Effects of Dietary Fats on Triacylglycerol Composition and Structure of Egg Yolk Lipids

Akihiro HIRATA*, Tetsuya MASUDA*, Teiji KIMURA* and Yoshiyuki OHTAKE*

**College of Agriculture & Veterinary Medicine, Nihon University, 3-34-1,
Shimouma, Setagaya-ku, Tokyo, 154*

Effects of dietary soybean oil, coconut oil, lard and beef tallow on the changes in triacylglycerol (TG) composition and structure in egg yolk lipids of laying hens were studied. Generally, the fatty acid composition of egg yolk TG reflected partially that of the dietary fats fed to hens, though, the short chain saturated fatty acids ($C_{8:0}$, $C_{10:0}$) were not available utilized for the egg yolk lipid formation. Egg yolk TG from hens fed soybean oil, lard and beef tallow was commonly composed of C_{50} , C_{52} and C_{54} species as main TG components. More TG species of $C_{44} \sim C_{50}$ were contained in egg yolk of coconut oil group than in that of the other diet groups, while, C_{52} and C_{54} components were less in coconut oil group. Egg yolk lipid of soybean oil group contained less amounts of TG comprising monoenoic acids and more of TG comprising dienoic acid than the other groups. Lipid of coconut oil group contained the most amount of S_2M and the least of U_3 among the experimented diet groups. Lipids from lard and tallow group comparatively resembled each other in distribution pattern of TG species. In egg yolk TG from every dietary group, saturated fatty acids were preferentially esterified at position 1 of TG, on the contrary, position 2 comprised predominantly unsaturated fatty acids. Position 3 was largely occupied by $C_{18:1}$ accompanied with $C_{16:1}$. This species specificity of positional distribution of fatty acids in hen's egg TG was not changed regardless of variation of dietary fats fed to hens.

Considerable attention has been given to the influence of dietary fats on the composition of hen's egg yolk lipid^{1)~3)}. The quantity of lipids in egg yolk cannot be influenced by the type or quantity of fat in the diet of the hen⁴⁾. Whereas, the fatty acid content of egg yolk lipid can be influenced significantly by the fatty acid composition of the diet^{5)~8)}. The fatty acid composition of egg yolk is generally a reflection of the dietary fatty acid pattern, and the effects of dietary fats on the egg yolk lipid appeared more distinctly in the fatty acid composition of neutral lipid fraction than in that of polar lipid fraction of egg lipid⁹⁾. As hen's egg yolk neutral lipid is mostly composed of triacylglycerols (TG), the changes of fatty acid composition of yolk lipid affected by dietary fats, may be caused by the variation of composition and structure of TG species found

in yolk lipid. A few informations related to the comparative influences of various dietary fats on the properties of egg yolk TG are now available¹⁰⁾¹¹⁾. They have reported the fatty acid composition and distribution at position 2 in the egg yolk TG, and have calculated the TG-type distribution on the basis of 1, 3-random-2-random theory. More detailed studies were required to estimate the effects of dietary fats on the changes of characteristics of egg yolk lipids. This investigation was designed to elucidate thoroughly the comparative effects of dietary fats on the composition and molecular species of TG in egg yolk lipids from hens fed fat-supplemented diets.

Materials and Methods

Treatment of the birds and egg samples

Twenty commercial strain of White Leghorn

hens were divided at random into four groups of five birds in each in individual cages. Hens were maintained on the semi-purified diets supplemented with 10% of soybean oil, coconut oil, lard or beef tallow for a period of 50 days as described previously⁹⁾. Feed and water were supplied to the birds *ad libitum* during the experimental period.

Egg samples were collected from hens on the 45th day of dietary treatment and used for lipid analysis.

Preparation of triacylglycerols

Total lipid of egg yolk was extracted from samples according to the method of FOLCH *et al.*¹²⁾ and was separated into neutral lipid and polar lipid fractions by the procedure of MOERCK and BALL¹³⁾. Then, the yolk triacylglycerol (TG) was isolated from the neutral lipid fraction by Unicil (Clarkson Chem. Co.) silicic acid column chromatography essentially as described by MOERCK and BALL¹³⁾.

Argentation thin-layer chromatography

TG was fractionated according to the degree of unsaturation of component fatty acids by argentation thin-layer chromatography (AgNO_3 -TLC). AgNO_3 impregnated Silica Gel G plates were prepared by the method of WOOD and SNYDER¹⁴⁾, and the separation of TG on the plates with a solvent system of hexane-ethyl ether-benzene-methanol (70:10:20:1, by vol.) was performed by the procedure of CHRISTIE and MOORE¹⁵⁾. Amount of TG fraction was calculated by reference to the methyl heptadecanoate added as the internal standard, and the TG types present in the fraction were estimated from the results of fatty acid composition determined on the each fraction, as described previously¹⁶⁾.

Stereospecific analysis

Stereospecific analysis of TG was carried out essentially following the scheme proposed by BROCKERHOFF¹⁷⁾ and modified by CHRISTIE and MOORE¹⁸⁾. Briefly, 1, 2 (2, 3)-diacylglycerols (DG) were prepared from TG by reaction with ethyl magnesium bromide and they were converted synthetically into phenyl phospholipids which were hydrolyzed with phospholipase A_2 of snake venom (*Trimersurus flavoviridis*, Wako

Pure Chemical Industries, Ltd.). The resulting lysophosphatide contained only the fatty acids of position 1 of the original TG, and the fatty acids of position 2 were obtained by pancreatic lipase hydrolysis of the TG. The fatty acid of position 3 could be determined by difference from the composition of the original TG.

Gas-liquid chromatography

Gas-liquid chromatography (GLC) of TG was performed on a Hitachi Model 163 Gas Chromatograph with an on-column injector equipped with dual columns and dual hydrogen flame ionization detectors. The stainless steel columns (3 mm $\times$ 0.5 m) were filled with 2% Silicon SE-30 packing on 80-100 mesh Chromosorb WAW. Nitrogen carrier gas flow was set at 60 ml/min., and air and hydrogen gas flow were adjusted to give maximum detector response. The temperature of the injection and detectors was held at 330°C. The oven temperature was lineary programmed at the rate of 7.5°C/min. over the range of 200~300°C. The peak areas on recorder were computed by YHP 3390 A integrator.

Distributions of various TG types by carbon number in dietary fats and egg yolk TG were estimated by the method described by KUKSIS *et al.*¹⁹⁾. TG type is indicated by the total number of fatty acid carbon. The fatty acid compositions of lipid samples were determined by the procedure described previously²⁰⁾, using Shimadzu GC-6 APF Gas Chromatograph and Shimadzu Chromatopac C-R 2 A.

Results and Discussion

Effects of dietary fats on the fatty acid composition of egg yolk lipid

Fatty acid compositions of TG in dietary fats and egg yolk lipids were presented in Table 1.

As shown in Table 1, egg yolk lipid from hens fed soybean oil-supplemented diet (soybean oil group) had the highest level of linoleic acid ($C_{18:2}$) among the all dietary treatment groups.

Egg yolk TG from hens fed coconut oil-supplemented diet (coconut oil group) and soybean oil group had less oleic acid ($C_{18:1}$) than those of lard and beef tallow feeding groups

Table 1 Fatty acid composition of triacylglycerol of dietary fats and egg yolk from hens fed fat-supplemented diets (mole %)

Fatty acid*	Dietary fat				Egg yolk TG			
	SO**	CO**	L**	B**	Dietary fat treatment			
					SO	CO	L	B
8:0		10.3						
10:0		7.4						
12:0		49.1			0.3	2.2	tr	0.4
14:0	tr***	17.4	1.8	3.7	1.8	10.0	0.7	1.2
14:1			0.2	1.0	0.2	3.5	tr	0.2
15:0			0.1	0.4				0.1
16:0	11.5	7.7	25.9	25.7	22.1	27.9	25.2	27.1
16:1			3.6	3.1	2.6	7.7	4.7	4.9
17:0 Br				0.9				0.5
17:0	0.1		0.4	1.2	0.2	0.1	0.2	0.5
17:1	3.7		0.3	0.6	0.2		0.3	0.6
18:0	22.2	22.1	12.1	18.0	3.7	3.7	3.8	4.2
18:1	53.6	4.9	43.4	40.7	37.4	37.8	55.3	54.1
18:2	8.6	1.1	10.5	3.6	28.8	6.4	9.0	5.6
18:3	0.3		0.7	0.5	2.1	0.4	0.1	0.2
20:1			1.0	0.6	0.2	0.3	0.3	0.3
20:2					0.2	tr	0.1	tr
20:3					tr	tr		
20:4					0.3	0.1	0.3	tr

* Number of carbon atoms : number of double bonds, Br : branched chain acid

** SO : soybean oil, CO : coconut oil, L : lard and T : beef tallow

*** tr : trace (below 0.1%)

(lard group and tallow group). TG of coconut oil group contained considerably more myristic ($C_{14:0}$), myristoleic ($C_{14:1}$) and palmitoleic ($C_{16:1}$) acids compared to that of the other groups. The presence of $C_{14:1}$ and $C_{16:1}$ in the TG of coconut group was probably due to desaturation of $C_{14:0}$ and palmitic acid ($C_{16:0}$) in the liver of birds, since neither fatty acid was present in the diet. Only a small amount of lauric acid ($C_{12:0}$) was found in egg TG of coconut group, although the coconut oil contained 50% of this acid. The low level of $C_{12:0}$ in egg TG suggested that only limited amounts of this acid were utilized for egg yolk formation. Fatty acid pattern of TG of lard group was similar to TG of tallow group, except that the former had a little more amounts of $C_{18:2}$ and less of $C_{16:0}$ than the latter.

In general, the fatty acid composition of hen's egg yolk TG reflected partially that of

the dietary fats, though, the short chain saturated fatty acids ($C_{8:0}$ to $C_{12:0}$) found in coconut oil were not available utilized for the egg yolk lipid formation. Results of present study on coconut oil feeding to hens agreed with the changes in fatty acid compositions of egg lipid observed by MACHLIN *et al.*⁷⁾ and CHEN *et al.*²⁾, and results on soybean oil feeding resembled to that reported by SELL *et al.*⁸⁾ and SIM *et al.*³⁾.

Effects of dietary fats on the egg yolk TG species

The GLC elution patterns for TG of dietary fats and of egg yolk from hens fed experimental diets were shown in Fig. 1 and 2, respectively. The chromatograms for egg yolk TG from soybean, lard and tallow groups showed commonly the presence of major TG species of C_{50} , C_{52} and C_{54} and minor TG of C_{42} ~ C_{48} . On the contrary, the GLC elution pattern for coconut group recorded the considerably large

Fig. 1 GLC separation of triacylglycerols of dietary fats
 Figures of peaks represent the total number of acyl carbon atoms.
 Instrument and operating conditions are given in the text.

Fig. 2 GLC separation of triacylglycerols of egg yolk lipids from
 hen fed fat-supplemented diets
 Figures of peaks represent the total number of acyl carbon atoms.

Table 2 Distribution of triacylglycerol types by carbon number in dietary fats and egg yolk lipids from hens fed fat-supplemented diets (wt.%)

TG type*	Dietary fat				Egg yolk TG			
	SO	CO	L	B	Dietary fat treatment			
					SO	CO	L	B
28		0.8						
30		3.5						
32		13.5						
34		17.3						
36		19.8						
38		17.3						
40		10.7						
42		7.5			0.5	1.5		
44		4.1	1.0	0.4	1.0	4.2		
46		2.1	1.9	1.6	1.9	9.5		0.5
48	0.6	1.6	4.8	7.0	4.4	21.7	1.7	3.7
50	3.9	0.9	16.6	19.8	9.0	24.2	12.2	17.5
52	28.8	0.7	55.5	48.0	56.4	33.9	67.8	63.4
54	66.7	0.2	20.2	23.2	26.8	5.0	18.3	14.9

* Total number of acyl carbon atoms

Other abbreviations used are the same as those described in Table 1.

peaks of TG species of $C_{44} \sim C_{48}$, resulting from the incorporation of $C_{12:0}$ and $C_{14:0}$ present in coconut oil into egg yolk lipid.

Distributions of TG types by carbon number in dietary fats and egg yolk lipid were presented in Table 2. Egg yolk of coconut oil group contained considerably more TG species of $C_{44} \sim C_{50}$ and less C_{52} and C_{54} than egg yolk TG of the other diet groups. The above-mentioned results were probably caused by scarce incorporation of $C_{8:0}$ and $C_{10:0}$ present in dietary fat into egg yolk lipid, and by utilization of a small amount of $C_{12:0}$ and of fairly amount of $C_{14:0}$ for egg yolk lipid formation by laying hens.

Distributions of TG types in egg yolk from lard and tallow groups comparatively resembled mutually, although the lard group contained less C_{50} and a little more of C_{52} and C_{54} than the tallow group, resulting from the less C_{16} acid and more C_{18} acid in lard than beef tallow.

Effects of dietary fats on the TG composition of egg yolk

TG species of dietary fats and yolk lipids were separated by means of $AgNO_3$ -TLC depending on the polarity of the TG into diffe-

Fig. 3 Argentation thin-layer chromatograms of dietary fats and egg yolk lipids from hens fed fat-supplemented diets

Plate: Silica Gel G impregnated with 10% $AgNO_3$. Developing solvent system: hexane/ethylether/benzene/methanol (70/10/20/1). SO, CO, L and B are soybean oil, coconut oil, lard and beef tallow, respectively (left hand), and respective those fats fed groups (right hand). S: saturated, M: monoenoic, D: dienoic and T: trienoic fatty acid moieties.

Table 3 Component triacylglycerol species of dietary fats and egg yolk lipids from hens fed fat-supplemented diets (mole %)

TG species*	Dietary fat				Egg yolk lipid			
	SO	CO	L	B	Dietary fat treatment			
					SO	CO	L	B
S ₃	tr**	56.8	4.9	11.0	1.0	5.6	1.0	1.9
S ₂ M	2.0	27.7	23.5	31.7	6.3	26.6	9.7	16.3
SM ₂	2.7	6.9	28.4	34.1	16.0	39.4	40.4	47.9
S ₂ D	3.8	6.5	6.9	6.5	6.1	6.8	8.3	4.4
M ₃	2.7	0.6	12.8	13.0	3.4	6.6	19.9	14.9
SMD	10.0	1.5	16.6	2.9	33.8	10.6	13.2	10.5
M ₂ D	7.0		3.3		10.6	2.6	5.9	3.2
SD ₂	13.1		2.2		5.0	0.2	0.4	
S ₂ T	1.9		1.5	0.7	0.3	0.8	1.0	0.7
MD ₂	17.1				5.6	0.6	0.2	0.2
SMT					6.8			
M ₂ T					1.0			
D ₃	17.0				4.1			
SDT	6.3							
MDT	10.3							
D ₂ T	5.9							

* S : saturated, M : monoenoic, D : dienoic and T : trienoic fatty acid

** tr : trace (below 0.1%). Other abbreviations used are the same as those described in Table 1.

rent classes of unsaturation. The results were shown in Fig. 3. Although, more number of bands of TG species were detected on chromatogram in soybean oil and in egg yolk lipid of soybean oil group than in the other TG samples tested, usually several groups of molecular species TG were detected. But for instance, the mixture of TG species of S₂D and M₃, and sometimes, the mixture of M₃ and SMD were identified as a single band on the chromatogram²¹⁾ and a similar case was observed among the other TG species (in this, S : saturated, M : monoenoic and D : dienoic fatty acid). In such case, the composition of those bands containing mixture of TG species were calculated on the basis of their fatty acid compositions²²⁾.

The results of quantitative analysis on TG components of dietary fats and egg yolk lipids were shown in Table 3. The major TG species in both lard and beef tallow were S₂M and SM₂, and lard contained less amounts of trisaturated TG (S₃) and disaturated monounsaturated TG (S₂U) and more of monosaturated diunsaturated

TG (SU₂) and triunsaturated TG (U₃) than beef tallow.

Egg yolk of soybean oil group contained less amounts of TG comprising monoenoic acids (S₂M, SM₂ and M₃) and more of TG comprising dienoic acid (SMD, M₂D, SD₂, MD₂ and D₃) than those of the other diet groups. While egg yolk of coconut oil group contained the most amount of S₂M and the least of U₃ among the dietary groups studied. Although the yolk lipid of lard group had more contents of S₂D, M₃ and SMD species and less of S₂M and SM₂ species than that of tallow group, it was considered that lipids from lard and tallow groups were not so far differed in their distribution patterns of TG species.

Effects of dietary fats on the fatty acids distribution in TG of egg yolk

The TG of dietary fats and egg yolk lipids were subjected to stereospecific analyses to investigate the distribution of fatty acids in position 1, 2 and 3 of TG. The results obtained were given in Table 4. Position 1 of soybean oil was composed of nearly same amounts of

Table 4 Positional distribution of fatty acids in triacylglycerols of dietary fats and egg yolk lipids from hens fed fat-supplemented diets (mole %)

Position	Dietary fat											
	CO			CO			L			B		
	1*	2*	3*	1	2	3	1	2	3	1	2	3
	(Fatty acid)											
8:0				8.3	0.7	21.9						
10:0				6.5	3.4	10.3						
12:0				35.1	80.8	31.4						
14:0				20.4	8.0	23.8	2.1	3.7		2.1	6.6	2.4
16	24.8	6.9	2.8	12.3	1.5	9.3	26.6	51.0	0.1	32.3	19.8	25.0
16:1							2.5	6.0	2.3	2.9	5.5	0.9
18:0	9.7	1.4		3.6	0.6	2.1	18.0	4.9	13.4	25.8	7.5	20.7
18:1	31.2	19.0	16.4	12.6	3.7	0.6	41.4	25.0	63.8	32.1	51.0	39.0
18:2	32.2	64.8	63.8	1.3	1.3	0.7	7.8	7.3	16.4	2.4	5.6	2.8
18:3	1.4	7.5	16.6				0.3	0.1	1.7		0.4	1.1
20:1	0.3	0.2					0.6	0.4	2.0	0.3	0.4	1.1
Others**	0.4	0.2	0.4				0.7	1.6	0.3	2.1	3.2	6.9
Sat. acid	34.7	8.5	2.8	86.2	95.0	98.8	47.2	60.7	13.0	62.0	35.2	52.4
Unsat. acid	65.3	91.5	97.1	13.8	5.0	1.3	52.8	39.3	87.0	38.0	64.8	47.5
	Egg yolk lipid (Dietary fat treatment)											
Position	SO			CO			L			B		
	1*	2*	3*	1	2	3	1	2	3	1	2	3
	(Fatty acid)											
12:0	0.7	0.1	0.1	0.7	2.0	3.9		0.3		0.3	0.7	0.2
14:0	1.1	1.8	2.5	5.8	5.9	18.3	0.7	0.9	0.5	0.5	2.0	1.1
14:1				0.2	2.9	7.4		0.1			0.2	0.4
16:0	52.5	9.2	4.6	63.2	9.4	10.1	56.0	5.2	14.4	52.1	9.1	20.1
16:1	0.7	2.0	5.1	5.1	6.6	11.4	5.0	2.8	6.3	0.5	4.1	10.1
18:0	7.4	3.9		3.9	3.7	3.5	4.9	2.7	3.8	12.5	4.2	
18:1	24.0	26.3	61.9	17.7	52.1	43.6	28.6	64.6	72.7	29.9	63.9	66.8
18:2	12.0	53.9	20.3	2.3	16.2	0.7	3.9	22.6	0.5	3.2	13.3	0.3
18:3	0.8	2.3	3.2		0.6	0.6	0.2	0.4		0.2	0.9	
20:1	0.3	0.2	0.1	0.1	0.3	0.5	0.1	0.1	0.7	0.2	0.4	0.3
Others**	0.3	0.3	2.2		0.3		0.6	0.3	1.1	0.6	1.2	0.7
Sat. acid	62.1	15.3	7.2	74.6	21.1	36.0	61.8	9.2	18.8	65.8	16.3	22.2
Unsat. acid	37.9	84.7	92.8	25.4	78.9	64.1	38.2	90.8	81.2	34.2	83.7	77.7

* Stereospecific number in triacylglycerol

** Contained 14:1, 15:0, 17:0 br, 17:0, 17:1 and 20:4

Other abbreviations used are the same as those described in Table 1.

saturated, monoenoic and dienoic fatty acids, both of position 2 and 3 were occupied over 60 % by dienoic acid, and small amounts of saturated acids were found in position 2 and 3.

In egg yolk TG from soybean oil group, C_{16:0} and C_{18:0} were preferentially esterified in posi-

tion 1, consequently this position was occupied largely by saturated fatty acids. Position 2 comprised predominantly unsaturated fatty acids, mostly C_{18:2} in the case of soybean oil group. Position 3 was largely occupied by C_{18:1}. This characteristic feature of positional

distribution of fatty acid in egg TG from soybean oil group, i.e. the preferential distributions of unsaturated fatty acids in position 2 and 3 of TG, was similarly observed in egg TG from the other dietary groups, though the position 2 of TG from coconut oil, lard and tallow groups were mainly composed of $C_{18:1}$ instead of $C_{18:2}$ in the case of the soybean oil group.

The arrangement of fatty acids in TG of egg yolk from each dietary group was fairly different from those of respective dietary fats fed to hens, for example unusual fatty acid distribution of lard was not observed in the egg yolk TG from lard group. Digested dietary fat, absorbed by intestinal epithelium, is again esterified to TG probably accompanying with rearrangement of fatty acids in TG molecule, and thus resynthesized TG enters to hepatic portal blood stream as lipoproteins²³⁾. This lipoproteins and TG synthesized *de novo* in liver are utilized for the formation of egg yolk lipids in ovary, maintaining the species specificity of hen's egg. Consequently, as described by HUSBANDS²⁴⁾, fatty acids of the 1, 3- and 2-positions in liver and in egg yolk TG show a similar distribution, in contrast to this, fatty acids arrangement in TG of egg yolk differs from that of dietary fat fed to laying hen.

Effects of dietary fats on the stereospecific structure of egg yolk TG

The amounts of individual species of TG could be calculated from the known fatty acids distribution in intact TG assuming a 1-random, 2-random, 3-random arrangement. Results obtained on TG of dietary fats and of egg yolk from each dietary group were given in Table 5.

The most abundant TG species in soybean oil was sn-UUU, followed by sn-SUU and sum amount of these two types of TG was attained nearly 90% of total TG of oil (in this, sn- means stereospecifically numbered). In contrast to soybean oil which contained only trace of sn-SSS, the amount of this TG was calculated for over 80% in coconut oil. Major TG of lard was the saturated fatty acids mostly present in position 2 of TG such as sn-SSU and sn-USU, on the other hand, beef tallow comprised sn-SUS and sn-SUU as main TG species. The most abundant TG species of egg yolk from every diet group was sn-SUU, then followed by sn-UUU except coconut group.

Table 6 compares the amounts of the TG groups determined by $AgNO_3$ -TLC with those calculated by the 1-random, 2-random, 3-random distribution. In general, the agreement is comparatively good, excepting the case of coconut oil TG, in which fairly large differences were recognized between the amounts found by $AgNO_3$ -TLC procedure and the values calculated by random hypothesis. That discrepancies observed among the values from different

Table 5 Predicted triacylglycerol compositions of dietary fats and egg yolk lipids from hens fed fat-supplemented diets (mole %*)

TG type**	Dietary fat				Egg		k lipid	
	SO	CO	L	B	SO	CO	L	B
sn-SSS	0.1	81.9	3.9	11.4	0.7	5.7	1.1	2.6
sn-SSU	2.9		24.7	10.4	8.8	10.1	4.6	8.2
sn-SUS	0.9	4.3	2.5	21.1	3.7	21.2	10.6	13.1
sn-USS	0.2	13.1	4.4	7.0	0.4	1.9	0.7	1.3
sn-SUU	30.9		16.0	19.1	48.8	37.6	45.7	41.9
sn-USU	5.4		27.7	6.4	5.4	3.4	2.8	4.3
sn-UUS	1.7	0.7	2.8	12.9	2.3	7.2	6.5	6.8
sn-UUU	58.1		17.9	11.7	29.8	12.8	28.0	21.8

* Calculated triacylglycerol type by means of 1-random, 2-random, 3-random distribution.

** sn-: stereospecifically numbered. S: saturated, U: unsaturated fatty acid. Other abbreviations used are the same as those described in Table 1.

Table 6 Comparison of observed and predicted values of triacylglycerols of dietary fats and egg yolk lipids (mole %)

TG type		Dietary fat				Egg yolk lipid			
						Dietary fat treatment			
		SO	CO	L	B	SO	CO	L	B
S ₃	Found*	tr	56.8	4.9	11.0	1.0	5.6	1.0	1.9
	Calculated**	0.1	81.9	3.9	11.4	0.7	5.7	1.1	2.6
S ₂ U	Found	7.7	34.2	31.9	38.9	12.7	34.2	19.0	21.4
	Calculated	4.0	17.4	31.6	38.5	12.9	33.2	15.9	22.6
SU ₂	Found	32.1	8.4	47.2	37.0	61.6	50.2	53.9	58.4
	Calculated	38.0	0.7	46.5	38.4	56.5	48.2	55.0	53.0
U ₃	Found	60.0	0.5	16.1	13.0	24.7	9.7	26.0	18.3
	Calculated	58.1		17.9	11.7	29.8	12.8	28.0	21.8

* Obtained from analysis by means of argentation thin-layer chromatography.

** Calculated from data obtained by means of stereospecific analyses.

Other abbreviations used are the same as those described in Table 1.

methods may be due to the reasons that, on the one hand, coconut oil TG assumed non-random distribution of fatty acid and/or that, on the other hand, the partial deacylation with a Grignard reagent was not enough suitable to provide DG from coconut oil containing medium molecular weight TG. Although, ethyl magnesium bromide i. e. Grignard reagent is usually used for the standard procedure of stereospecific analysis, MORRISON and HAWKE²⁵⁾ recommended that pancreatic lipase gave relatively representative 1, 2 (2, 3)-DG from the low and medium weight TG.

Egg yolk lipids from every dietary group showed fairly good agreements, though not complete, between their actual and predicted values of TG. CHRISTIE and MOORE²⁶⁾ obtained good agreement between actual and predicted values of TG on the hen's egg. From these results, a 1-random, 2-random, 3-random distribution of the fatty acids was assumed on the hen's egg yolk TG.

References

- 1) FISCHER, H. and LEVEILLE, G.H.: *J. Nutr.*, **63**, 119 (1957).
- 2) CHEN, P.H., COMMON, R.H., NIKOLAICZEK, N. and MACRAE, H.F.: *J. Food Sci.*, **30**, 838 (1965).
- 3) SIM, J.S., BRAGG, D.B. and HODGSON, G.C.: *Poultry Sci.*, **52**, 51 (1973).
- 4) ØSTRANDER, J.G., JORDAN, R., STADELMAN, W.J., ROGLER, J.C. and VAIL, G.E.: *Poultry Sci.*, **39**, 796 (1960).
- 5) EVANS, J.F., BANDMER, J.A. and DAVIDSON, J.A.: *J. Nutr.*, **39**, 1199 (1960).
- 6) LEVEILLE, G.A. and FISCHER, H.: *Poultry Sci.*, **37**, 658 (1958).
- 7) MACHLIN, L.J., GORDON, R.S., MARR, J. and POPE, C.W.: *Poultry Sci.*, **41**, 1340 (1962).
- 8) SELL, J.L., CHOO, S.H. and KONDRA, P.A.: *Poultry Sci.*, **47**, 1296 (1968).
- 9) HIRATA, A., NISHINO, M., KIMURA, T. and OHTAKE, Y.: *Nippon Shokuhin Kogyo Gakkaishi*, **32**, 892 (1985).
- 10) COUCH, J.R. and SALOMA, A.E.: *Lipids*, **8**, 385 (1973).
- 11) OHTAKE, Y. and HOSHINO, Y.: *Jap. J. Zootech. Sci.*, **47**, 430 (1976).
- 12) FOLCH, J., LEAS, M. and STANLEY, G.H.S.: *J. Biol. Chem.*, **226**, 497 (1957).
- 13) MOERCK, K.E. and BALL, Jr., H.R.: *J. Food Sci.*, **38**, 978 (1973).
- 14) WOOD, R. and SNYDER, F.: *J. Am. Oil Chem. Soc.*, **43**, 53 (1966).
- 15) CHRISTIE, W.W. and MOORE, J.H.: *Biochim. Biophys. Acta*, **210**, 45 (1970).
- 16) OHTAKE, Y.: *Jap. J. Zootech. Sci.*, **54**, 179 (1983).
- 17) BROCKERHOFF, H.: *J. Lipid. Res.*, **6**, 10 (1965).
- 18) CHRISTIE, W.W. and MOORE, J.H.: *Biochim. Biophys. Acta*, **176**, 445 (1969).
- 19) KUKSIS, A., MCCARTHY, M.J. and BEVERIGE, J.M.R.: *J. Am. Oil Chem. Soc.*, **40**, 530

- (1963).
- 20) OHTAKE, Y.: *Jap. J. Zootech. Sci.*, **53**, 797 (1982).
- 21) CHRISTIE, W.W. and MOORE, J.H.: *Lipids*, **4**, 345 (1969).
- 22) BLANK, M.L., VERDINO, B. and PRIVETT, O.S.: *J. Am. Oil Chem. Soc.*, **42**, 87 (1965).
- 23) NOYAN, A., LOSSOW, W.J., BROTH, N. and CHIAKOFF, I.L.: *J. Lipid Res.*, **5**, 583 (1964).
- 24) HUSBANDS, D.R.: *Biochem. J.*, **120**, 365 (1970).
- 25) MORRISON, I.M. and HOWKE, J.C.: *Lipids*, **12**, 1005 (1977).
- 26) CHRISTIE, W.W. and MOORE, J.H.: *Biochim. Biophys. Acta*, **218**, 83 (1970).

(Received Oct. 6, 1986)

卵黄のトリアシルグリセロール組成ならびに
構造におよぼす飼料油脂の影響

平田明弘*・増田哲也*

木村貞司*・大武由之*

*日本大学農獣医学部 (〒154 東京都世田谷区
下馬 3-34-1)

大豆油, ココヤシ油, ラードならびに牛脂の給与が,

鶏卵卵黄のトリアシルグリセロール (TG) の組成および構造に及ぼす影響を調べた。短鎖飽和脂肪酸は卵黄脂質の生成に利用されなかったが、卵黄 TG は一般に飼料油脂の脂肪酸組成を反映するところがあった。大豆油区, ラード区および牛脂区の卵黄 TG はいずれも C_{50} , C_{52} および C_{54} の TG を主な構成成分としていた。ココヤシ油区の卵黄には、かなりの量の C_{44} から C_{50} までの TG 種が含まれ、反面 C_{52} と C_{54} の成分は試験区中で最も少なかった。大豆油区の卵黄脂質は他の飼料区のものに比べて、(モノエン酸を含む TG の量が少なく、ジエン酸を含む TG が多かった。ココヤシ油区の卵黄脂質は、他の飼料区に比べて S_2M が最も多く U_3 成分が最も少なかった。ラード区と牛脂区との TG 種の分布パターンは類似していた。いずれの飼料区の卵黄脂質にあっても、飽和脂肪酸は TG の 1-位置に優先的にエステル化し、これに対して 2-位置は顕著に不飽和脂肪酸で占められ、3-位置には $C_{16:1}$ とともに $C_{18:1}$ が多かった。このような鶏卵卵黄の TG 内における脂肪酸の位置的分布の種属的特異性は、飼料中の油脂の違いにかかわらず変化が認められなかった。(C_{50} はアシル炭素原子数 50 の TG で、他はこれに準ずる。また、S は飽和脂肪酸、M はモノエン酸、U は不飽和脂肪酸をあらわす。)