The Fatty Acid Composition and Glyceride Structure of Indian Wild-boar Fat

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Only a few land-animal fats have been studied in detail so far with respect to their fatty acid composition and the pattern of glyceride molecules. Among those whose fatty acid compositions are available are lion and cat (Hilditch, Sime & Maddison, 1942; Gunstone & Russell, 1954), puma (Giral, 1945), tiger (Pathak & Agarwal, 1952; Gunstone, 1955), sacred baboon, Ceylon sloth bear (Hilditch *et al.* 1942), badger (Gupta, Hilditch & Meara, 1950), man (Cramer & Brown, 1951; James & Wheatley, 1956), horse, camel, deer, ox, sheep and pig (Hilditch, 1956), representing carnivorous, omnivorous and herbivorous types of animals. The present investigation of the component acids and glyceride structure of Indian wild-boar depot fat was undertaken to add more data to the scanty literature on herbivorous-animal fats.

EXPERIMENTAL

A colourless fat was obtained from the upper left thigh region of the wild boar (male) of the forest of Hamirpur (Northern India). The saponification equivalent (s.e.) of the purified fat was 282.6 and iodine value (i.v.) was 50.8 with 2.7% of free fatty acid (as oleic).

Component acids. A portion (92 g.) of the fat was saponified and the mixed fatty acids (87 g.; i.v. 52.4) were recovered; the mixed acids so obtained were resolved by the lead salt-ethanol method (Hilditch, 1956) into two groups of simpler mixtures of acids differing in unsaturation, whereupon each group of the acid was esterified with methanol, with the precautions suggested by Bjarnason & Meara (1944), and fractionated through the electrically heated and packed (E.H.P.) column of Longenecker (1937) as usual. The composition of the mixed acid was calculated from the s.e. and i.v. values of the ester subfractions by the method described by Hilditch (1956). The mean equivalent of each homologous ester group was found by interpolation and extrapolation of the degree of unsaturation of each fraction.

Component glyceride. A sample (221 g.) of the neutral fat (i.v. 48.9) was dissolved in acetone (2.2 l.) and kept at 10°, when 41.8 g. (i.v. 28.8) of the glyceride crystallized out. The soluble portion, 179.2 g. (i.v. 54.8), was again kept in acetone (1.8 l.) at 0°, which deposited 33.5 g. (i.v. 35.8) of glyceride. The soluble portion of glyceride in acetone at 0°, 145.7 g. (i.v. 59.1), was further crystallized in acetone (1.5 l.) at -10°, and 27.3 g. (i.v. 43.2) of glyceride separated out and 118.4 g. (i.v. 62.8) of acetone-soluble glyceride at

-10° was recovered separately. The glycerides precipitated in acetone at 0° were dissolved in ether (0.2 l.) and cooled to -5°, when 6.2 g. (i.v. 31.4) of ether-insoluble glyceride was obtained. The ether-soluble glyceride, 27.3 g. (i.v. 36.8) at -5°, was recovered separately.

The fractions thus obtained were combined with respect to the nearly similar iodine values. Thereby three fractions, 48 g. (i.v. 29.1), 54.6 g. (i.v. 40.0) and 118.4 g. (i.v. 62.8), were formed and named A, B and C respectively. The mixed acids recovered from each glyceride fraction were resolved into solid (A) and liquid (B) acid groups by the lead salt-ethanol method. These resolved fractions were called AA, AB, BA, BB, CA and CB respectively. Each fraction was converted into methyl ester and then fractionated through the E.H.P. column as usual.

The possible component glycerides were calculated from the composition of the individual group on the theory of computation given by Hilditch (1956).

RESULTS

The fractional crystallization data of the mixed fatty acids of wild boar by the lead salt-ethanol method are given in Table 1.

Table 2 records the component acids of wild-boar fat.

The results obtained by crystallization of neutral wild-boar fat from acetone and ether at various temperatures are recorded in Table 3.

Table 4 presents the separation of the mixed acids of glyceride fractions A, B and C by the lead salt-ethanol method.

The component acids of the glyceride fractions A, B and C are given in Table 5.

The possible component glycerides of wild-boar fat are given in Table 6.

DISCUSSION

Component acids. The wild-boar fat contains 47.9% by weight of the saturated acids, which includes 29.5% of palmitic and 16.8% of stearic acid as major components and 1.6% of myristic acid as a minor part. The unsaturated acids, which form 52.1% of the total acids, contain 13.2% of hexadecenoic and 36.3% of oleic acid together with 0.7% of tetradecenoic and 1.9% of linoleic acid. This is, in general, similar to the pattern in other fats of other herbivorous land animals.

Table 1. *Separation of the acids of wild-boar fat by the lead salt-ethanol method*

Group	Solubility of lead salt in ethanol at 15°	Weight		Iodine value
		(g.)	(%)	
A	Insoluble	34.2	40.2	7.5
B	Soluble	50.8	59.8	82.6

Table 2. *Component acids in groups A and B from the whole fat of the wild boar*

Figures in parentheses indicate unsaturation, e.g. -2.0 H means monoethenoid.

Acids	Component acids* of groups (%)		Total (%)	Fatty acids in the whole fat excluding non-saponifiable fraction	
	A	B		% (w/w)	% (mol.)
Saturated					
Myristic	0.5	1.1	1.6	1.6	1.9
Palmitic	25.8	3.6	29.4	29.5	31.0
Stearic	10.7	6.1	16.8	16.8	15.9
Unsaturated					
C ₁₄	—	0.8 (-2.0 H)	0.8 (-2.0 H)	0.8	0.9
C ₁₆	1.4 (-2.0 H)	11.8 (-2.0 H)	13.2 (-2.0 H)	13.2	14.0
C ₁₈	1.7 (-2.0 H)	36.3 (-2.2 H)	38.0 (-2.2 H)	38.1	36.3
Unsaponifiable	0.1	0.1	0.2	—	—

* Figures are derived from the quantities of fractions actually obtained on fractionation; loss was little and was ignored. Hence the figures total 100.

Table 3. *Crystallization of neutral wild-boar fat from acetone and ether*

Fraction	Description*	Weight		Iodine value
		(g.)	(%)	
A	Glycerides insoluble in acetone (10) at 10° and 0° and insoluble in ether (5) at -5°	48.0	21.7	29.1
B	Glycerides soluble in acetone (10) at 10°, insoluble at 0° and soluble in ether (5) at -5° but insoluble in acetone (10) at -10°	54.6	24.7	40.0
C	Glycerides soluble in acetone (10) at 10°, 0° and -10°	118.4	53.6	62.8

* Figures in parentheses represent ml. of acetone and ether/g. of fat.

Table 4. *Separation of the mixed acids of glyceride fractions A, B and C*

Fraction	Description*	Weight		Iodine value
		(g.)	(%)	
Fraction A	AA	26.8	63.8	1.2
	AB	15.2	36.2	79.9
Fraction B	BA	25.5	53.1	4.9
	BB	22.5	46.9	82.6
Fraction C	CA	26.5	25.0	2.7
	CB	79.5	75.0	83.8

Table 5. *Component acids of glyceride fractions A, B and C (% mol.)*

Component acids	A	B	C	Total
Myristic	0.2	0.6	1.6	2.4
Palmitic	8.6	9.7	13.9	32.2
Stearic	6.1	3.3	3.6	13.0
Tetradecenoic	0.1	0.4	0.8	1.3
Hexadecenoic	1.7	1.9	8.7	12.3
Oleic	5.0	8.4	22.5	35.9
Linoleic	—	0.4	2.5	2.9

Table 7 shows that the wild-boar fat and pig fat are extremely similar in their composition. The same saturated and unsaturated acids, except C₂₀-C₂₂, are present in each case. The characteristic difference between wild-boar fat and pig fat is that the wild-boar fat has a larger amount of hexadecenoic acid, formed mostly at the expense of oleic and octadecadienoic acid, whereas pig fat has a lower percentage of hexadecenoic acid but the

Table 6. *Component glycerides of wild-boar fat*

	A	B	C	Whole fat
Component acid groups (% mol.)				
Myristic and palmitic	8.8	10.3	15.4	34.5
Stearic	6.1	3.3	3.6	13.0
Tetradecenoic and hexadecenoic	1.7	2.4	9.5	13.6
Oleic and linoleic	5.0	8.8	25.1	38.9
Component glyceride groups (% mol.)				
(a) Fully saturated group	1.5	—	—	1.5
Disaturated-mono-unsaturated	20.1	16.0	3.5	39.6
Monosaturated-diunsaturated	—	8.8	50.1	58.9
(b) Dipalmito-mono-others	4.8	6.1	—	10.9
Monopalmito-di-others	16.8	18.7	46.3	81.8
Tri-others	—	—	7.3	7.3
(c) Dioleo-mono-others	—	1.6	21.6	23.2
Mono-oleo-di-others	18.2	23.1	32.0	73.3
Tri-others	3.5	—	—	3.5
Possible component glycerides (% mol.)				
Fully saturated (1.5%)				
Myristodipalmitin	0.6	—	—	0.6
Dipalmitostearin	1.0	—	—	1.0
Disaturated-mono-unsaturated (39.6%)				
Dipalmitohexadecenin	3.2	—	—	3.2
Dipalmito-olein	—	6.1	—	6.1
Palmitostearohexadecenin	2.0	—	—	2.0
Palmitostearo-olein	14.9	9.9	3.5	28.3
Monosaturated-diunsaturated (58.9%)				
Hexadeceno-oleopalmitin	—	7.1	17.8	24.9
Hexadeceno-oleostearin	—	—	10.7	10.7
Palmitodiolein	—	1.6	21.6	23.2

Table 7. *Component acids (% by wt.) of pig and wild-boar fats*

Acids	Wild boar (present work)	Pig (back, outer) (Hilditch, Lea & Pedelty, 1939)	Pig (back, inner) (Hilditch <i>et al.</i> 1939)
Myristic	1.6	1.3	1.0
Palmitic	29.5	28.3	30.1
Stearic	16.8	11.9	16.2
Tetradecenoic	0.7	—	—
Hexadecenoic	13.2	2.7	2.7
Oleic	36.3	47.5	40.9
Octadecadienoic	1.9	6.0	7.1
C ₂₀ -C ₂₂	—	2.1	1.7

Table 8. *Distribution of acyl groups in the glyceride of wild-boar fat*

	Actual	Computed	
		Even (Hilditch, 1956)	Random (Kartha, 1949, 1953)
Fully saturated glyceride	1.5	0	10.7
Disaturated-mono-unsaturated	39.6	42.6	35.6
Monosaturated-diunsaturated	58.9	57.4	39.3
Triunsaturated	0	0	14.4

unsaturated acids octadecadienoic and C₂₀-C₂₂ acids are in higher proportion in pig fat, showing more unsaturation than the wild-boar fat. There is thus a generic similarity between domestic and wild varieties of the animal, which is a usual feature in both animal and vegetable fats from related species.

Component glycerides. The wild-boar fat contains 1.5 % of fully saturated glycerides (myristodipalmitin 0.5 % and dipalmitostearin 1.0 %); 39.6 % of disaturated-mono-unsaturated glycerides (dipalmitohexadecenin 3.2 %, dipalmito-olein 6.1 %, palmitostearohexadecenin 2.0 % and

palmitostearo-olein 28.3%) and 58.9% of mono-saturated-diunsaturated glycerides (hexadeceno-oleopalmitin 25.0%, hexadeceno-oleostearin 10.7% and palmitodiolein 23.2%). No triunsaturated glyceride was found.

The experimental values for the distribution of acyl groups in the glycerides of wild-boar fat, together with the computed values of the 'even' and 'random' types, are given in Table 8, and it is clear that wild-boar fat follows the rule of 'even' distribution, according to which the component fatty acids tend to be distributed as widely as possible among all the triglyceride molecules. In this respect wild-boar fat does not fall into line with the general land-animal type of fat. The 'random' distribution would require an appreciable amount of fully saturated triglycerides, lower proportions of disaturated-mono-unsaturated, and monosaturated-diunsaturated glycerides, and an appreciable quantity of triunsaturated glycerides. As the wild-boar fat follows the 'even-distribution' pattern, Kartha's (1953) theory of restricted random distribution need not be discussed.

SUMMARY

1. The composition of the depot fat from a wild-boar (*Sus cristatus indicus*) has been studied. The mixed acids were separated by applying the lead salt-ethanol method and their composition was studied by the ester-fractionation procedure.

2. The proportions of individual fatty acids in the fat were, in general, similar to those in the fats of other herbivorous animals and were very close to those of pig fat.

3. The glyceride structure of the wild-boar fat has been investigated by low-temperature crystallization of neutral fat with acetone and ether as crystallizing medium. Three main fractions thus obtained were studied separately and possible glyceride composition was computed from the observed data.

4. The observed glyceride pattern in wild-boar fat follows Hilditch's rule of 'even distribution' and so it does not correspond with general land-animal types.

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Plant Enzyme Reactions Leading to the Formation of Heterocyclic Compounds

3. PLANT AMINE OXIDASE AND THE FORMATION OF PYRROLIDINE AND PIPERIDINE ALKALOIDS*

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The products of the oxidation of 1:4-diaminobutane and 1:5-diaminopentane, catalysed by plant amine oxidase in the presence of catalase, accumulate in the reaction mixtures as compounds of Δ^1 -pyrroline and of 2:3:4:5-tetrahydropyridine respectively (Mann & Smithies, 1955a; Hasse & Maisack, 1955). Mann & Smithies (1955a) suggested that these compounds arise by spontaneous

cyclization of the aldimines, which are probably the primary products of the enzyme reactions, or of the amine aldehydes formed from the aldimines by spontaneous reaction with water. Thus with 1:4-diaminobutane as substrate, the suggested reactions were those given in Scheme 1. With 1:4-diaminobutane and 1:5-diaminopentane as enzyme substrates the amine aldehydes postulated as possible intermediates in the reactions would be γ -aminobutyraldehyde and δ -aminovaleraldehyde.

* Part 2: Mann & Smithies (1955b).