (Hirai *et al.*, 1980; Cherian and Sim, 1991; Grobas *et al.*, 2001), antithrombic (Herod and Kinsella, 1986) and rheumatoid arthritis (Kremer *et al.*, 1987). Health recommendations have encouraged a reduction in the consumption of total lipids, saturated fatty acid and cholesterol but to increasing the proportion of mono-unsaturated and polyunsaturated fatty acids (PUFA) in human diets (Walsh *et al.*, 1975; Temple, 1996). Grundy (1980) found that dietary mono-unsaturated fatty acids (e.g. oleic) were very effective in lowering blood

cholesterol concentration and may be important in preventing coronary heart disease. Also genetic, age and pharmacology agents are known to affect egg cholesterol deposition (Hargis, 1988; Halle, 1996 and 2001). The objective of this research was to determine the effect of feeding calcium soap of fatty acids and canola oil on cholesterol and fatty acid composition of egg yolk of laying hen.

Materials and Methods

The experiment was carried out using 210 Hy-line white layers (45-week old) in the Animal Research Station of the College of Agriculture, Shiraz University, Shiraz, Iran in year 2006. A basal diet (Table 1) was formulated to contain 16.27% crude protein and 2642 kcal Kg⁻¹ Metabolizable Energy (ME). Dietary treatments consisted of either 0% supplemented fat (basal diet), the basal diet with 1% added Calcium Soap of Fatty Acids (CSFA), the basal diet with added 3% canola oil (3% CO) and the basal diet with 5% added canola oil (5% CO). Basal diet was formulated according to NRC (1994). Hens were kept in wire cages (five hens per cage). Pre-experiment (14 days) was conducted using basal diet. Four different experimental diets were given for eight weeks. Each diet was given to six replicated (five hens per cage). Hens

Table 1: Basal diet composition (%) and calculated nutrient content

Ingredients	(%)
Yellow corn	60.59
Soybean meal	18.00
Canola meal	10.00
Calcium carbonate	8.60
Bone meal	1.80
Salt	0.30
Vitamin E	0.10
Methionine	0.11
Vitamin and Mineral premix ¹	0.50
Nutrient content	
Metabolizable energy kcal kg ⁻¹	2642.00
Crude protein (CP) (%)	16.27
Calcium (%)	3.73
Available phosphorous (%)	0.37
Arginine (%)	0.89
Lysine (%)	0.75
Methionine (%)	0.36
Methionine+cystine (%)	0.62
Tryptophane (%)	0.19

¹Vitamin and mineral premix provides per 2.50 kg of product: Vit. A, 7700000 IU; 15000 mg B₁; 4400 mg B₂; 55000 mg B₃; 3000 mg B₆; 8.8 mg B₁₂; 3300000 IU D₃; 6600 IU E; 550 mg K₃; 110 mg B₉; 22000 mg B₅; 55 mg H₂; 275 mg cholin chloride; 100 mg antioxidant; 66 mg Mn; 33000 mg Fe; 66000 mg Zn; 8800 mg Cu; 300 mg Se and 900 mg I

had free access to feed and water during experimental period and 16 h day⁻¹ light was provided. Eggs were collected and egg weight, yolk weight and white egg weight were measured. Fat, cholesterol, content and percentage, linolenic and docosahexaenoic (DHA) fatty acids were calculated (on 3 eggs from each replicate). Fat content was determined according to AOAC (2000). Fatty acids and cholesterol content were assayed by Gas chromatography and Zak (1977) procedures, respectively.

Data were analyzed as a complete randomized design with four treatments and six replicates. Statistical analysis of data was carried out using SAS statistical package program (SAS, 1999) and means were compared with Duncan's multiple range test at ($p < 0.05$).

Results and Discussion

The search of new procedures to improve the quality of food of animal origin is an unquestionable tendency in animal production. One of the relevant subjects, in this context, is the attempt to improve the quality of the egg-yolk lipids content profile of commercial laying hens for human consumption. In the present study it was found that the content of linolenic and omeg-3 fatty acids of egg yolk could be enriched through the diet of the laying hen (Sim, 1990; Yang *et al.*, 2000). Results regarding egg weight, white and yolk weights and egg and yolk cholesterol content are shown in Table 2. Egg weight did not differ significantly ($p > 0.05$) between diets. This result is in agreement with the results of previous research in which no significant effect on egg weight was observed

when canola oil was added to the diet (Farrel, 2002) but is not in the line of findings of Grobas *et al.* (2001) who reported higher egg weight with feeding soybean oil and flax oil. Egg white weight was not affected by diets ($p > 0.05$). Our findings would agree with Horniakov (1997) who did not observe any increase in egg white weight with 2 and 6% canola oil supplementation. The addition of 3 and 6% canola oil did not have any effect on egg white weight but it has been reported that the addition of 8% safflower oil increased egg and egg white weights possibly due to high content of linoleic acid (75%) of safflower oil (Wang, 1996).

The egg-yolk weight was significantly ($p < 0.05$) higher with adding 5% canola oil which is in agreement with the findings of Niemiec *et al.* (1999) who fed canola and flax oil to laying hens. In contrast, Horniakova (1997) did not observed an increase in yolk weight with 2 and 6% canola oil supplementation. Also Shafey *et al.* (2003) reported no significant effect of feeding 2% olive oil or safflower oil on egg-yolk weight.

Due to the differences between weight of egg-yolk among diets, cholesterol content was compared as mg per g yolk. Egg cholesterol concentration was highest when hens were fed diet with 5% canola oil with no difference ($p > 0.05$) with 3% canola oil supplementation but both levels were significantly ($p < 0.05$) higher than control diet. This might be due to the higher yolk weight with canola oil supplementation. Also with feeding unsaturated fatty acids, lipogenesis would decrease but cholesterol synthesis would increase in liver and since liver cholesterol mainly deposited in egg, the cholesterol content of egg will increase (Weiss *et al.*, 1967a). In contrast, Wang (1996) reported a decrease in cholesterol concentration and an increase in egg and egg white weights with supplementing diet with 8% safflower oil.

The addition of CSFA had no significant effect on egg and yolk cholesterol concentration which might be due to the low level of fatty acids or malabsorption of fatty acids in CSFA. It has been reported that feeding animal or saturated fats would decrease total lipid synthesis but cholesterol biosynthesis in liver will not change, therefore the extent of egg cholesterol content would not increase as compared with feeding unsaturated fats (Weiss *et al.*, 1967a,b).

The type of fat content of laying hen diet has an effect on the amount of transportation of liver cholesterol into ovaries, so feeding unsaturated fats would increase the phospholipids synthesis which are the essential constituents of lipoproteins (Weiss *et al.*, 1967a).

In other research eggs from feeding diets containing fish oil showed the highest and poultry fat showed the lowest cholesterol concentration (Melluzzi *et al.*, 1996). In contrast, Watkins and Elkin (1992) did not observe any changes in egg cholesterol concentration with olive oil, soybean oil or tallow supplementation. The discrepancies between studies on cholesterol content

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Table 2: Effects of dietary Calcium Soap of Fatty Acids (CSFA) and canola oil on egg weight, white weight yolk weight and cholesterol concentrations of yolk and egg (Mean±SE)

Treatments	Egg weight (g)	White weight (g)	Yolk weight (g)	Yolk cholesterol (mg/g)	Egg cholesterol
Control	57.68 ^a ±4.28	35.96 ^a ±2.21	17.98 ^{bc} ±0.25	12.07 ^a ±0.06	216.80 ^a ±0.24
1% CSFA	59.68 ^a ±1.48	36.37 ^a ±4.19	17.45 ^c ±0.7	12.57 ^a ±0.4	219.11 ^{bc} ±0.38
3% canola oil	58.66 ^a ±3.36	35.54 ^a ±2.53	18.07 ^{ab} ±0.67	12.28 ^a ±0.51	221.93 ^{ab} ±0.35
5% canola oil	58.88 ^a ±4.34	36.05 ^a ±0.87	18.24 ^a ±0.49	12.30 ^a ±0.47	224.26 ^a ±0.53

a-c: Means in the same row with the same letter (s) are not significantly different (p>0.05)

Table 3: Effects of dietary Calcium Soap of Fatty Acids (CSFA) and canola oil on linolenic acid (Lin) and Docosahexaenoic acid (DHA) content of egg (mg/egg and % of total fatty acids) (Mean±SE)

Treatments	Lin (mg/egg)	DHA (mg/egg)	Lin (%)	DHA (%)
Control	10.8 ^a ±1.56	5.90 ^a ±0.51	1.27 ^a ±0.21	0.15 ^a ±0.05
1% CSFA	13.04 ^a ±2.83	6.40 ^a ±0.71	1.4 ^a ±0.23	0.16 ^a ±0.05
3% canola oil	31.60 ^b ±3.72	13.98 ^b ±1.73	3.43 ^b ±0.52	1.31 ^b ±0.32
5% canola oil	54.08 ^b ±6.93	14.91 ^b ±0.93	6.02 ^b ±0.36	1.47 ^b ±0.13

a-c: Means in the same row with the same letter (s) are not significantly different (p>0.05)

Table 4: Effects of dietary Calcium Soap of Fatty Acids (CSFA) and canola oil on linolenic acid (Lin), Docosahexaenoic acid (DHA) (mg/g yolk) and Omega-3 fatty acid (% of total fatty acids and mg/egg) (Mean±SE)

Treatments	Lin (mg/g yolk)	DHA (mg/g yolk)	Omega-3 (%)	Omega-3 (mg/egg)
Control	0.628 ^a ±0.095	0.295 ^a ±0.029	1.43 ^a ±0.20	17.83 ^a ±1.67
1% CSFA	0.730 ^a ±0.151	0.357 ^a ±0.039	1.57 ^a ±0.21	18.96 ^a ±3.95
3% canola oil	1.720 ^b ±0.176	0.761 ^a ±0.051	4.72 ^b ±0.46	46.21 ^b ±4.37
5% canola oil	2.997 ^b ±0.432	0.823 ^a ±0.262	6.8 ^b ±0.58	70.05 ^b ±8.33

a-c: Means in the same row with the same letter (s) are not significantly different (p>0.05)

of egg might be due to the genetic and dietary factors (Hargis, 1988). The results in the literature concerning the effect of dietary fatty acids intake on egg and plasma cholesterol concentrations, are contradictory. Holland *et al.* (1980) and Mori *et al.* (1999) verified that polyunsaturated fatty acids of dietetic oils decreased both the egg and plasma cholesterol concentrations. On the other hand, Bartov *et al.* (1971) and Washburn and Nix (1974) did not observed such effect. In this study, only linolenic acid and DHA were identified. The amount of linolenic acid was affected by the addition of canola oil (p<0.05) and was highest with 5% canola oil supplementation with no differences between control and CSFA diets. The addition of 3 and 5% canola oil increased percentage of linolenic acid by 2.7 and 4.73 folds, respectively as compared with the control diet. As compared with the control diet, the percentage of linolenic acid increased (p<0.05) from 1.27 to 3.43 with 3% canola oil and from 1.27 to 6.02 with 5% canola oil, respectively (Table 3). The amount of DHA was affected significantly (p<0.05) by canola oil supplementation with no differences between 3 and 5% canola oil, respectively. The percentage of omega-3 fatty acid was higher (p<0.05) with 3 and 5% canola oil (4.72 vs 6.80) as compared with the control and CSFA diets (Table 4). Similar results was reported by Cherian and Sim (1991) with feeding 16% canola seed. Also Grobas *et al.* (2001) reported when alpha-linolenic acid content of the diets increased from 0 to 0.8%, the arachidonic, DPA and DHA acids in the egg-yolk increased. This indicates that the laying hen can convert linolenic acid to omega-3 fatty

acid and deposited into the egg yolk.

The percentage of DHA increased from 0.15 with control diet to 1.31 and 1.47 with 3 and 5% canola oil supplementation, respectively (Table 3) which correspond to 8.73 and 9.8 folds increase in DHA percentage of total fatty acids. Similar results were reported previously (Vogtmann and Clandinin, 1975; Ferrier *et al.*, 1995; Scheideler and Froning, 1996). CSFA had no significant effect on linolenic, DHA and omega-3 fatty acids, indicating the necessity of further investigations. In conclusion, in terms of human health benefits, the higher linolenic and omega-3 fatty acids with feeding canola oil (especially 5%) to laying hen, may represent an improvement in the fatty acid profile of egg.

References

- Association of Official Analytical Chemists, 2000. Official Methods of Analysis. 17th Ed., Washington, D.C.
- Balnave, D., 1970. Essential fatty acids in poultry nutrition. World's Poult. Sci. J., 26: 442-459.
- Bartov, I., S. Bornstein and P. Budowski, 1971. Variability of cholesterol in plasma and egg yolk of hens and evaluation of the effects of some dietary oils. Poult. Sci., 50: 1357-1364.
- Cherian, G. and J.S. Sim, 1991. Effect of feeding full fat flax and canola seeds to laying hens on the fatty acids composition of eggs, embryos and newly hatched chickens. Poult. Sci., 70: 917-922.
- Farrel, D.J., 2002. Adding value to the hen's egg. Nutr. Rep. Int., 45: 1052-1057.

- Ferrier, L.K., L.J. Caston, S. Leeson, J. Squires, B.J. Weaver and B.J. Holub, 1995. α -linolenic acid and docosahexaenoic acid-enriched egg from hens fed flaxseed: Influence of blood lipids and platelet phospholipid fatty acids in humans. *Am. J. Clin. Nutr.*, 62: 81-86.
- Grundy, S.M., 1980. Comparison of mono-unsaturated fatty acids and carbohydrates for lowering plasma cholesterol. *New England J. Med.*, 314: 745-748.
- Grobass, S., J. Mendez, R. Lazaros, C.D. Blas, G.G. Mateos and B.C. De, 2001. Influence of source of fat added to diet on performance and fatty acid composition of egg yolks of two strains of laying hens. *Poult. Sci.*, 80: 1171-1179.
- Halle, I., 1996. Effect of dietary fat on performance and fatty acid composition of egg yolk in laying hens. *Arc. Fur. Gef.*, 60: 65-72.
- Halle, I., 2001. Effect of dietary fish oil and linseed oil on performance, egg component and fatty acid composition of egg yolk in laying hens. *Arc. Fur. Gef.*, 65: 13-21.
- Hargis, P.S., 1988. Modifying egg yolk cholesterol in domestic fowl-a review. *World's Poult. Sci. J.*, 44: 17-29.
- Herod, P.M. and J.E. Kinsella, 1986. Fish oil consumption and decreased risk of cardiovascular disease: A comparison of findings from animal and human feeding trials. *Am. J. Clin. Nutr.*, 43: 566-598.
- Hirai, A., T. Hamazaki and T. Terano, 1980. Eicosapentaenoic acid and platelet function in Japanese. *Lancet*, D: 1132.
- Holland, K.G., A.A. Grunder and C.L. Williams, 1980. Response to five generations of selection for blood cholesterol levels in White Leghorns. *Poult. Sci.*, 59: 1316-1323.
- Horniakova, E., 1997. Effect of different content of fat source on production and indices of egg quality. *Proceedings of the 16th Scientific Conference of the Feedstuffs Res.*, pp: 183-188.
- Kremer, J.M., W. Jubiz and A. Michalek, 1987. Fish oil supplementation in active rheumatoid arthritis. *Ann. Int. Med.*, 104: 497.
- Melluzzi, A., F. Sirri, L. Vandi, C. Cristofori and A. Franchini, 1996. Lipid profile of eggs laid by hens fed on diets supplemented with different fats and oils. *Riv. Di. Acl.*, 65: 27-32.
- Mori, A.V., C.X. Mendonca and C.O.F. Santos, 1999. Effect of dietary lipid lowering drugs upon plasma lipids and egg yolk cholesterol levels of laying hens. *J. Agri. Food Sci.*, 47: 4731-4735.
- National Research Council (NRC), 1994. *Nutrients Requirements of Poultry*. 9th rev. Ed., National Academy of Science, Washington, DC.
- Niemiec, J., M. Stepinska, E. Swierczewska, J. Riedel and R. Kakowska, 1999. Effect of diet with oil seeds on laying hen's performance and egg quality. *Ros. Oil.*, 20: 305-310.
- SAS Institute, Inc, 1999. *SAS users guide Version 8*. SAS Inst. Inc. Cary, NC, USA.
- Scheideler, S.E. and B. Froning, 1996. The combined influence of dietary flaxseed variety, level, form and storage conditions on egg production and composition among vitamin-E supplemented hens. *Poult. Sci.*, 75: 1221-1226.
- Shafey, T.M., J.G. Dingle, M.W. McDonald and K. Kostner, 2003. Effect of type of grain and oil supplement on the performance, blood lipoprotein, egg cholesterol and fatty acid of laying hens. *Int. J. Poult. Sci.*, 2: 200-206.
- Sim, J.S., 1990. Flax seed as a high energy/protein/omega-3 fatty acid feed ingredient for poultry. In: *Proceeding of the 53 rd Flax Institute of the United States*, Fargo, ND., pp: 65-72.
- Temple, N.J., 1996. Dietary fats and coronary heart disease. *Biomed. Pharmacother.*, 50: 261-268.
- Vogtammann, H. and D.R. Clandinin, 1975. The effect of crude and refined low uric acid rapeseed oils in diets for laying hens. *Br. Poult. Sci.*, 16: 55-61.
- Walsh, R.J., M.F. Day, F.J. Fenner, M. McCall, E.G. Saint, T.W. Scott, M.V. Tracey and E.J. Underwood, 1975. *Diet and Coronary Heart Disease*, Report Number 18 (Canberra, Australian Academy of Science).
- Washburn, K.W. and D.F. Nix, 1974. A rapid technique for the extraction of yolk cholesterol. *Poult. Sci.*, 53: 1118-1122.
- Wang, B.W., 1996. Effect of safflower seed oil on productivity and polyunsaturated fatty acid and cholesterol in egg yolk. *Chi. J. Anim. Sci.*, 32: 39-40.
- Watkins, B.A. and R.G. Elkin, 1992. Dietary modulation of oleic and stearic acids in egg yolks. *J. Food. Comp. Anal.*, 5: 209-215.
- Weiss, J.F., E.C. Naber and R.M. Johnson, 1967a. Effect of dietary fat and cholesterol on the *in vitro* incorporation of acetate-14C into hen liver and ovarian lipids. *J. Nutr.*, 93: 153-160.
- Weiss, J.F., E.C. Naber and R.M. Johnson, 1967b. Effect of dietary fat and d-thyroxin on the incorporation of acetate-1-14C into egg yolk lipids. *J. Nutr.*, 93: 153-160.
- Yang, C.X., C. Ji, L.M. Ding and Y. Rong, 2000. N-3 fatty acid metabolism and effects of alpha-linolenic acid on enriching n-3 FA eggs. *J. Chi. Agri. Uni.*, 95: 117-122.
- Zak, B., 1977. Cholesterol methods. A review. *Clin. Chem.*, 23: 1201.