EFFECT OF REPLACEMENT TIME AND RATE OF SOYBEAN OIL BY SESAME OIL IN LAYING HENS' DIET ON POLYUNSATURATED FATTY ACID PROFILE IN EGGS

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SUMMARY

The study was aimed to evaluate the effect of replacement time and rate of soybean oil (SB) by sesame oil (SO) on polyunsaturated fatty acid (PUFA) profile in egg of laying hens. Two hundred White Leghorn hens with 30 weeks of age were divided into five treatments with four replicates of 10 birds each. Treatments were assigned randomly and consisted of 0.00%, 0.75%, 1.50%, 2.25% and 3.00% SO in commercial corn-soybean meal diets, in which the soybean oil was partially replaced. The main research findings are: feed intake, egg production rate, egg weight and feed conversion were not influenced by time and dietary treatment. Fatty acid content was significantly altered ($P < 0.05$) by SO, showing a progressive increase in egg n-3 fatty acid (especially docosahexaenoic acids (DHA) and eicosapentaenoic acids (EPA)) when SO was added. Levels of EPA and DHA were higher ($P < 0.05$) in the egg lipids of SO fed hens than those in the control group. However, no significant differences were observed either in egg weight or egg production among groups. The highest incorporation ($P < 0.05$) of total n-3 fatty acid content in eggs was obtained with 3% SO/kg. This increase was proportional to SO inclusion levels in the diets.

Key words: *Egg enriched, laying hens, n-3 and n-6 fatty acids, Sesame oil*

INTRODUCTION

Lipids one of the important nutrient ingredients in animal nutrition due to its carried of lipid soluble vitamine (A, D, E, K), minerals and its role as essential fatty acid precursor, which animal body can't synthesize it, so it must be added to the diet. We can found these fatty acids in some animal oils like fish oil and vegetable oils like sesame oil, soya bean oil and corn oil. Omega fatty acids act an important role in human body in metabolism, cells membrane activity and enzymes activity (Nishida C. and Uauy R. 2009). The World Health Organization recommends that diets should provide less than 1% of total energy intake as trans fatty acids (Burlingame B., 2009). In many countries, the consumption of oil products is low; hence the benefit which could be derived from a diet rich in n-3 PUFA, does not reach the majority of the population. Simopoulos A. P. (2009) reported that fatty acid (FA) content of the egg yolk can be modified through nutrition. Currently, sesame oil (SO) and marine products are used commercially to achieve this effect. Sesame plant grows in tropical and subtropical regions with a dry and rainy season. It is grown in many parts of the world today for its important uses as edible oil, spices, insecticides, medicines, soap, green manure and ornaments (Diarra et al., 2008). Sesame oil have a very high level of unsaturated fatty acids, which is assumed to have reducing effect on plasma cholesterol, as well as on coronary heart disease (Nguyen Duy Hoan, 2015; El – Tinay et al., 2007; Tashiro et al., 1990).

MATERIALS AND METHODS

Birds and Diets

Experiments were arranged according to multivariate testing methods. Total 200 White Leghorn hens were divided into five treatments (10 hens/treatment) with 4 replicates. Experimental hens were housed in individual iron cages with density 0.15 m^2/hen. The age of the hens at the start of the experiment was 30 weeks and an average body weight was 1,848.24 ± 80g. The

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treatments were assigned randomly and consisted of the incorporation of 0.75%, 1.5%, 2.25% and 3% in substitution of identical amount of soybean oil in commercial corn-soybean diets. The diets were calculated as shown in Table 1 to meet the recommendations of the Thai Nguyen University of Live-Science Institute, and the experiment lasted 90 days (three months production periods). Diets were formulated based on chemical analysis of metabolizable energy (ME), n-3 and n-6 fatty acid profiles in the soybean oil and SO used in this study (Table 2). Feed mixtures were made fresh just prior to each month production period. Feed and water were offered for *ad libitum* consumption. Data from feed intake, egg production, egg weight and feed conversion ratio were calculated and egg samples were collected over a month production period.

Analytical Methods

At days 28, 56 and 84 (1, 2 and 3 months, respectively) after the study started, 10 eggs from each replicate (40 eggs/group) were collected and stored at 4°C for whole egg (yolk and albumen) chemical analysis. In this study, the lipid content was analyzed in whole eggs (yolk and albumen) as pools of 10 eggs per sample. Three replicate of each sample were processed according to the methods described by Folch et al (1957). Methyl esters of fatty acids were obtained using boron trifluoride. Fatty acids were quantified by gas chromatography using a DB-23 column (JW 122-2332 of 30m × 0.25mm internal diameter) on a Varian 3400 CX gas liquid chromatograph, equipped with an auto sampler and a flame ionization detector (Varian Associates, Inc., Sugar Land, TX). Nitrogen was the carrier gas at a flow rate of 30 mL/min. Temperatures were: column, 230°C; injector, 150°C; detector, 300°C. Myristic acid (Sigma Co., St. Louis, MO) was used as an internal standard for fatty acid. Retention times were compared with fatty acid methyl ester standards.

Table 1. *Analysis and percentage composition of the experimental diets with different levels of sesame oil (%).*

Variables	Sesame oil (%)				
	0	0.75	1.50	2.25	3.0
Ingredient (%)					
Corn meal	61.04	61.04	61.04	61.04	61.04
Soybean meal	25.35	25.35	25.35	25.35	25.35
Soybean oil	3.00	2.25	1.50	0.75	0.00
Sesame oil	0.00	0.75	1.50	2.25	3.00
Calcium carbonate	8.33	8.33	8.33	8.33	8.33
Calcium phosphate	1.28	1.28	1.28	1.28	1.28
Salt	0.40	0.40	0.40	0.40	0.40
Mineral premix[1]	0.25	0.25	0.25	0.25	0.25
Vitamin premix[2]	0.35	0.35	0.35	0.35	0.35
Total	100.0	100.0	100.0	100.0	100.0
Calculated analysis					
Metabolizable energy (kcal)	2,857	2,849	2,841	2,834	2,827
Crude protein (%)	16.08	16.12	16.05	16.10	16.00
Lysine (%)	0.77	0.77	0.77	0.77	0.77
Methionine (%)	0.30	0.30	0.30	0.30	0.30
Methionine + cysteine (%)	0.59	0.59	0 59	0.59	0.59
Ca (%)	3.50	3.50	3.50	3.50	3.50
Available phosphorus (%)	0.35	0.35	0.35	0.35	0.35

[1]Vitamin premix supplied the following per kilogram of complete feed: vitamin A: 3,600 µg; vitamin D3: 62.5 µg vitamin E: 20.1 mg; vitamin K3: 2 mg; thiamine: 2.25 mg; riboflavin: 7.5 mg; pyridoxine: 3.5 mg; cobalamine: 0.02 mg; niacin: 45 mg; D-pantothenic acid: 12.5 mg; biotin: 0.125 mg; folic acid: 1.5 mg.

[2]Mineral premix supplied the following per kilogram of complete feed: zinc: 50 mg; copper: 12 mg; iodine: 0.3 mg; cobalt. 0.2 mg; iron: 100 mg; selenium: 0.1 mg.

Table 2. *Metabolizable energy (kcal/100 g) and PUFA composition of the soybean and sesame oil used in the experimental diets (g/100 g)*

Variables	Soybean oil	Sesame oil
ME	889.43 ± 12.02	886.80 ± 11.12
Fatty acid composition		
ALA (C18:3)	6.19 ± 0.68	0.97 ± 0.10
EPA (C20:5)	0.39 ± 0.10	0.88 ± 0.10
DHA (C22:6)	0.02 ± 0.00	0.37 ± 0.10
DPA (C22:5)	0.02 ± 0.00	0.09 ± 0.00
LA (C18:2)	48.97 ± 2.12	49.03 ± 0.90
AA (C20:4)	0.01 ± 0.00	0.52 ± 0.10

Data is presented as mean ± SE. ALA = linolenic acid; EPA = eicosapentaenoic acid; DHA = docosahexaenoic acid; DPA = docosapentaenoic acid; LA = linoleic acid; AA = arachidonic acid.

Statistical Analysis

Data from reproductive performance and PUFA content in the egg were evaluated by variance analysis using the general linear models (GLM) procedure. Significant differences ($P < 0.05$) were further separated using Duncan's multiple range test and statistical analysis system (SAS) 9.2 software (SAS user's guide: statistics, SAS Institute Inc.) with length of supply and replacement rate of soybean oil by SO as two effects. Regression analysis between the inclusion of SO and n-3 fatty acid and n-6 fatty acid concentration in the egg content were submitted to analysis of variance (ANOVA; 2005).

RESULTS AND DISCUSSION

Reproduction Performance

Table 3. *Effect of the replacement rate of soybean oil by sesame oil on feed intake, egg weight, egg production and feed conversion ratio*

Variables \ Sesame oil (%)	0.00	0.75	1.50	2.25	3.00
First month					
Feed intake (g/day)	102.00 ± 2.00	103.12 ± 1.80	103.36 ± 1.80	99.99 ± 1 88	98.64 ± 1.23
Egg weight (g)	57.05 ± 1.80	58.63 ± 0.81	57.66 ± 1.10	58.84 ± 0 98	56.80 ± 0.90
Egg production (%)	92.84 ± 1.50	93.70 ± 1.12	91 88 ± 0.90	93.80 ± 1.20	92.00 ± 0.80
Feed conversion ratio (kg/kg)	1.79 ± 1 70	1 83 ± 0.60	1 81 ± 0.56	1.75 ± 0.63	1.78 ± 0.55
Second month					
Feed intake (g/day)	108.00 ± 1.61	111.00 ± 2.11	112.22 ± 1 98	110.20 ± 1.03	109 31 ± 1.87
Egg weight (g)	58.02 ± 0.67	58.60 ± 1.00	58.97 ± 0 70	59.43 ± 0.70	57 64 ± 0.98
Egg production (%)	93.08 ± 0.90	93.00 ± 1.00	92.19 ± 1.00	93 57 ± 0.90	91.58 ± 1.00
Feed conversion ratio (kg/kg)	1.87 ± 0.20	1.86 ± 0.46	1.89 ± 0.40	1.88 ± 0.100	1.91 ± 0.44

Data is presented as mean ± SE. In each column, there were no significant differences ($P > 0.05$).

Results in Table 3 showed that the use of SO did not affect the reproduction performance of the Leghorn hen. Feed intake, egg weight, egg production and feed conversion ratio (FCR) of four treatments groups were equivalent with control group at the both of experiment 3 months. It also showed that feed intake, egg weight, egg production and FCR were not affected by replacement rate of SB by SO in the diet of the Leghorn hen. It is in agreement with Howe et al.; Baucells et al., who incorporated different PUFA into hens' diets without finding any effect.

Fatty Acid Composition

Fatty acid composition of egg yolk is readily altered by dietary manipulation. Results in Table 4 showed that fatty acid content was altered by SO inclusion with a progressive increase in egg n-3 PUFA, especially docosahexaenoic acid (DHA, C22:6) and eicosapentaenoic acid (EPA, C20:5) whit increasing levels. The increase was associated with a progressive decrease in α-linolenic acid (ALA, C18:3), a precursor of the more biologically active forms of n-3, EPA and DHA. Levels of EPA were higher ($P < 0.05$) in the egg lipids of hens fed SO than those in the control group. Likewise, eggs from hens fed SO had higher DHA content than the control eggs. Means in each fatty acid per month with no common superscripts are different ($P < 0.05$). The results of analyzing the relationship between SO replacement rate in the diets and the incorporation of EPA into the egg yolk proved that there was a high correlation between the SO replacement rate in the diets and the incorporation of EPA ($P <$ 0.05) or DHA into the egg yolk.

In the present study, a progressive decrease in linoleic acid (LA, C18:2) and arachidonic acid (AA, C20:4) was observed when SO was added (Table 5). The results of analyzing the relationship between SO replacement rate in the diets and the incorporation of LA into the egg yolk showed that there was a high correlation ($P < 0.05$) between the SO replaced in the diets and the incorporation of LA into the egg yolk. The highest incorporation of total n-3 fatty acid content in eggs was obtained with 3% SO (Table 6). This increase was proportional to SO inclusion levels ın the diets.

Among the fatty acids, n-3 PUFA has been described to have the most effective immunomodulatory activities; and among the n-3 PUFA, those from fish oil, EPA and DHA are more biologically potent than ALA (Simopoulos A. P., 2009). Current westem diets typically contains excessive amounts of n-6 PUFA and high ω-6/ω-3 ratio which have been associated with several pathological conditions, such as cardiovascular disease, cancer and inflammatory and autoimmune diseases, whereas increased levels of ω-3 PUFA have been reported to reduce those conditions. It is in agreement with Carrillo-Dominguez, S et al., 2005; El – Yamany et al., 2008.

Table 4. *ω-3 PUFA content (mg/100 g) of eggs from hens fed sesame oil*

Variables \ Sesame oil (%)	0.00	0.75	1.50	2.25	3.00
EPA (C20:5)					
Month 1	3.41 ± 0.34^{e}	6.56 ± 0.82^{d}	12.86 ± 1.22^{c}	24.47 ± 2.15^{b}	32.37 ± 4.01^{a}
Month 2	3.80 ± 0.23^{c}	7.34 ± 1.84^{d}	14.32 ± 1.67^{c}	23.67 ± 2.05^{b}	44.12 ± 4.14^{a}
Month 3	3.16 ± 0.12^{e}	7.50 ± 0.89^{d}	15.07 ± 1.26^{c}	23.52 ± 2.99^{b}	45.88 ± 3.30^{a}
Average	3.45 ± 0.22^{c}	7.89 ± 0.86^{d}	16.69 ± 1.03^{c}	25.91 ± 1.66^{b}	46.99 ± 2.55^{a}
DPA (C22:5)					
Month 1	73.50 ± 5.4^{a}	39.00 ± 1.9^{b}	48.19 ± 1.4^{c}	55.45 ± 2.2^{b}	60.49 ± 1.3^{b}
Month 2	49.82 ± 3.2^{a}	37.08 ± 3.7^{b}	53.17 ± 2.1^{b}	55.36 ± 1.13^{b}	64.48 ± 2.1^{b}
Month 3	60.40 ± 1.9^{a}	34.52 ± 3.1^{b}	53.75 ± 1.9^{b}	55.08 ± 1.6^{b}	63.23 ± 1.6^{b}
Average	61.24 ± 3.8^{a}	36.87 ± 1.8^{b}	61.52 ± 1.1^{bc}	55.30 ± 1.45^{b}	62.83 ± 1.0^{b}
DHA (C22:6)					
Month 1	129.86 ± 6.2^{c}	242.43 ± 22.3^{b}	265.81 ± 28.9^{b}	400.74 ± 31.2^{a}	$422.94 \pm 33\ 5^{a}$
Month 2	115.74 ± 8.5^{d}	256.93 ± 44.2^{c}	352.56 ± 33.2^{b}	362.02 ± 38.7^{b}	538.16 ± 44.6^{a}
Month 3	127.50 ± 6.7^{d}	228.79 ± 31.8^{c}	326.77 ± 27.0^{b}	360.20 ± 38.8^{b}	503.35 ± 40.3^{a}
Average	124.36 ± 4.3^{d}	239.72 ± 21.5^{c}	319.5 ± 19.9^{b}	368.38 ± 22.6^{b}	491.18 ± 36.4^{a}
ALA (C18 3)					
Month 1	136.94 ± 8.8^{ab}	142.12 ± 8.6^{a}	114.38 ± 8.6^{b}	97.54 ± 6.2^{bc}	76.34 ± 5.7^{cd}
Month 2	$149\ 41 \pm 6.8^{a}$	126.57 ± 11.4^{b}	120.47 ± 10.1^{b}	96.65 ± 6.1^{c}	84.93 ± 5.0^{c}
Month 3	138.99 ± 5.7^{a}	114.11 ± 10.1^{b}	118.36 ± 7.3^{b}	87.82 ± 6.3^{c}	85.39 ± 4.6^{c}
Average	141.78 ± 4.6^{a}	130.26 ± 8.7^{ab}	117.04 ± 5.8^{b}	94.67 ± 4.6^{c}	82.13 ± 3.5^{c}

Data presented as mean ± SE. $^{a-e}$Means with unlike superscripts differ significantly ($P < 0.05$). EPA = eicosapentaenoıc acıd; DPA = docosapentaenoic acid; DHA = docosahexaenoıc acid; ALA = α-linolenic acid.

Table 5. *ω-6 PUFA content (mg/100g) of eggs from hens fed sesame oil*

Variables \ Sesame oil (%)	0.00	0.75	1.50	2.25	3.00
LA (C18:2)					
Month 1	1833.38 ±121.4^{ab}	2009.13 ± 122.2^{a}	1560.60 ± 102.2^{b}	1346.3 ± 76.1^{cd}	1130.4 ± 56.7^{d}
Month 2	1891.48 ± 89.0^{a}	1889.99 ± 268.2^{a}	1653.99 ± 123.0^{b}	1391.1 ± 74.2^{b}	1182.7 ± 67.2^{b}
Month 3	1851.73 ± 85.6^{a}	1677.73 ± 130.0^{a}	1480.83 ± 98.5^{b}	1215.4 ± 90 0^{c}	1201.5 ± 76.4^{c}
Average	1860.20 ± 66.7^{a}	1854.28 ± 119.1^{a}	1417.07 ± 68 6^{b}	1318.6 ± 46 8^{bc}	1156.1 ± 40.8^{c}
AA (C20:4)					
Month 1	304.03 ± 21.1^{a}	244.52 ± 18.2^{a}	155.59 ± 6.4^{b}	132 89 ± 5 8^{b}	108.42 ± 8.3^{b}
Month 2	318.77 ± 16.9^{a}	224.46 ± 22.2^{a}	189.33 ± 8.5^{b}	133.51 ± 6.6^{c}	124.81 ± 8.2^{c}
Month 3	300.29 ± 15.6^{a}	204.95 ± 19.8^{b}	158.81 ± 8.6^{b}	115.13 ± 9.1^{c}	119.71 ± 8.1^{c}
Average	330.83 ± 10.4^{a}	224.64 ± 15.7^{b}	166.16 ± 7.0^{c}	126.91 ± 22.3^{d}	117 40 ± 6.0^{d}

Data presented as mean ± SE. $^{a-d}$ Means with unlike superscripts differ significantly ($P < 0.05$). LA = linoleic acid; AA = arachidonic acid.

Table 6. *Total n-3 and n-6 PUFA content (mg/100 g) of eggs from hens fed sesame oil*

Variables \ Sesame oil (%)	0.00	0.75	1.50	2.25	3.00
n-3 PUFA					
Month 1	343.71 ± 19.2^{c}	430.11 ± 16.2^{b}	441.34 ± 18 0^{b}	578.2 ± 36.1^{a}	592.14 ± 37.2^{a}
Month 2	314.82 ± 13.5^{d}	427.92 ± 72.1^{c}	540.52 ± 36.7^{b}	537.70 ± 43.3^{b}	731.69 ± 49.1^{a}
Month 3	332.07 ± 11.9^{d}	384.92 ± 46.8^{c}	513.95 ± 37.8^{b}	526 62 ± 38.5^{b}	697.85 ± 42.0^{a}
Average	331.24 ± 19.7^{d}	414.74 ± 30 8^{c}	514.75 ± 62.0^{b}	544.26 ± 34.4^{b}	673.89 ± 33.8^{a}
n-6 PUFA					
Month 1	2141.4 ± 144.0^{a}	2353.65 ±160 8^{b}	1716.19 ± 110.1^{b}	1479.19 ±70.7^{b}	1238.82 ± 66 2^{c}
Month 2	2179.58 ± 104.2^{a}	2114 45± 300.2^{b}	1843.32 ± 120.2^{a}	1524.61 ± 78.5^{b}	1307.51 ± 65.6^{c}
Month 3	2152.02 ± 100.9^{a}	1882.68 ± 162.0^{ab}	1639 64 ± 69.3^{b}	1330.53 ± 80.0^{c}	1321.21 ± 66.4^{c}
Average	2157.67 ± 68.7^{a}	2116.98 ± 166.3^{b}	1733.05 ± 66.5^{b}	1444 77 ± 82.4^{c}	1289.18 ± 65.6^{c}

Data presented as mean ± SE $^{a-d}$Means with unlike superscripts differ significantly ($P < 0.05$).

CONCLUSIONS

Our results indicate that the use of Sesame oil for replacement Soybean oil in the laying diet from 0.75 to 3% of concentration, did not have any detrimental effect on feed intake, egg weight, egg production and egg feed conversion ratio, while produce n-3 fatty acid enriched eggs.

The Sesame oil serves as n-3 fatty acids alternative feed ingredient in layer hen diets to produce a healthier choice of egg because the n-3 PUFA content in eggs can be increased by dietary supplementation with Sesame oil.

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TÓM TẮT

ẢNH HƯỞNG CỦA THỜI GIAN VÀ TỶ LỆ THAY THẾ DẦU ĐẬU TƯƠNG BẰNG DẦU VỪNG ĐẾN HÀM LƯỢNG VÀ THÀNH PHẦN AXIT BÉO KHÔNG NO NHIỀU NỐI ĐÔI TRONG TRỨNG

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Nghiên cứu được tiến hành nhằm đánh giá ảnh hưởng của tỷ lệ và thời gian thay thế dầu đậu tương (SB) bằng dầu vừng (SO) đến hàm lượng và thành phần các loại axits béo không no nhiều nối đôi (PUFA) trong trứng gà đẻ. Thí nghiệm được tiến hành trên 200 gà đẻ giống Leghorn lúc 30 tuần tuổi, được chia thành năm lô tương ứng với 5 mức thay thế 0,00%, 0,75%, 1,50%, 2,25% và 3,00% trong khẩu phần có nguyên liệu chính là bột ngô và bột đậu tương với bốn lần lặp lại. Kết quả nghiên cứu cho thấy các chỉ tiêu: Tiêu thụ thức ăn, năng suất trứng, khối lượng trứng và tiêu tốn thức ăn/kg trứng không bị ảnh hưởng bởi tỷ lệ và thời gian thay thế. Việc thay thế dầu đậu tương bằng dầu vừng đã làm tăng đáng kể (P <0,05) hàm lượng các loại axit béo không no omega 3 như axit docosahexaenoic (DHA) và axit eicosapentaenoic (EPA). Hàm lượng các loại axit béo như EPA và DHA trong trứng gà sử dụng dầu vừng cũng cao hơn so với lô đối chứng với mức tin cậy (P <0,05). Lô được thay thế với mức 3% dầu đậu tương bằng dầu vừng có tổng hàm lượng axit béo n-3 trong trứng đạt mức cao nhất, điều đó dẫn tới kết luận hàm lượng axit béo n-3 trong trứng gà đẻ tỷ lệ thuận với tỷ lệ dầu vừng được bổ sung vào khẩu phần ăn của gà đẻ.

Từ khóa: *trứng gà, gà đẻ, axit béo n-3 và n-6, dầu đậu tương, dầu vừng.*

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