Effects of High Oleic Acid Sunflower Oil on Egg Quality and Fatty Acid Composition of Egg Yolk in Laying Hens

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Abstract—**This study was conducted to investigate the effect of dietary high oleic acid sunflower oil (HOSO) on egg quality and fatty acid composition of egg yolk in laying hens. Twenty White Leghorn laying hens (about 90 weeks old) were placed in individual cages and assigned to four experimental diets namely, control (3% corn oil), L-HOSO (1% HOSO+2% corn oil), M-HOSO (1.5% HOSO+1.5% corn oil), and H-HOSO (3% HOSO). Diets and water were offered ad libitum throughout the 21 d of the experimental period. The results revealed that hen-day production, feed intake, feed conversion ratio, and yolk color did not differ among dietary groups (*P*>0.05). The egg quality parameters, such as specific gravity and the percentage of yolk weight were significantly different among dietary groups, where the highest values were found in H-HOSO group. On the other hand, yolk color was not affected significantly by diets. Oleic and linoleic acids in egg yolk increased and decreased with increasing level of dietary HOSO, respectively. In conclusion, the inclusion of HOSO in laying hen diets may alter the fatty acid composition in egg yolk without any detrimental effects on egg productivity.**

Index Terms—**egg quality, fatty acid, high oleic acid, laying hen, sunflower oil**

I. Introduction

Two types of sunflower oil are available on the market. One is a conventional sunflower oil which is rich in linoleic acid [1]. The other is a high oleic acid sunflower oil (HOSO) which is produced from seeds of high oleic acid sunflower lines and rich in oleic acid [2]. This HOSO is genetically produced due to rising health consciousness of the public: Monounsaturated Fatty Acid (MUFA), such as oleic acid is preferable for human health [3], but Polyunsaturated Fatty Acids (PUFA), such as linoleic acid. Recently, the demand of wholesome foods is rising with incraese in health consciousness of consumers and the prevalence of functional food is a typical example of this trend. In this context, meat and eggs rich in MUFA may have a greater appeal to consumers, comparing with those rich in PUFA. Therefore, poultry products containing increased MUFA may be welcomed in the market.

Recently, many researches have been conducted to modify the fatty acid profile of egg yolk lipids by dietary fat modification in laying hens. For instance, Ref. [4] reported that diets supplemented with soy oil, with moderate levels of α-linolenic acid and high levels of linoleic acid, increased arachidonic and docosahexaenoic acids in the egg yolk but not eicosapentaenoic acid. Also, Ref. [5] reported that an improvement of omega-3 type fatty acids of the egg would result in a higher susceptibility to lipid oxidation and possibly a shorter shelf-life of stored eggs. Similarly, an increase in the degree of polyunsaturation of chicken meat may lead to an increased susceptibility to lipid oxidation [6]. Moreover, HOSO also contains high levels of naturally occurring antioxidants (tocopherols) [7], which may hypothesize that fatty acids profile of egg yolk can be modified by adding of HOSO in laying hen diets.

Therefore, the present study was conducted to investigate the effect of different levels of HOSO on fatty acid composition in egg yolk along with production performance and egg quality in laying hens.

II. Materials and Methods

A. Experimental Birds and Diets

A total of twenty White Leghorn laying hens (about 93 weeks old) were placed in individual cages. After a seven-day adaptation period, all laying hens were randomly allotted to the four experimental diets (5 hens each) namely, control (3% corn oil), L-HOSO (1%

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HOSO+2% corn oil), M-HOSO (1.5% HOSO+1.5% corn oil), and H-HOSO (3% HOSO) (Table II). Diets (about 17% of CP and about 2822 kcal/kg of ME) were formulated to meet or exceed the nutrient requirement for laying hens according to Ref. [8]. Hens were given *ad libitum* access to feed and water throughout the 21 d of the experimental period.

TABLE I. Fatty Acids Composition of High Oleic Acid Sunflower Oil[1]

Fatty acid (g/ 100 g fat)	HOSO[2]
Palmitic acid (C16:0)	3.28 ±0.06
Stearic acid (C18:0)	3.85 ±0.50
Oleic acid (C18:1n-9)	87.17 ±0.22
Linoleic acid (C18:2n-6)	5.70 ±0.11
Linolenic acid (C18:3n-3)	ND[3]

[1]Values for each fatty acid represent mean ±standard deviation (n=3).
[2]HOSO=high oleic acid sunflower oil; [3]ND=not detected.

TABLE II. Ingredients and Chemical Composition of Diets

Ingredients (g/kg)	Experimental diets			
	Control	L-HOSO	M-HOSO	H-HOSO
Commercial feed[1]	400	400	400	400
Maize	268	268	268	268
Soybean Meal	183	183	183	183
Corn oil	30	20	15	0
HOSO[2]	0	10	15	30
Calcium carbonate	73	73	73	73
Tri-calcium phosphate	25	25	25	25
Salt	3	3	3	3
DL-Methionine	2.5	2.5	2.5	2.5
Premix[3]	15	15	15	15
Calculated composition				
ME, kcal/kg	2823	2821	2820	2817
Crude protein, g	170	170	170	170
Calculated fatty acid compositions (g/ 100 g fat)				
Palmitic acid, C16:0	11.71	9.98	8.14	4.07
Stearic acid, C18:0	1.99	2.33	2.68	3.49
Oleic acid, C18:1n-9	23.54	34.47	46.12	71.82
Linoleic acid, C18:2n-6	61.81	52.39	42.36	20.21
Linolenic acid, C18:3n-3	0.95	0.83	0.70	0.41
SFA[4]	13.70	12.31	10.82	7.56
MUFA[5]	23.54	34.47	46.12	71.82
PUFA[6]	62.76	53.22	43.06	20.62

[1]Laying hens diet (CP≥17.0%, ME≥2850 kcal/kg, Nippon Fomula Feed Mfg., Kanagawa, Japan
[2]HOSO=high oleic acid sunflower oil.
[3]According to NRC (1994).
[4]SFA=saturated fatty acid.
[5]MUFA=monounsaturated fatty acid.
[6]PUFA=polyunsaturated fatty acid.

B. Data Recording

Feed intake and hen-day production were recorded daily. Feed Conversion Ratio (FCR) was also calculated. Egg quality parameters such as egg weight, specific gravity, yolk color, and yolk weight were measured at d 0, 6, 12, and 21. Egg and yolk were weighed using an electronic balance. Specific gravity was measured by the floating method using NaCl solutions (10, 11, 12, 13, and 14% of NaCl) ranging in specific gravity from 1.056 to 1.083. Yolk color was measured visually by the Roche yolk color fan (F. Hoffman-La Roche Ltd., Basal, Switzerland) having 15 sample colors of ranging from 1 (the lightest) to 15 (darkest), and was scored by means of a color fan.

C. Fatty Acid Analysis

Fatty acid composition of egg yolk was determined according to Ref. [9]. At first, 50mg of yolk sample was weighed into a 50-mL screw-capped tube (Teflon-line). Heptadecanoic acid (C17:0) (2.0mg) dissolved in 1 mL hexane was added as an internal standard, followed by 1mL of methanol and 3mL of 3N methanolic-HCl. The tubes were capped tightly and refluxed in a water bath at 95 ℃ for 1h. After cooling to the room temperature, 8 mL of 0.88% (w/v) NaCl solution and 3 mL of hexane were added into the tube, and the contents were mixed well. After centrifugation, an aliquot of the top layer was collected into a vial.

Fatty acid methyl esters were separated and quantified using gas chromatograph (GC-4000, Nihon Bunko Co. Ltd. Tokyo, Japan) equipped with a capillary column inertcap (30m×0.25mm inside diameter). The temperature of the injector and detector were 240 ℃, and the oven temperature was 230 ℃. Helium, at 1.2mL/min, was used as the carrier gas.

D. Statistical Analysis

Statistical significances among groups were determined by Tukey's multiple comparison tests at a significance level of 5% after one-way ANOVA. In addition, two-way ANOVA was done to test for main and interaction effects between HOSO levels and duration.

III. Results and Discussion

A. Laying Performance and Egg Quality

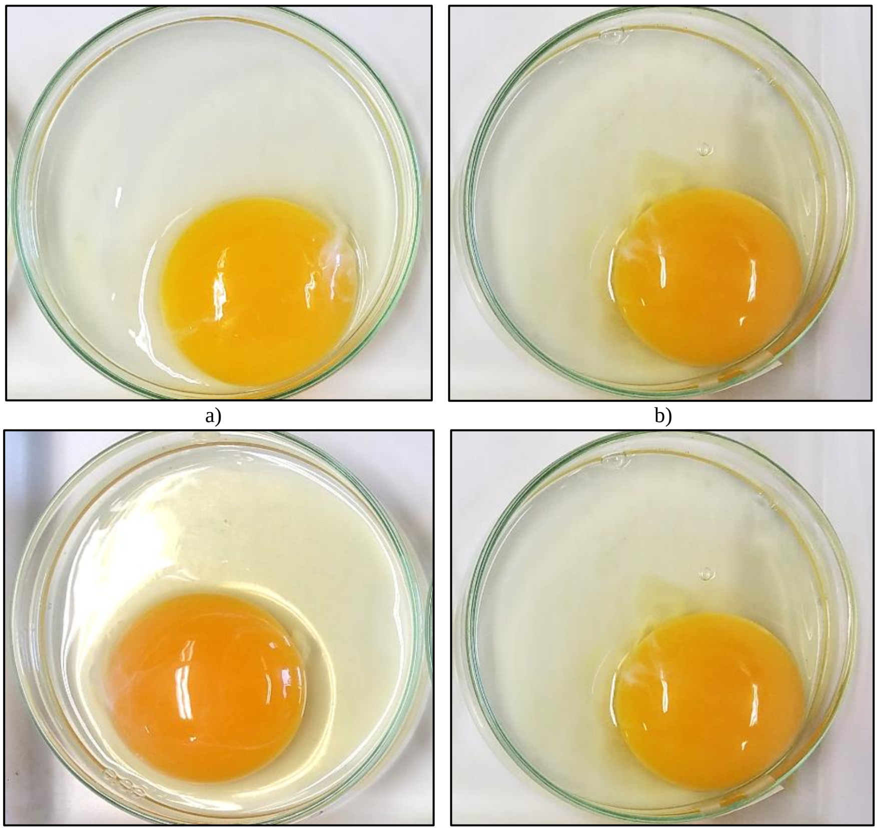
The results obtained here showed that the dietary HOSO had no significant effects on hen-day production, feed intake, and FCR (Table III). Similar observation was found when the diet contained different oil sources in laying hen diets [10], and [11]. Yolk color tended to be darker in the HOSO groups than control group, may be due to the high level of pigment (β-carotene) in the diets (Table III and Fig. 1), becuase sunflower oil contains β-carotene a natural pigment [12].

On the other hand, egg weight, specific gravity, and the percentage of yolk weight were significantly different among the treatment groups. The numerically highest specific gravity and the percentage of yolk weight were observed in H-HOSO diet. It may be associated with the ratio of stearic acid to oleic acid which is an important parameter to determine the membrane integrity and homeostasis of fat metabolism that ultimately influence egg quality [13].

TABLE III. EFFECTS OF HIGH OLEIC ACID SUNFLOWER OIL ON LAYING PERFORMANCE AND EGG QUALITY[1]

Parameters	Control	L-HOSO	M-HOSO	H-HOSO
Hen-day production (%)	89.8±13.1	87.3±11.6	85.5±12.6	85.5±16.5
Feed intake (g)	110.5±5.4	109.9±5.5	113.5±4.4	112.6±5.5
Feed conversion ratio	1.57±0.07	1.57±0.07	1.63±0.07	1.56±0.07
Egg weight (g)	71.1±1.3^{ab}	70.1±1.4^{b}	70.2±1.5^{b}	72.9±1.7^{a}
Specific gravity	1.071±0.004^{ab}	1.069±0.007^{b}	1.071±0.003^{ab}	1.076±0.004^{a}
Yolk color	12.6±0.8	12.8±0.9	13.1±1.0	13.3±1.2
Egg yolk weight (%)	27.4±1.2^{a}	24.7±1.0^{b}	26.4±1.3^{a}	26.0±1.3^{ab}

[1]Values for each parameter represent mean ±standard deviation (n=5).
[a-b] Mean in a row with different superscripts are significantly different (*P*<0.05).



a) b) c) d)

Figure 1. Egg yolk color: a) control diet, b) L-HOSO diet, c) M-HOSO diet, and d) H-HOSO diet.

B. *Fatty Acid Contents of Egg Yolk*

Time-course changes of fatty acid in egg yolk were presented in Fig. 2. Over the experimental period, there was no great difference in concentrations of palmitic and stearic acids in egg yolk among all groups (data not shown).

Oleic acid in egg yolk of control and L-HOSO groups showed a similar pattern: both of them tended to increase gradually with increasing days, but their levels were kept lower than 2 groups. Oleic acid in M-HOSO and H-HOSO groups increased steeply to day 6 and kept high thereafter. The increasing magnitude was higher in HOSO groups. On the other hand, linoleic acid in control group increased with increasing days, which may be due to replacement of a commercial diet with a control diet rich in linoleic acid at the beginning of this experiment. Similar increasing pattern was observed also in L-HOSO and M-HOSO groups, but their magnitude was less greater than control group. It is noteworthy that linoleic acid in H-HOSO group rather decreased although this increased temporarily on day 6.

Such modification of fatty acid profiles in egg yolk by dietary treatment has been reported: the addition of HOSO in the laying hen diets resulted in increased oleic acid and decreased linoleic and saturated fatty acids in the egg yolk [10], and addition of soybean soapstock (high in oleic acid) in the laying hen diet resulted in decreased linoleic acid content in the egg yolk [14]. Also in Japanese quail hens, oleic acid riches diet led to high level of oleic acid in the egg yolk, plasma and liver lipids [15]. In case of broiler chickens, diet containing HOSO led to increased oleic acid and decreased linoleic acid content in broiler meat [16], [17], which suggests that the addition of oleic acid to the diet affect not only fatty acid composition in egg yolk but also that in broiler meat.

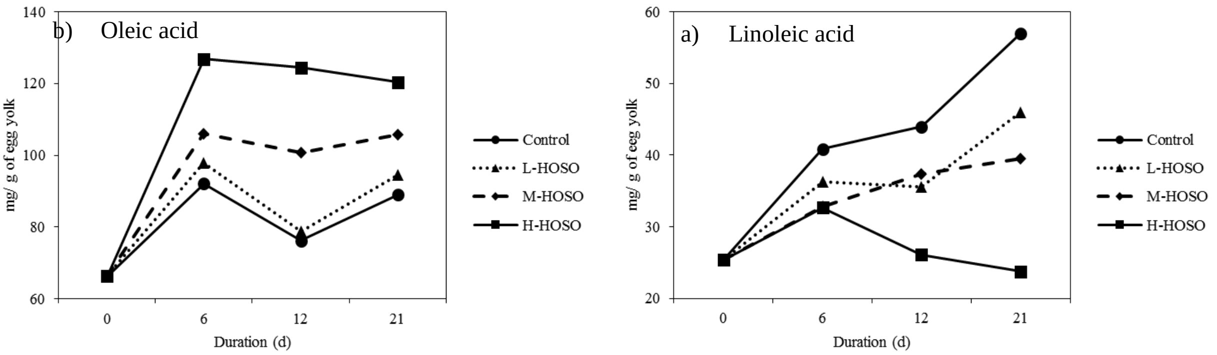


Figure 2. Effects of HOSO levels and time duration on fatty acid composition in egg yolk lipid (n=3).

It has been reported that dietary HOSO has beneficial effects on serum peroxides, plasma α-tocopherol and thromboxane B_2 levels in human [18], which may, in part, be due to increased dietary oleic acid level. Moreover, Ref. [19] evaluated the effects of olive oil (rich in oleic acid) and HOSO on low-density lipoprotein cholesterol in human serum, and then reported that this value decreased when both oils were given.

Taking these into account, HOSO can be used as an excellent alternative fat source, and eggs from hens given HOSO based diets may have potential to appeal for health-conscious consumers, but effects of such eggs on human health remains to be solved.

IV. Conclusion

The results obtained here suggest that addition of HOSO in the laying hen diet did not show any detrimental effect on laying performance and egg quality. The fatty acid composition of egg yolk changed with the level of HOSO and duration of feeding. As expected, oleic acid content increased and linoleic acid content decreased when hens given HOSO based diet. In conclusion, it is suggested that HOSO can be used as an alternative fat source for laying hen diets to modify the fatty acids composition in egg yolk fat.

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