Table 3. *Component acids of some herbivorous animal fats*

All values are % (w/w).

	Iodine value	Saturated		Unsaturated				Total saturated	Total C ₁₈ acids
		C ₁₆	C ₁₈	C ₁₆ (-2.0 H)	C ₁₈ (-2.0 H)	C ₁₈ (-4.0 H)	C ₁₈ (-6.0 H)		
Camel ¹	35.1	29	27	3	26	2	1	64	56
Deer ¹	35.5	25	35	3	25	3	3	66	66
Ox ²	43.2	29	21	3	41	2	—	54	64
Sheep ³	43.4	25	28	1	37	6	—	56	71
Sheep ³	49.1	28	16	1	47	4	—	47	67
Kangaroo ⁴	50.1	26	14	3	45	3	—	47	62
Pig ⁵	54.3	30	16	3	41	7	—	47	64
Chimpanzee	58.1	30	7	5	45	8	—	40	60
Pig ⁵	60.0	28	12	3	48	6	—	41	66
Giant Panda ⁴	64.8	26	7	4	45	12	—	38	64

¹ Gunstone & Paton (1953); ² Hilditch & Longenecker (1937); ³ Hilditch & Pedelty (1941); ⁴ Hilditch, Sime & Maddison (1942); ⁵ Hilditch, Lea & Pedelty (1939).

(35–65) the total content of saturated acids falls steadily (65–40 %). This is entirely due to the decreasing amount of stearic acid (35–7 %), the content of palmitic acid being constant (25–30 %) throughout the range (cf. Banks & Hilditch, 1931). The total amount of C₁₈ acids also remains fairly constant (60–70 %) for as the iodine value rises the decrease in stearic acid is balanced by an increase in the amount of oleic acid and, in the higher range of iodine value (55–65), by the appearance of larger amounts of octadecadienoic acid.

The values obtained for this sample of chimpanzee fat fit well into this general scheme.

SUMMARY

Chimpanzee fat contains palmitic (30 %) and oleic acid (45 %) as major components with octadecadienoic (8 %), stearic (7 %), and hexadecenoic acid (5 %) as the most important minor component

acids. It is similar to fats of similar iodine value from other herbivorous animals.

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Animal Fats

6. THE COMPONENT ACIDS OF TIGER FAT AND OF PUMA FAT

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This communication is concerned with the component acids of tiger fat (*Felix tigris*) and of puma fat (*F. concolor*). Despite the fact that the composition of fats from these animals has already been reported (for references, see Table 5) it was considered of interest to examine the samples available in view of their higher iodine value.

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EXPERIMENTAL

These two fat samples were obtained through the kindness of Professor T. F. Hewer from animals which had died in Bristol Zoological Gardens. One sample was taken from the subcutaneous region of the groin of a 14-month-old male tiger, whilst the other came from the abdominal wall, the mesentery, and the omentum of an 11-year-old female puma which had been reared in captivity in this country. Both animals were fed on a mixture of raw cow and horse

flesh; the wild members of the species live mainly on deer and sheep.

The fats were treated by the methods described in earlier papers in this series and the mixed acids were separated into three fractions by low-temperature crystallization, each ester fraction being examined as before. The results are set out in Tables 1-4.

Identification of acids

Samples of myristic (m.p. 52-54°), palmitic (m.p. 60-63°), and stearic acid (m.p. 68-71°) were isolated from appropriate fractions of the tiger fat analysis and the presence of hexadec-9-enoic, oleic, and linoleic acid confirmed by the

preparation of 9:10-dihydroxypalmitic (m.p. 124-125°), 9:10-dihydroxystearic (m.p. 129-131°), and 9:10:12:13:15:16-hexabromostearic acid (m.p. 181-184°). None of these melting points were depressed when samples were mixed with specimens of the authentic compound. Attempts to isolate the 9:10:12:13-tetrabromostearic acid characteristic of linoleic acid were unsuccessful; from a series of crystallizations several fractions melting within the range 85-100° were obtained the analysis of which showed them to be essentially tetrabromostearic acid but it is doubtful whether any fraction was entirely homogeneous.

Myristic (m.p. 51-54°), palmitic (m.p. 61-63°), stearic (68-71°), 9:10-dihydroxypalmitic (m.p. 123-125°), 9:10-dihydroxystearic acid (m.p. 129-131°) and 9:10:12:13:15:16-

Table 1. *Characteristics of tiger fat and of puma fat*

Animal	Fat			Mixed acids	
	Iodine value	Sapon. equiv.	Free acid (as % oleic)	Iodine value	Sapon. equiv.
Tiger ¹	56.8	286.4	—	—	—
Tiger ²	49.2	286.5	7.9	50.6	—
Tiger ³	70.5	284.6	1.6	73.9	271.7
Puma ⁴	38.8	324.7	1.8	46.7	278.7
Puma ³	69.7	283.6	1.9	72.7	272.9

¹ Pathak & Godbole (1945); ² Pathak & Agarwal (1952); ³ Present work; ⁴ Giral (1945).

Table 2. *Low-temperature crystallization of the mixed fatty acids*

Fraction	Acids			Esters	
	Wt. (g.)	% (w/w)	Iodine value	Iodine value	Sapon. equiv.
Tiger					
A Insoluble at -20°	26.51	35.0	1.7	1.6	—
B Soluble at -20°, insoluble at -45°	22.85	30.2	82.4	78.6	—
C Soluble at -45°	26.29	34.8	137.9	131.6	—
Puma					
A Insoluble at -20°	46.0	34.4	1.5	1.6	—
B Soluble at -20°, insoluble at -45°	43.7	32.6	84.7	80.2	290.7
C Soluble at -45°	44.2	33.0	133.1	125.6	290.2

Table 3. *Component acids of tiger fat*

All values except in last column are % (w/w) of total.

	Fraction			Total	% (wt.)*	% (mol.)*
	A	B	C			
Myristic	0.69	0.57	1.75	3.01	3.0	3.6
Palmitic	22.89	2.57	1.29	26.75	26.8	28.4
Stearic	10.64	—	—	10.64	10.7	10.2
Tetradecenoic	—	0.16	0.42	0.58	0.6	0.7
Hexadecenoic	0.04	1.22	4.34	5.60	5.6	6.0
Hexadecadienoic	—	—	0.21	0.21	0.2	0.2
Hexadecatrienoic	—	—	0.16	0.16	0.2	0.2
Octadecenoic	0.61	24.89	12.43	37.93	38.1	36.6
Octadecadienoic	—	0.72	5.47	6.19	6.2	6.0
Octadecatrienoic	—	—	6.78	6.78	6.8	6.6
As eicosenoic†	—	—	1.74	1.74	1.8	1.5
Unsaponifiable	0.13	0.07	0.21	0.41	—	—

* Excluding unsaponifiable material.

† Includes all unsaturated acids higher than C₁₈ (average unsaturation -4.7 H).

hexabromostearic acid (m.p. 181–182°), none of which depressed the melting point of an authentic specimen, were similarly isolated or prepared from appropriate fractions of the puma fat analysis. A crude sample of 9:10:12:13-tetrabromostearic acid (softens at 86°, melts at 106–109°; when mixed with an authentic specimen softens at 85°, melts at 109–112°) was also prepared.

DISCUSSION

In general terms the two fats reported in this paper are very similar in composition. Both contain oleic (38–40 %), palmitic (24–27 %), and stearic acid (10–11 %) as major components. The minor components include octadecadienoic acid (6–9 %), octadecatrienoic (4–7 %), hexadecenoic (5–6 %), myristic (3–4 %) and acids higher than C_{18} (2–3 %). The main difference between these two lies in the relative amounts of octadecadienoic and octadecatrienoic acid (see Table 5).

These results differ considerably from those previously recorded for the fats of these and other carnivorous animals (Table 5). The content of palmitic acid is fairly constant at about the usual

level apart from one analysis of tiger fat but myristic acid is slightly higher than in the previous analyses of tiger and of puma fat. The amount of stearic acid (10–11 %) is considerably less than reported hitherto with the result that the total of the saturated acids (about 40 %) is lower than in the other analyses (46–54 %). Hexadecenoic acid falls between the lower values quoted for lion and cat (2–4 %) and the higher values of the earlier analyses of tiger and puma fat (7–13 %). The most interesting feature of these results is the presence of appreciable quantities of polyethenoid C_{18} acids (12–13 %) which seldom exceed 10 % in land animals; the quantity of octadecatrienoic is particularly interesting and recalls the much higher values for wild rabbit (42 %, Shorland, 1953) and horse (16 %, Gupta & Hilditch, 1951; 13–20 %, Shorland, Bruce & Jessop, 1952). The triene acid is essentially linolenic acid but the composition of the diene acid is less certain; puma fat probably contains some linoleic acid along with isomeric diene acids but no evidence of linoleic acid among the C_{18} diene acids of tiger fat was obtained.

Table 4. *Component acids of puma fat*

All values except in last column are % (w/w) of total.

	Fraction			Total	% (wt.)*	% (mol.)*
	A	B	C			
Myristic	0.98	1.44	1.70	4.12	4.1	4.9
Palmitic	21.54	1.89	0.67	24.10	24.2	25.7
Stearic	10.47	—	—	10.47	10.5	10.1
Arachidic	0.78	—	—	0.78	0.8	0.7
Tetradecenoic	0.01	0.05	0.79	0.85	0.9	1.0
Hexadecenoic	0.02	1.08	3.45	4.55	4.6	4.9
Octadecenoic	0.48	26.54	12.27	39.29	39.5	38.1
Octadecadienoic	—	1.08	7.42	8.50	8.6	8.3
Octadecatrienoic	—	—	3.59	3.59	3.6	3.5
As eicosenoic†	—	0.42	2.76	3.18	3.2	2.8
Unsaponifiable	0.12	0.10	0.35	0.57	—	—

* Excluding unsaponifiable material.

† Includes all unsaturated acids higher than C_{18} (average unsaturation – 3.4 H).

Table 5. *Component acids of some carnivorous animal fats*

All values are % (w/w).

	Saturated				Unsaturated					
	C_{14}	C_{16}	C_{18}	C_{20}	C_{14} (–2.0 H)	C_{16} (–2.0 H)	C_{18} (–2.0 H)	C_{18} (–4.0 H)	C_{18} (–6.0 H)	C_{20} *
Lion ¹ (<i>Panthero leo</i>)	4.9	28.9	17.8	0.1	0.6	1.9	40.3	—	—	3.0
Cat ² (<i>Felis catus</i>)	3.6	29.2	16.6	—	1.2	4.3	40.8	1.9	—	Trace
Tiger ³ (<i>F. tigris</i>)	1.3	12.8	26.8	5.0	—	—	54.1	—	—	—
Tiger ⁴	1.0	22.5	24.6	1.2	0.6	7.1	38.9	4.1	—	—
Tiger ⁵	3.0	26.8	10.7	—	0.6	5.6	38.1	6.2	6.8	1.8
Puma ⁶ (<i>F. concolor</i>)	1.3	22.4	26.9	3.7	—	12.6	26.2	2.3	—	4.6
Puma ⁷	4.1	24.2	10.5	0.8	0.9	4.6	39.5	8.6	3.6	3.2

* Includes all unsaturated acids higher than C_{18} .

¹ Hilditch, Sime & Maddison (1942), also decanoic, 1.4 %; lauric, 1.1 %; ² Hilditch *et al.* (1942), also lauric, 2.4 %; ³ Pathak & Godbole (1945); ⁴ Pathak & Agarwal (1952); ⁵ present work, also hexadecadienoic, 0.2 %; hexadecatrienoic, 0.2 %; ⁶ Giral (1945); ⁷ present work.

Table 6. *Relation between diet and fatty acid composition*

All values % (w/w) except for iodine values.

		Iodine value	Saturated		Unsaturated			
			C ₁₆	C ₁₈	C ₁₆ (-2.0 H)	C ₁₈ (-2.0 H)	C ₁₈ (-4.0 H)	C ₁₈ (-6.0 H)
Dietary animals	{ Deer ¹	35.5	25	35	3	25	3	2
	{ Sheep ²	41.2	25	31	—	36	4	—
Carnivores fed on above	{ Puma ³	38.8	22	27	13	26	2	—
	{ Tiger ⁴	49.2	23	25	7	39	4	—
Dietary animal	Horse ⁵	95.6	26	5	7	34	5	16
Carnivores fed on above	{ Puma ⁶	69.7	24	11	5	40	9	4
	{ Tiger ⁶	70.5	27	11	6	38	6	7

¹ Gunstone & Paton (1953); ² Collin, Hilditch & Lea (1929); ³ Giral (1945); ⁴ Pathak & Agarwal (1952); ⁵ Gupta & Hilditch (1951); ⁶ present work.

In an earlier paper (Gunstone, 1955) it was stated that the fall in stearic acid content which accompanies the increase in iodine value over a range of land animal fats is balanced by an increase in oleic acid and, in the higher range of iodine value, by the appearance of large amounts of octadecadienoic acid. This is borne out by the present results if total polyethenoid C₁₈ acids be substituted for octadecadienoic acid.

It is now recognized that animal fat is a mixture of synthesized and assimilated fat, the relative amounts of these two varying with the species of animal. These figures for tiger and puma fat appear to provide an example of the effect of diet on fat composition, for the fats previously examined come from animals in their natural habitat and feeding mainly on deer and sheep both of which produce 'stearic-rich' fats. The fats now examined, on the other hand, come from animals fed partly on horse flesh and the composition of their fats shows some resemblance to horse fat which is not stearic-rich, but highly unsaturated with octadecatrienoic acid as a major component acid. These figures are collected together in Table 6, the values for stearic and the polyethenoid C₁₈ acids being particularly illustrative.

The results now available suggest that the fat laid down by carnivorous animals contains a high proportion of assimilated fat, so that the composition will be highly dependent on the diet. In

particular, captive animals fed on horse flesh will produce fat quite different from animals living on species which produce 'stearic-rich' depot fats.

SUMMARY

1. Specimens of fat from a tiger and a puma kept in captivity have been examined. They are more unsaturated than specimens previously reported from wild animals of the same species.

2. These differences are probably related to differences of diet.

The author wishes to thank Professor T. F. Hewer of Bristol for supplying the fats used in this investigation.

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