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Article

Effect of Feeding Soybean and Palm Blended Oil on Laying Performance and Egg Quality

Niwat MUANGKEOW

Division of Animal Production Technology, School of Agricultural Technology, Walailak University, Nakhon Si Thammarat 80161, Thailand

(Corresponding author; e-mail: mniwat@wu.ac.th)

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Abstract

The effect of blended dietary oil on the laying performance of hens and the fatty acid profiles of eggs produced by 21 to 40 wk old Dekalb Brown laying hens were investigated. The experimental design was a completely randomized design using a 4 × 2 factorial arrangement with one control. The different oil sources did not influence egg production, egg weight, egg mass, feed intake, feed efficiency, Haugh unit or egg shell thickness. However lipid profile of the egg yolk changed as a function of dietary lipid sources. The fatty acid composition of egg yolks produced by the laying hens was analyzed. The fatty acid profile of eggs can be modified by varying the lipid composition of their diet. High inclusion levels of dietary palm olein oil (POO) or blended oil (POO plus soybean oil - SBO) concentrations of total saturated fatty acid (SFA) in egg yolks decreased, with SFA = 24.8167 - 0.63Oil, $r^2 = 0.66$ ($P < 0.05$). Eggs laid by hens fed the diet containing a high portion of soybean oil had a large amount of n-6 polyunsaturated fatty acids (PUFA), whereas egg laid by hens fed the diet containing POO or blended oil 25 % POO plus 75 % SBO at 1.5 % level of inclusion had a high percentage of n-3 PUFA and n-9 family. The addition of blended palm olein oil plus soybean oil decreased the concentration of saturated fatty acids while increased the concentrations of monounsaturated fatty acid, α-linolenic and docosahexaenoic acid (DHA). It did not promote the enrichment of the eggs with PUFA.

Keywords: Palm olein oil, soybean oil, laying hen, egg yolk fatty acids

Introduction

Birds can synthesize saturated fatty acids *de novo* and to oxidize them to mono- and di-unsaturated fatty acids up to the ninth carbon inward from the carboxyl end (Δ^9). They lack the enzymatic capacity to introduce double bonds past the Δ^9. Thus they cannot use stearic acid to synthesize linoleic acid (C18:2 $\Delta^{9,12}$) or α-linolenic acid (C18:3$\Delta^{9,12,15}$). Only plants have enzymes capable of inserting Δ^{12} or Δ^{15} double bonds into C18 fatty acids and consequently linoleic and linolenic acids are essential fatty acids for birds. Once consumed, these two fatty acids can be further metabolized by enzymes within the endoplasmic reticulum of chicken hepatocytes. Linoleic acid can be desaturated between the sixth and seventh carbons to γ-linolenic acid (C18:3$\Delta^{6,9,12}$), which may be elongated by two carbons and desaturated again to give arachidonic acids (C20:4$\Delta^{5,8,11,14}$). Arachidonic acid may be further metabolized to C22 fatty acids, such as the prostaglandins. Likewise, dietary α-linolenic acid can be elongated and desaturated by hepatocytes to give eicosapentanoic acid (C20:5$\Delta^{5,8,11,14,17}$) and then further metabolized to other C22 fatty acids (i.e., docosahexaenoic acid - C22:6 n-3) [1]. The C18, C20 and C22 polyunsaturated fatty acids (PUFAs) are stored in phospholipids of cell membranes, where they contribute to structural integrity and fluidity. They may be released by the action of phospholipases as important events in cellular communication. Released PUFAs serve as precursors for the eicosanoids: prostaglandins, leukotrienes, and thromboxanes. In birds, the eicosanoids regulate almost every physiological system, including oviposition, embryonic development, growth, immunity, bone development, thermoregulation, and behavior [2-4]. Chickens require linoleic acid at 1 % of the diet [5]. This level is also adequate for reproduction [1]. Diets that utilize fat-extracted ingredients (e.g., soybean meal) often require the inclusion of vegetable oil or animal fat to provide essential fatty acids. Substrates used for *de novo* synthesis depend on the diet. Chicken use dietary carbohydrate fatty acid, especially glucose, to synthesize fatty acids. Most dietary energy that is consumed in excess of immediate needs is stored as triglycerides, particularly in adipose tissue. A typical adipose cell is about 90 % lipid and the triglycerides are relatively inert. The length of time an average triglyceride molecule resides in the cell without being hydrolyzed by hormone-sensitive lipase is known as the turnover rate. The endogenous fat synthesized by chickens fed a fat free diet is mostly C16:0 and C18:1, with smaller amounts of C16:1 and C18:0. When fat is consumed, the fatty acids may be deposited in stores, diluting endogenously synthesized fatty acids. Three parameters determine the extent to which the types of fatty acids in a bird resemble that of the diet: (i) preferential oxidation or esterification of some types of fatty acids; (ii) modification of dietary fatty acids by elongation and/or desaturation; and (iii) the amount of dietary fatty acids relative to the amount synthesized *de novo* [1]. The increased egg weight was associated with total dietary fat contents of diet rather than the linoleic acid content over 1.0 % [6]. Comparing the effects of various dietary energy sources on egg weight, it was suggested that corn oil significantly increased the egg weight compared to poultry fat [7].

Therefore, this experiment was conducted to evaluate the effect of blended dietary lipids (palm olein oil - POO, a mixture of 25 % POO plus 75 % Soybean oil - SBO, 50 % POO plus 50 % SBO, and 75 % POO plus 25 % SBO). The inclusion level of the experiment oil was 1.5 and 3.0 % in the diets on the laying performance of hens and the fatty acid profiles of eggs produced by 21 to 40 wk old Dekalb Brown laying hens.

Materials and methods

Birds and diets

Four hundred and thirty-two commercial Dekalb Brown laying hens 21 wk old, were randomly assigned to 9 dietary treatments. The experimental design was a completely randomized design using a 4 × 2 factorial arrangement with one control. The dietary treatments were as follows:

i) Control (0.00 % oil)
ii) 1.5 % Palm olein oil
iii) 3.0 % Palm olein oil
iv) 1.5 % Blended oil 25 % POO + 75 % SBO
v) 3.0 % Blended oil 25 % POO + 75 % SBO
vi) 1.5 % Blended oil 50 % POO + 50 % SBO
vii) 3.0 % Blended oil 50 % POO + 50 % SBO
viii) 1.5 % Blended oil 75 % POO + 25 % SBO
ix) 3.0 % Blended oil 75 % POO + 25 % SBO

The experiment comprised 4 replicates with 12 birds in each treatment combination. Hens were housed in cages equipped with nipple drinkers and trough feeders, and placed individually in each cage, in an open-sided house with light control (16L : 8D). The diets were isocaloric and isonitrogenous (**Table 1**). Performance characteristics (feed intake, egg production, egg weight, egg mass, and feed conversion) were evaluated every 28 days. Egg mass was calculated with the following formula:

$$Egg \quad mass = \frac{Egg \quad weight \quad (g) \quad x \quad \% \quad Egg \quad production}{100}$$

Sampling eggs laid from days 26 to 28 of each 28 day period were collected from each experimental unit for Haugh unit, and egg shell thickness determination.

Chemical analysis

At 38 wk old, the profile of the main fatty acids, 5 fresh eggs per replicate were determined. Total lipids were extracted from egg yolk with chloroform:methanol (2:1, vol/vol) by a modified Folch method following the methodologies described by Fletcher *et al* [8] 2 g of sample was weighed into a centrifuge tube with 20 ml of chloroform:methanol and homogenized. The homogenate was filtered through Schleicher & Schuell filter paper 595 into a 100 ml volumetric flask and 5 ml of 0.88 % sodium chloride solution was added and mixed. The fatty acid profile of the samples was determined by gas chromatography Shimadzu [9].

Statistical analysis

Prior to analyses, data expressed as a percent of egg production was arcsine and square root transformed. Analysis of variance was performed. Where significant differences among treatments were obtained, comparisons among means were performed by DMRT. Orthogonal polynomial contrasts were used to test the linear or quadratic nature of the response [10,11].

Table 1 Composition of experimental diets (as fed basis).

Item, %	Control	Palm olein oil (POO)		Blended oil (POO + SBO)	
		1.5 %	3.0 %	1.5 %	3.0 %
Ingredients					
Broken Rice	54.10	48.90	44.61	48.90	44.61
Defatted Rice Bran	8.00	12.00	15.00	12.00	15.00
Soybean Oil Meal 42 % CP	19.60	19.30	19.12	19.30	19.12
Fish Meal 58 % CP	5.00	5.00	5.00	5.00	5.00
Palm Olein Oil	0.00	1.50	3.00	0.00	0.00
Blended Oil (POO plus SBO)	0.00	0.00	0.00	1.50	3.00
Leucaena leucocephala Leaf Meal	4.00	4.00	4.00	4.00	4.00
Oyster Shell	8.00	8.00	8.00	8.00	8.00
Dicalcium Phosphate 18 % P	0.70	0.70	0.67	0.70	0.67
Common Salt	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.10	0.10	0.10	0.10	0.10
Vitamin-Mineral Premix[1/]	0.25	0.25	0.25	0.25	0.25
Calculation composition					
Crude Protein	17.50	17.50	17.51	17.51	17.51
AME (kcal/kg)	2,710	2,720	2,740	2,720	2,750
Crude Fiber	2.90	3.32	3.63	3.32	3.63
Calcium	3.53	3.53	3.57	3.53	3.53
Available Phosphorus	0.36	0.36	0.36	0.36	0.36
Lysine	1.05	1.05	1.05	1.05	1.05
Methionine	0.49	0.49	0.48	0.49	0.48
Methionine + Cystine	0.76	0.76	0.76	0.76	0.76
Threonine	0.78	0.78	0.77	0.77	0.77
Tryptophan	0.24	0.24	0.24	0.24	0.24

[1/] Supplied per kg of diets : vitamin A, 19,200 IU; vitamin D_3, 3,840 IU; vitamin E, 8 IU; vitamin K_3, 3.2 mg; thiamin, 2.4 mg; riboflavin, 6.4 mg; vitamin B_{12}, 0.0024 mg; nicotinic acid, 2.4 mg; folic acid, 0.8 mg; biotin, 0.16 mg; pantothenic acid, 16 mg; manganese, 96 mg; zinc 160 mg; iron, 128 mg; copper, 9.6 mg; selenium, 0.24 mg.

Table 2 Fatty acids profile of palm olein oil, soybean oil and blended oil.

Fatty acid	Palm olein oil (POO)	Soybean oil (SBO)	Blended oil		
			25 % POO + 75 % SBO	50 % POO + 50 % SBO	75 % POO + 25 % SBO
Lauric acid (C 12:0)	0.40	ND	0.20	0.20	0.30
Myristic acid (C 14:0)	0.70	ND	0.30	0.40	0.70
Palmitic acid (C 16:0)	41.80	9.00	17.90	24.80	33.90
Stearic acid (C 18:0)	2.70	2.90	3.90	3.40	3.60
Oleic acid (C 18:1)	40.10	19.30	25.90	29.10	35.20
Linoleic acid (C 18:2)	14.30	57.30	43.20	35.50	22.80
Linolenic acid (C 18:3)	ND	11.10	7.30	6.30	3.50
Arachidic acid (C 20:0)	ND	0.40	1.30	0.30	ND

ND: not detected.

Results

The lipid profiles of the oil and blended oil were determined by gas chromatography Shimadzu (**Table 2**), palm olein oil contained palmitic acid (41.80 %) but no linolenic acid was detected. In contrast, soybean oil contained linoleic acid (57.30 %) and also linolenic acid (11.10 %). Blended oil (POO plus SBO) contained fatty acids profile depending on the ratio of inclusion. However, the amount of arachidic acid was unclear.

Performance parameters are presented in **Tables 3** and **4**, Haugh unit and egg shell thicknesses are presented in **Table 5**; they are grouped according to the percentage of replacement of POO with SBO (0, 25, 50 or 75 % replacement). There were no statistically significant differences among treatments. Egg productions (% hen day) were on average 80 % in the first period and more than 90 % in the 2nd to 5th period.

Table 3 Egg production, egg weight and egg mass of birds fed diet containing palm olein or blended oil.

Item	21 - 24 wk	25 - 28 wk	29 - 32 wk	33 - 36 wk	37 - 40 wk	Over all
Egg production (% Hen Day)						
Blended oil (POO + SBO)						
0 (Control)	78.52	92.32	92.27	91.82	91.46	89.94
25 % POO + 75 % SBO	81.84	93.80	92.14	92.55	91.63	90.32
50 % POO + 50 % SBO	80.08	94.94	93.01	92.50	90.23	90.15
75 % POO + 25 % SBO	82.40	94.15	93.59	93.09	91.53	90.95
100 % POO	79.63	94.38	92.69	92.58	90.79	90.01
Level of inclusion in the diet						
1.50 %	81.84	94.41	92.32	92.27	91.27	90.42
3.00 %	80.14	94.23	93.39	93.09	90.82	90.29
Pooled SEM	4.03	2.60	2.97	2.99	2.69	2.24
C.V. (%)	6.29	3.42	3.98	4.02	3.69	2.48
Egg weight (g)						
Blended oil (POO + SBO)						
0 (Control)	54.60	57.29	57.75	59.50	60.87	57.81
25 % POO + 75 % SBO	55.97	57.23	58.96	60.19	62.15	58.90
50 % POO + 50 % SBO	57.07	57.84	59.25	60.29	61.86	59.24
75 % POO + 25 % SBO	55.07	56.55	58.02	59.24	60.39	57.91
100 % POO	55.45	57.65	59.17	59.59	61.53	58.43
Level of inclusion in the diet						
1.50 %	55.64	56.98	58.34	59.60	61.13	58.34
3.00 %	56.14	57.66	59.36	60.05	61.83	58.90
Pooled SEM	1.19	1.22	1.28	1.05	1.41	1.03
C.V (%)	2.13	2.12	2.18	1.77	2.30	1.76
Egg mass (g/day)						
Blended oil (POO + SBO)						
0 (Control)	42.84	52.88	53.28	54.63	55.66	52.04
25 % POO + 75 % SBO	45.78	53.67	54.32	55.70	56.94	53.24
50 % POO + 50 % SBO	45.72	54.91	55.11	55.77	55.82	53.45
75 % POO + 25 % SBO	45.38	53.25	54.31	55.16	55.27	53.73
100 % POO	44.18	54.41	54.84	55.17	55.85	52.68
Level of inclusion in the diet						
1.50 %	45.52	53.80	53.86	54.99	55.80	52.80
3.00 %	45.03	54.33	55.43	55.90	56.14	53.37
Pooled SEM	3.38	1.71	1.9	1.86	1.88	1.69
C. V. (%)	7.52	3.17	3.51	3.37	3.35	3.19

Table 4 Feed intake and feed efficiency of birds fed diet containing palm olein or blended oil.

Item	21 - 24 wk	25 - 28 wk	29 - 32 wk	33 - 36 wk	37 - 40 wk	Over all
Feed intake (g)						
Blended oil (POO + SBO)						
0 (Control)	98.37	104.71	106.19	115.05	113.28	107.05
25 % POO + 75 % SBO	98.50	107.25	106.58	114.57	114.38	108.13
50 % POO + 50 % SBO	97.69	106.27	107.70	114.35	113.90	107.98
75 % POO + 25 % SBO	97.86	104.98	108.70	113.66	114.54	107.95
100 % POO	98.61	105.38	107.77	115.22	113.00	107.91
Level of inclusion in the diet						
1.50 %	98.12	104.79	106.52	114.08	113.89	107.48
3.00 %	98.21	107.15	108.92	114.81	114.01	108.51
Pooled SEM	1.12	1.96	2.52	1.13	2.26	1.26
C.V. (%)	1.14	1.85	2.35	0.99	1.99	1.17
Feed intake / Egg mass						
Blended oil (POO + SBO)						
0 (Control)	2.30	1.86	1.85	1.80	1.85	2.07
25 % POO + 75 % SBO	2.16	1.83	1.82	1.77	1.82	2.03
50 % POO + 50 % SBO	2.15	1.78	1.77	1.75	1.77	2.02
75 % POO + 25 % SBO	2.17	1.84	1.81	1.78	1.81	2.05
100 % POO	2.24	1.81	1.80	1.79	1.80	2.05
Level of inclusion in the diet						
1.50 %	2.16	1.83	1.82	1.79	1.76	2.037
3.00 %	2.20	1.81	1.77	1.76	1.75	2.040
Pooled SEM	0.16	0.06	0.07	0.06	0.06	0.05
C.V. (%)	7.49	3 .09	3.66	3.45	3.49	2.61

Table 5 Haugh unit and egg shell thickness of birds fed diet containing palm olein or blended oil.

Item	Haugh unit	Egg shell thickness (mm)
Blended oil (POO + SBO)		
0 (Control)	84.50	0.3725
25 % POO + 75 % SBO	79.05	0.3856
50 % POO + 50 % SBO	81.00	0.3732
75 % POO + 25 % SBO	82.37	0.3788
100 % POO	83.02	0.3807
Level of inclusion in the diet		
0.00 %	84.50	0.3725
1.50 %	81.41	0.3788
3.00 %	81.19	0.3804
Pooled SEM	6.51	0.0205
C.V. (%)	7.97	5.40

The fatty acid profiles of egg yolk extraction were determined by gas chromatography Shimadzu (**Table 6**). The concentration of total saturated fatty acid (SFA) decreased linearly ($P < 0.05$) by level of inclusion (**Table 7**), with SFA = 24.8167 - 0.63Oil, $r^2 = 0.66$. A higher concentration of palmitoleic acid ($P < 0.05$) was observed in eggs laid by hens fed the diet containing palm olein oil (100 % POO), compared with hens fed the control diet. In contrast, the concentration of palmitoleic acid decreased in egg yolk from hens fed the diet containing blended oils with 25 % POO up to 75 % POO.

Table 6 Fatty acid composition of egg yolk (% w/w) as influenced by hen diets containing palm olein or blended oil.

Fatty acids	Control	Palm olein oil (POO)		25 % POO + 75 % SBO		50 % POO + 50 % SBO		75 % POO + 25 % SBO	
		1.5 %	3.0 %	1.5 %	3.0 %	1.5 %	3.0 %	1.5 %	3.0 %
Lauric acid (C 12;0)					0.01			0.02	
Myristic acid (C 14;0)	0.25	0.26	0.30	0.30	0.29	0.35	0.19	0.36	0.32
Palmitic acid (C 16;0)	20.13	19.59	19.55	19.23	18.63	20.68	18.78	19.09	18.42
Stearic acid (C 18;0)	4.11	3.43	3.11	4.58	4.02	3.82	4.13	4.46	3.63
Saturated fatty acid (SFA)	24.49	24.11	22.95	24.85	23.10	23.90	22.37	23.28	22.96
Palmitoleic acid (C 16:1)	7.04	9.34	8.10	6.31	4.70	5.94	5.61	5.76	5.59
Oleic acid (C 18:1)	48.34	44.74	48.69	40.81	39.81	44.72	42.39	44.34	43.98
Linoeic acid (C 18:2) n-6	16.36	15.34	15.36	17.39	28.23	20.54	19.95	21.13	20.55
Linolenic acid (C 18:3) n-3	0.11	1.61	1.06	2.23	0.92	0.35	1.87	0.25	1.01
Docosahexaenoic (C 22:6) n-3	0.22	0.66	0.51	0.27	0.48	0.20	0.42	0.56	1.05
Polyunsaturated fatty acid (PUFA)	16.69	17.61	16.93	19.89	29.63	21.09	22.24	21.94	22.61
n-3	0.33	2.27	1.57	2.50	1.40	0.55	2.29	0.81	2.06
Unsaturated fatty acid (UFA)	72.07	67.01	74.14	71.75	70.24	72.04	71.18	71.69	73.72
Others	3.44	5.03	3.32	8.88	2.91	3.40	6.66	4.04	5.45
UFA/SFA	2.94	2.78	3.23	2.89	3.04	3.01	3.18	3.08	3.21

Table 7 Response of fatty acid composition of eggs yolk (% w/w) as influenced by hen diets containing palm olein or blended oil.

Item	Saturated fatty acid	Palmitoleic acid C16:1	Linoleic acid C18:2	Linolenic acid C18:3	Docosahexaenoic acid C22:6	Polyunsaturated fatty acid	Total n-3
Blended oil POO + SBO							
0 (Control)	24.49	7.04^{ab}	16.36	0.11	0.22	16.69	0.33
25 % POO + 75 % SBO	23.98	5.51^{b}	22.81	1.58	0.38	24.76	1.95
50 % POO + 50 % SBO	23.14	5.78^{b}	20.25	1.11	0.31	21.67	1.42
75 % POO + 25 % SBO	23.12	5.68^{b}	20.84	0.63	0.81	22.28	1.44
100 % POO	23.53	8.27^{a}	15.35	1.34	0.59	17.27	1.92
SEM	0.925	0.730	3.483	0.783	0.211	3.844	0.887
P-value	0.699	0.045	0.432	0.584	0.239	0.325	0.641
Level of inclusion in the diet							
0.00 %	24.49^{a}	7.04	16.36	0.11	0.22	16.69	0.33
1.50 %	24.04^{ab}	6.84	18.60	1.11	0.43	20.13	1.53
3.00 %	22.85^{b}	6.00	21.03	1.22	0.62	22.85	1.83
SEM	0.512	1.577	4.236	0.753	0.259	3.916	0.762
P-value	0.025	0.718	0.568	0.459	0.381	0.377	0.287

$^{a-b}$ Means within a column with no common superscript differ significantly (P < 0.05)

The amount of linolenic acid in the egg yolk of the hens fed the diet containing 1.5 % POO was higher than the control and those fed a diet containing 3.0 % POO. Linolenic acid in the egg yolk produced by hens fed the diet containing 1.5 % blend oil (25 % POO + 75 % SBO) was the highest among the groups (2.23 %). Increasing the amount of oil to 3 % in the hen's diet, tended to decrease the amount of linolenic acid (**Figure 1**).

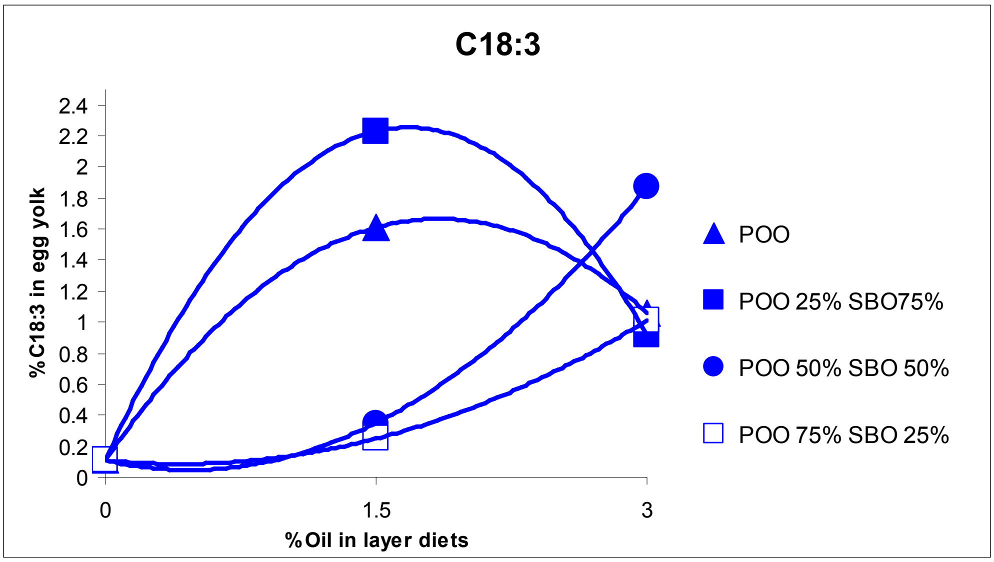

Figure 1 Amount of linolenic acid (LNA - C18:3) in the egg yolks produced by hens fed a diet containing palm olein or blended oil.

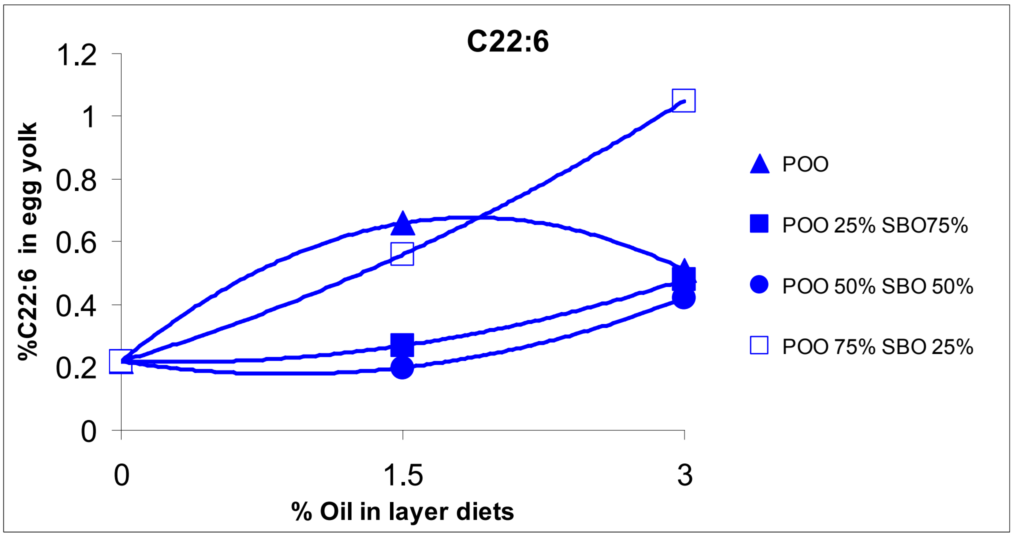

Figure 2 Amount of docosahexaenoic acid (DHA - C22:6) in the egg yolks produced by hens fed the diet containing palm olein or blended oil.

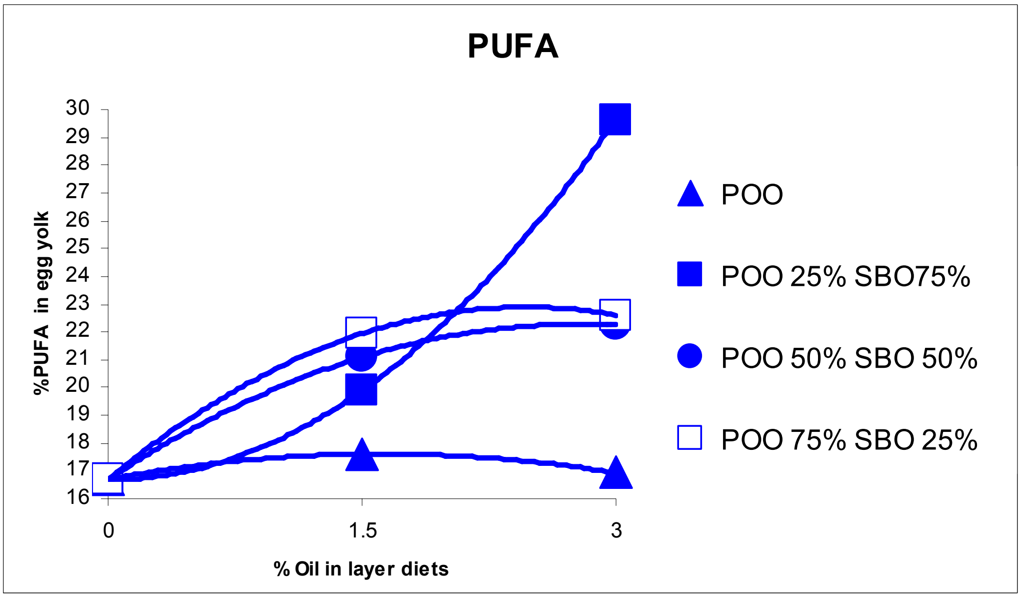

Figure 3 Amount of polyunsaturated fatty acid (PUFA) in the egg yolks produced by hens fed the diet containing palm olein or blended oil.

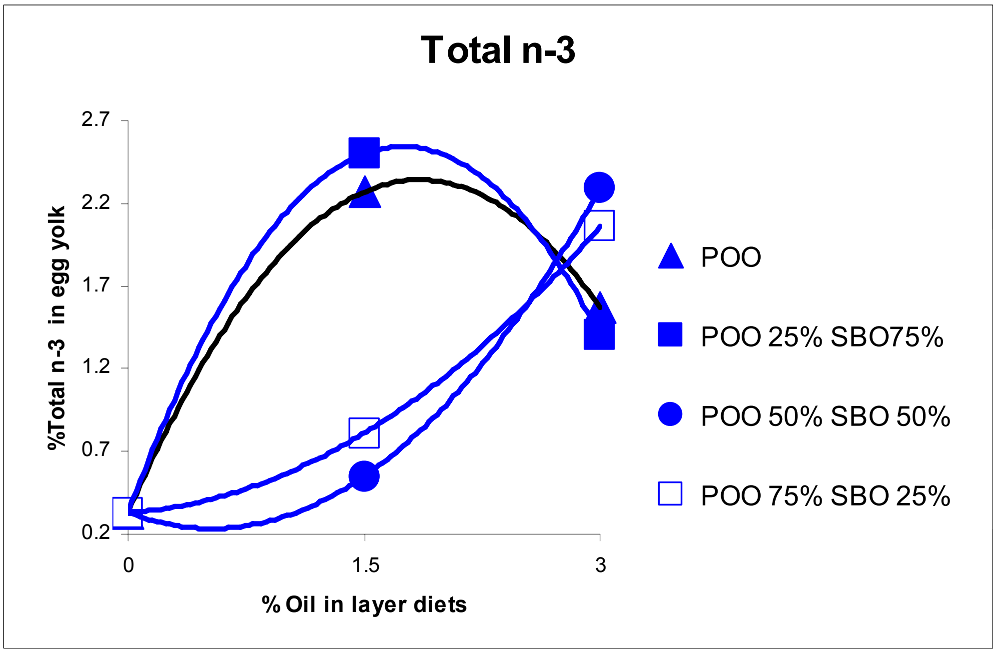

Figure 4 Total n-3 (C18:3 and C22:6) in the egg yolks produced by hens fed the diet containing palm olein or blended oil.

Birds that consumed 3.0 % blended oil between 75 % POO and 25 % SBO deposited higher amounts of docosahexaenoic acid (**Figure 2**), and total n-3 fatty acids into their eggs, whereas hens fed a diet of 3.0 % POO deposited less DHA than hens fed a diet of 1.5 % POO. The DHA content of the total fatty acids in the egg yolk of laying hens was 0.22 % for the control, egg yolks from hens fed a diet containing POO at a level of 1.5 % was 0.66 % DHA. The highest amount of DHA (1.05 %) in the egg yolks was from hens fed a diet containing 3.0 % blended oil composed of 75 % POO plus 25 % SBO.

The highest polyunsaturated fatty acid content was found in egg yolks of hens fed a diet containing 3.0 % blended oil (25 % POO plus 75 % SBO - **Figure 3**). Total n-3 in egg yolks from laying hens showed the same trend as C18:3, the egg yolks from hens fed a diet containing 1.5 % blend oil (25 % POO plus 75 % SBO) was the highest value which decreased when increased to 3.0 % (**Figure 4**).

Discussion

In the past, fish meal, fish oil, linseed, flaxseed, and algae products have been utilized to increase the amount of n-3 PUFA in chicken eggs and meat. However, fish odour is a regular concern with the increasing amount of dietary fish oil [12]. Increasing the α-linolenic acid content in chicken diets may result in a meat source high in n-3 PUFA that may reduce pressure on diminishing marine stocks [4]. The fatty acids composition of palm olein oil agreed with the report by Aida *et al* [13], soybean oil agrees with the reports of Grobas *et al* [6] and Mazalli *et al* [14]. Values obtained are in the range indicated by AOCS [15].

The performance parameters were analyzed according to the level of POO and blended oil inclusion, there were no statistically significant differences in the studied parameters among treatments. These results are in accordance with the linoleic acid requirements determined by the NRC [5].

The lipid composition of yolk was influenced by fatty acid sources [16]. From this result fatty acid sources (**Table 3**) while DHA was not detected, but egg yolks from hens fed any diets showed a moderate amount of DHA. Leskanich and Noble [17] and Meluzzi *et al* [18] conclude that it must be recalled that DHA is obtained in yolk from a double path; the direct deposition of DHA from the diet and a final result of the *de novo* synthesis from its precursors (linolenic acid, eicosapentanoic acid, and docosapentaenoic acid) given in the diet.

Aida *et al* [13] report that dietary palm olein at a level of 3 % altered the fatty acid composition of the egg yolk and total lipid in Lohmann Brown laying hens as C16:0, C16:1, C18:0, C18:1, and C18:2n-6 were 19.96, 8.40, 8.30, 29.10 and 10.61 %, respectively. The different levels of dietary palm olein oil (POO 0 - 4.5 %) did not affect the saturated fatty acid content of the egg yolk. The oleic acid (major fatty acid in the omega-9 family) content did not increase as the level of POO increased in the diet. The SFA and SFA/PUFA ratio did not change with the level of dietary palm olein oil Hosseini-Vashan *et al*, [19]. The type of supplemental fats (4 % of crude palm oil, 1 % to 4 % palm stearin oil, 4 % palm olein oil, 4 % soybean oil, 4 % tallow and 4 % tuna oil) did not affect egg production, egg weight, feed intake, feed intake per dozen egg produced, egg quality, egg composition and cholesterol content in serum and egg yolk. There were significant differences in feed intake per kg egg produced and egg mass. The supplementation of palm olein and tuna oil at 4 % in the diet provided higher feed cost per kg egg weight when compared to the control. It was found that the unsaturated fatty acid affected the change of fatty acid composition in the egg yolk [20]. The yolk and blood cholesterol content increased in 3.0 % palm olein oil and were statistically different among the palm olein oil levels and control [21]. Eggs laid by hens fed the diet containing high portions of soybean oil at 3.0 % had a large amount of n-6 polyunsaturated fatty acids (PUFA), whereas eggs from hens fed the diet containing palm olein oil (POO) or high proportion of POO had a high percentage of n-3 PUFA. This suggests that egg yolk lipid modifications by blended oil, soybean oil 75 % plus palm olein oil 25 % at a level of 3.0 % had more n-6 PUFA or soybean oil 25 % plus palm olein oil 75 % at the same level had more n-3 PUFA, whereas egg yolk from hens fed the diet containing palm olein oil at a level of 3.0 % decreased both n-3 and n-6 PUFA when compared with 1.5 % in the diet. Inclusion of 3.0 % palm olein oil in the feed for Lohman Brown laying hens also resulted in the lowest content of saturated fatty acids - palmitic and stearic acids, as well as linoleic acid from the group of n-6 PUFA [13]. Filardi *et al* [16] showed that fat sources influenced the fatty acid profiles, except for the concentrations of the PUFA C20:3n-3 and C20:3n-6. Thus, an excess of linoleic acid will prevent the transformation of α- linolenic acid into its derivates eicosapentaenoic acid (EPA, C20:5n-3) and DHA, and the opposite is also true.

The fatty acids composition of total yolk lipids reflected that of the hen's diets. The fact that both linoleic and linolenic acid are substrates of Δ^6 desaturase, linolenic acid can establish a competitive inhibition of the linoleic desaturation [2,14]. Aymond and Van-Elswyk [22], who observed that high amounts of n-6 fatty acids reduced the activity of Δ^6 desaturase enzyme in the conversion of linolenic acid to docosapentaenoic acid (DPA, C22:5n3) and DHA, causing a reduction of these acids in the egg yolks. The regulation of DHA levels in tissues remains an enigma. The fact that DHA can be formed from linolenic acid, albeit at a very low rate, but cannot be increased by increased dietary linolenic acid, suggests that DHA concentrations, at least in circulating phospholipid pools, are regulated to satisfy a relatively low metabolic demand that can be satisfied by the relatively low levels observed in vegans with no dietary DHA intake [23]. To enrich eggs with DHA by using vegetable sources, only moderate amounts of linolenic acid in the diet are required (less than 1 %). Also, it is possible to moderately increase arachidonic acid and DHA in the egg yolk at the same time, provided that an adequate source of fat, such as soybean oil, rich in linoleic acid and with a moderate amount of linolenic acid, is used as a substrate. Saturation of the different Δ-unsaturases seems to be dependent on the concentration of dietary fatty acid [24].

Conclusions

Blended oil had no effect on the efficiency of production, egg weight, egg mass output, feed conversion, Haugh unit and egg shell thickness. Results obtained in the present study indicate that the fatty acid profile of eggs can be modified by varying the lipid composition of the diet. Eggs laid by hens fed the diet containing high portions of soybean oil at 3.0 % had a large amount of n-6 polyunsaturated fatty acids (PUFA), whereas eggs laid by hens fed the diet containing palm olein oil (POO) or blended oil 25 % POO plus 75 % SBO at 1.5 % had a high percentage of n-3 PUFA and n-9 family. The addition of blended palm olein oil plus soybean oil decreased the concentration of saturated fatty acids, increased the concentrations of monounsaturated fatty acid, α-linolenic and DHA, and with moderate amounts of linolenic acid, used as substrate. In addition blended oil did not promote the enrichment of the eggs with PUFA.

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