LONG-CHAIN MONOETHYLENIC FATTY ACIDS IN PRIMATES

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INTRODUCTION

The dietary needs of man and of other primates are normally satisfied by a diet rich in the C 18 fatty acids. The publications recording the compositions of the depot and organ lipids are most often restricted to 16:0 (palmitic), 18:0 (stearic), 18:1 (oleic), 18:2 (linoleic), 18:3 (linolenic) and sometimes 20:4ω6 (arachidonic) acids.

In a pilot study of the effect of 22:1 (docosenoic) acids in non-human primates, the cynomolgus monkey Macaca fascicularis, animals were fed for six months on high-fat diets (25 % w/w) containing LCO (lard-corn oil), RSO (rapeseed oil), or PHMO (partially hydrogenated marine oil). The fatty acid compositions of depot fat and heart muscle have been published elsewhere (Ackman and Loew, 1977; Ackman et al., 1977), and a summary of the 20:1 and 22:1 proportions is given in Table 1. The substantial deposition of the 22:1 of RSO and PHMO origin was not unexpected in view of earlier findings in several animal species (Beare-Rogers, 1977). The 22:1 isomer compositions from the RSO and PHMO groups generally reflected dietary input, but with subtle differences in detail between depot and heart triglycerides (Ackman and Loew, 1977). In the case of the RSO group this included a very small proportion of 22:1ω11 not included in the diet, in the case of the PHMO group rather less trans-22:1ω11 relative to cis-22:1ω11 in the heart TG than in the diet or depot fat. There was also less 22:1 in the cardiac muscle, for equal input, with PHMO than with RSO. All of the LCO group depot fats and heart lipids unexpectedly showed low levels of what appeared to be trans and cis-22:1ω11 as well as the cis-22:1ω9 expected to be deposited from diet. We have therefore examined various human lipid sources of 22:1 in an attempt to see if 22:1 isomer discrimination can be informative as to exposure of population groups to these dietary factors. Sample of human heart tissue, trimmed of all external fat, and of corresponding depot fats, were the basic materials. The analytical technology followed that described in detail for non-human primates (Ackman and Loew, 1977).

TABLE 1

HALIFAX LABORATORY ANALYSES - % 20:1 FATTY ACIDS IN HEART LIPIDS OF MACACA FASCICULARIS*

	Diet** and Animal Number						
	Lard-Corn Oil			Rapeseed Oil		P. Hyd. Mar. Oil	
	5	9	10	3	7	8	12
Heart Total Lipid							
% 20:1	1.0	0.8	0.4	6.4	7.5	8.4	9.9
% 22:1	0.3	0.2	0.4	21.3	22.6	13.7	7.8
Heart Triglyceride							
% 20:1	1.5	1.2	2.2	9.2	9.6	10.0	11.5
% 22:1	0.5	0.3	0.9	36.2	31.7	18.2	8.9
% Lipid in Tissue (*Recovery by B. Walker)	4.6	8.5	7.5	14.2	11.2	8.2	9.0

**Both rapeseed oil and PHMO contained 25 % 22:1.

RESULTS AND DISCUSSION

The analyses of further non-human primate samples from cynomologus monkeys on the PHMO and LCO diets for two years confirmed the earlier results. Pending conclusion of this study in August of 1978 we have collected comparative data for human populations.

TABLE 2

SELECTED FATTY ACIDS OF TRIGLYCERIDES FROM HUMAN HEART MUSCLE LIPIDS AND OF TOTAL LIPID FROM DEPOT FAT (LOT I)

Fatty acid	Subject and tissue 9745 Heart	9745 Depot	9740 Heart	9740 Depot	9777 Heart	9777 Depot	9768 Heart	9768 Depot	9796 Heart	9796 Depot
14:0	2.6	5.3	2.9	2.8	3.2	3.7	3.0	2.5	2.5	2.2
16:0	23.9	21.3	23.7	27.0	23.6	24.5	21.9	19.2	17.6	14.9
18:0	6.7	8.0	5.6	2.6	5.5	4.3	6.5	7.1	4.5	6.4
20:0	0.3	0.5	0.2	0.1	0.1	0.3	0.2	0.3	0.2	0.5
22:0	0.1	0.1	0.1	TRA	TRA	TRA	0.1	0.1	0.1	0.2
Σ Sat	35.9	38.5	34.4	33.8	34.3	34.6	33.3	31.3	26.4	25.7
16:1	4.9	3.9	8.6	10.9	4.8	5.3	3.7	2.3	4.7	3.7
18:1	49.9	47.8	46.3	47.1	49.6	48.0	49.3	51.0	55.3	55.8
20:1	1.3	0.8	1.1	0.8	1.1	0.8	1.5	2.7	1.9	2.7
22:1	0.5	0.1	0.5	0.1	0.2	0.1	0.5	1.1	0.8	2.4
24:1	NB	TRA	TRA	0.1	TRA	TRA	ND	TRA	0.1	0.1
Σ Mono	57.7	53.8	58.5	60.3	56.6	55.1	57.0	58.3	64.2	65.6
18:2ω6	4.7	6.2	5.3	4.2	6.9	8.0	7.3	8.0	7.2	6.9
20:4ω6	0.3	0.3	0.2	0.3	0.4	0.2	0.4	0.2	0.3	0.1
22:4ω6	0.1	TRA	0.1	0.1	0.2	0.1	0.2	0.2	0.1	TRA
$\Sigma\omega$6 PUFA	5.2	6.8	5.8	4.9	7.6	8.6	8.3	8.8	7.7	7.2
18:3ω3	0.1	0.2	0.2	0.2	0.3	0.4	0.2	0.2	0.2	0.3
20:5ω3	TRA	TRA	TRA	TRA	TRA	TRA	TRA	TRA	TRA	TRA
22:5ω3	TRA	TRA	0.1	TRA	0.2	TRA	0.1	0.2	0.1	0.1
22:6ω3	TRA	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	TRA
$\Sigma\omega$3 PUFA	0.3	0.3	0.7	0.3	0.7	0.5	0.6	0.7	0.6	0.4

The fatty acid analyses of depot and heart triglycerides for one regional group (western Canada) are given in part in Table 2. Omitted are a variety of methyl branched fatty acids, and saturated and monoethylenic oddchain fatty acids, described by Kingsbury et al. (1964), and specific PUFA (polyunsaturated fatty acids) not often published except in marine lipid analyses (e.g. 20:3ω3, 20:4ω3, etc.). The broad details for major components are similar to those for North American men published by Insull et al. (1967). However from our analyses it is clear that C 20, C 22 and even C 24 fatty acids of the three basic types are well established in human heart and depot fat triglycerides as minor components. The 20:1 and 22:1

totals are similar to the LCO M. fascicularis group.

It is interesting to note from the details (Table 3) that for heart lipid in the range from 2.1 % to 2.6 the heart TG had more total 22:1 than the depot fat TG. However in the two hearts with 3.7 % lipid the proportion of 22:1 was higher in the depot fat TG than in the heart TG. The cis-22:1ω9 (erucic acid) component was always the major isomer, but was accompanied in this demographic group by the earlier-eluting isomers tentatively identified as 22:1ω11 and previously noted in the primate study (Ackman and Loew, 1977). This very limited study suggests that cis-22:1ω9 > 0.1 % may be a typical proportion of fatty acids in the human heart, with less of the 22:1ω11 isomers of possibly exogenous origin (e.g. partially hydrogenated marine oils are consumed in Canada). As the cis-22:1ω9 in the depot fat rises ten or twenty-fold, the 22:1ω11 apparently does not increase in proportion. The significance of this is obscure but suggests preferential catabolism of the 22:1ω11 isomers (Ackman and Loew, 1977). There is also a reasonable possibility that modest levels of dietary cis-22:1ω9 can drastically alter the depot fat cis-22:1ω9 (i.e., increase it from 0.1 to 2 %) with a reduced effect (no more than a 50 % increase?) on the heart TG 22:1ω9. Depot fat samples from the U.S.A., where partially hydrogenated marine oils (and rapeseed oil) are not consumed, show only cis-22:1ω9. We have also established, in collaboration with Danish scientists, that a diet high in cis-22:1ω11 of marine origin results in the circulating lipids being dominated by this isomer clearly linked to their diet of seals, fish, etc.

Further studies are in progress. Since it is known that dietary 22:1 influences circulating 22:1 (Del Carmine et al., 1975) plasma fatty acids will be included.

TABLE 3

LIPID CONTENT OF HUMAN TISSUE, PERCENTAGE OF TRIGLYCERIDES IN LIPIDS, AND W/W % 22:1 ISOMER DETAILS OF TRIGLYCERIDES FROM HEART MUSCLE LIPIDS AND OF TOTAL LIPID FROM DEPOT FATS (LOT 1)

	Subject and tissue									
	9745		9740		9777		9768		9796	
	Heart	Depot	Heart	Depot	Heart	Depot	Heart	Depot	Heart	Depot
% lipid	2.1	37	2.5	51	3.0	73	3.7	66	3.7	56
% TG	15.6	-	65.3	-	37.8	-	9.2	-	52.9	-
% 22:1ω11	0.15	0.02	0.10	0.01	0.02	0.02	0.13	0.08	0.08	0.12
% 22:1ω9	0.30	0.06	0.38	0.05	0.18	0.11	0.38	1.04	0.69	2.27
Σ 22:1	0.45	0.08	0.48	0.06	0.20	0.13	0.51	1.12	0.77	2.39

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