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The Component Acids of Milk Fats of *Balaenoptera physalus* (Finner Whale)

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Although the component acids of the milk fats of many land animals, especially ruminants, are characterized by the presence of acids of lower molecular weight than those present in their respective depot fats, the component acids of milk fats of marine mammalia so far examined are qualitatively and to a greater or lesser extent quantitatively similar to those of their blubber fats. Thus Schmidt-Nielsen & Frog (1933) were unable to identify any acids of lower molecular weight than lauric in the component acids of milk fat of finner whale (*Balaenoptera physalus*) and showed that the proportions of the chief groups of acids (saturated and unsaturated together) were: C_{14} , 5.5; C_{16} , 22; C_{18} , 32; C_{20-22} , 39. These results, taken in conjunction with the iodine value of the oil (137.8) and the presence of palmitoleic, oleic, gadoleic, and 'clupanodonic' acids, were considered to indicate the close similarity between the milk and blubber fats. Similar figures reported by Klem (1935) for the milk fat of the blue whale (*Balaenoptera musculus*) are in agreement with this view. The values obtained by Klem are nevertheless somewhat speculative, since he reported the loss of a fraction comprising about 24% of the mixed acids, and was obliged to make tentative assumptions as to the composition of this fraction. In spite of this indeterminacy the results obtained by Klem are in good agreement with those obtained in the present work. Meara (1952), however, showed that although the component acids of seal milk fat were broadly similar to those of seal blubber fat there were certain significant differences notably in the palmitic acid contents.

The present investigation, which was made possible by Dr J. C. D. White, who kindly placed four specimens of finner-whale milk at our disposal, was carried out to determine how far the broad

similarity between the milk and blubber fats holds, and to determine whether any significant differences similar to those which obtain in the case of seal milk and blubber fatty acids also occur in whale milk and blubber fats respectively.

METHODS AND RESULTS

The following data supplied by Dr White indicate the origin of the milk from which the fats were extracted. For each finner whale the length, and the time after death at which the sample was taken, are given. *A*: 72 ft. (23.5 m.), 7 hr. 45 min.; *B*: 68 ft. (22.1 m.), 6 hr.; *C*: 69 ft. (22.3 m.), 16 hr. (sample obtained from nipple and probably purest sample); *D*: 73 ft. (23.7 m.), 19 hr. (whale appeared to be drying off; a little blood present from external source).

The samples were viscous, resembling condensed milk in consistency, pale pink in colour, and appeared to be in good condition, with the exception of specimen *D*, which had a highly rancid fishy odour and was contaminated with blood and aqueous medium. Each sample was extracted in the manner described by Meara (1952) for seal milk fat, the extraction data together with the chemical characteristics of the extract being given in Table 1.

The component acids of each milk fat were determined as reported by Meara (1952). Unsaponifiable matter was removed from the soaps after saponification of the fat. Steam distillation of the regenerated fatty acids, followed by titration of the steam distillate, indicated the absence of the lower molecular weight steam-volatile fatty acids. The recovered acids were resolved by low-temperature crystallization into groups which consisted of mainly saturated, mainly monoethenoid, and mainly polyethenoid acids, respectively, each group being methylated (Bjarnason & Meara, 1944) and fractionally distilled. From the analytical data obtained the composition of each ester fraction was computed (Hilditch, 1947, pp. 498-510); thence the composition of each group of acids, and finally the composition of the whole fat was deduced.

The final results of these analyses, together with data on related fats, are given in Table 2.

Table 1. *Extraction and analytical data of whale milks and fats*

Extraction of milks								
Specimen ...	...	...	...	...	A	B	C	D
Milk (g.)					211	348	349	115
Fat extracted (g.)					115.0	140.5	129.4	26.38
(%)					54.5	40.4	37.1	22.9
Solid residue (g.)					21.0	17.0	39.0	23.0
(%)					9.9	4.9	11.2	20.0
Water content (g.)					75.2	190.5	180.6	65.6
(%)					35.6	54.7	51.8	57.0
Analytical data for milk fats								
Specimen ...	...	...	...	...	A	B	C	D
Saponification equivalent					295.5	295.4	297.3	293.5
Iodine value					170.3	177.3	149.0	162.1
Free fatty acids (% as oleic acid)					0.7	0.7	0.6	1.1
Unsaponifiable matter (%)					0.9	0.7	1.2	1.8
Iodine value of unsaponifiable matter					168.0	169.0	124.5	169.6

Table 2. *Component fatty acids of whale and seal milk and blubber fats*

(All values are %, w/w.)

	Finner-whale milk				Blue-whale milk (Klem, 1935)	Whale blubber (Hilditch & Maddison, 1948)	Grey seal	
	A	B	C	D			Milk	Blubber
	(Present investigation)						(Meara, 1952)	(Cardin, 1952)
Iodine value of fat	170.3	177.3	149.0	162.1	171.8	95.0	146.2	157.9
Acid								
Lauric	0.7	—	—	—	—	Trace	—	—
Myristic	7.1	7.3	10.0	2.4	8.4	9.2	2.8	3.4
Palmitic	15.8	16.6	17.6	14.0	16.8	15.6	16.4	8.9
Stearic	3.7	2.9	3.4	3.1	1.8	1.9	2.8	1.8
Arachidic	—	0.8	0.3	—	—	0.6	—	0.2
Unsatd. C ₁₄	1.0	2.4	1.4	0.5	1.2	2.5	1.7	2.0
Unsatd. C ₁₆	7.9	6.2	8.1	6.7	6.2	13.9	12.7	15.6
Unsatd. C ₁₈	29.7	29.7	26.6	37.2	26.8	37.2	36.6	33.3
Unsatd. C ₂₀	18.2	19.1	17.6	21.5	25.9	12.0	13.6	18.7
Unsatd. C ₂₂	15.9	15.0	15.0	14.6	12.9	7.1	13.4	16.0
Mean unsaturation of								
Unsatd. C ₁₄	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
Unsatd. C ₁₆	-2.2	-2.7	-2.8	-2.9	-2.0	-2.1	-2.2	-2.2
Unsatd. C ₁₈	-2.8	-3.3	-2.4	-2.8	-3.3	-2.4	-2.3	-2.5
Unsatd. C ₂₀	-7.9	-8.2	-7.6	-6.0	-8.5	-7.1	-6.6	-6.2
Unsatd. C ₂₂	-11.0	-10.8	-10.1	-10.9	-11.0	-9.4	-11.2	-10.1

DISCUSSION

The pink coloration of whale milk appears to be due to natural pigmentation and not to contamination from the mammary glands, from which the material of specimens *A* and *B* were obtained, since the specimen *C* drawn from the nipple was equally pink in colour.

Clowes (1929) indicated that considerable difficulties arise in the sampling of whale milk. If the milk is obtained by dissection of the mammary glands, blubber oil and blood are possible contaminants. Specimen *D* was contaminated in this way, whereas specimens *A* and *B*, also obtained by dissection of the mammary gland, showed no signs of contamination.

In order to obtain a representative sample of the milk of ruminants it is desirable to take the whole content of the milk reservoir. Thus the 'fore-milk' drawn from the lower part of a cow's udder may contain only 1.7% of fat while the last drawn 'strippings' may contain 4–10% of fat. It is not known, however, whether the fats from 'fore-milk' and 'strippings' differ in composition to any marked extent; though Baldwin & Longenecker (1944) have shown that cow colostrum fat differs slightly from milk fat produced later in the lactation period. In the present instance where the milks have a high viscosity it is unlikely that creaming of the milk, or preferential segregation of the glycerides, occurs.

In this discussion only specimens *A*, *B* and *C* will be considered, since specimen *D* being rancid and

contaminated cannot be perhaps regarded as representative. A further limitation is that small samples of highly complex fats cannot be analysed as accurately as larger specimens. The differences between the results obtained for specimen *D* and the other two fats of approximately the same iodine value (specimens *A* and *B*) are, however, considerably in excess of any expected experimental error.

Table 2 includes the component fatty acids of the milk fat of blue whales reported by Klem and the component fatty acids of a commercial specimen of whale oil (Hilditch & Maddison, 1948). Whilst the latter specimen consists predominantly of that of the blue whale, these values may be regarded as typical of commercial Antarctic-whale blubber oils, since it is known (Armstrong & Allan, 1924; Tveraen, 1935; Hilditch & Maddison, 1948) that the composition of whale oils varies but little from season to season. The possibility of slight variation in composition of the blubber fat with species differences, however, cannot be completely eliminated. The table also includes data for the composition of milk and blubber fats of the grey Atlantic seal (*Halichoerus grypus*).

It is apparent from the table that no such marked divergency occurs between the component fatty acids of the milk and blubber fats of the whale as occurs between the milk and depot fats respectively of the ruminants and other land animals. The saturated-acid contents of the present milk fats are in remarkably close agreement with those obtained by Klem (1935) for the milk fat of the blue whale, and with those recorded by Hilditch & Maddison (1948) for whale blubber fat. These values are in marked contrast to those in seal milk and blubber fats; here the palmitic acid content of the milk fat (16.4%) is about twice that (8.9%) of the blubber fat. There is, however, little difference between the unsaturated acids of seal milk and blubber fats.

Although the whale milk and blubber fats are practically identical in their saturated acid contents, this is not so for the unsaturated acids. Thus, while the unsaturated C_{14} acid content remains approximately constant in all the fats, the milk fats contain about 6–8% C_{16} unsaturated acids whilst the blubber fat contains 14%. Similarly, the percentage content of C_{18} unsaturated acids in the milk fat is about 6–7 units lower than that in the blubber. On the other hand, milk fat contains more C_{20} and C_{22} unsaturated acids than blubber fat.

The low iodine value of the fat from specimen *C* is not apparently due to any one particular cause. The total content of saturated acids is only 4–5% higher than that of specimens *A* and *B*; this is due to an

increase in the myristic and palmitic acid content at the expense primarily of the unsaturated C_{18} and C_{20} acids, the mean unsaturations of which are also significantly lower.

Though broadly speaking the milk fats of the marine mammalia are similar to their respective blubber fats, it may be difficult to arrive at a simple correlation between them. It is probable, however, that a simpler relationship exists between the milk and blubber fats of marine mammalia than obtains in the milk and depot fats of land animals. The iodine values in Table 2 show that the mean unsaturation of whale milk fat is greater than that of the blubber fat, while the converse is true in the case of the seal. If in marine mammalia the milk fat is derived more or less directly from the blubber fats, it follows that a preferential mobilization of the more unsaturated components of the blubber fat has taken place. This would result in the blubber of a lactating whale being somewhat richer in the more saturated components, the blubber fat therefore having a lower iodine value. Klem (1935) has reported lower iodine values for the blubber fats of lactating whales than for the fats from the same sites in healthy males and non-lactating females. The lactating seal, however, appears to metabolize the more saturated components of the blubber for milk production thereby increasing the mean unsaturation of its blubber fat. Unfortunately no adequate data are available for the comparison of the blubber fats of the lactating and non-lactating seal since it is now well established (Hilditch & Pathak, 1949; Winter & Nunn, 1950*a, b, c*; Cardin, 1952) that seal blubber fats vary considerably in composition depending among other things on diet, sex and age.

SUMMARY

1. Finner-whale (*Balaenoptera physalus*) milks resemble that of the grey Atlantic seal (*Halichoerus grypus*) in that the fat content is of the order of 10 times that of the milk of land animals.

2. Whale milk fat contains only those acids which occur in the blubber fat; though there is a broad similarity between milk and blubber fats, differences occur in the proportions of the unsaturated acids.

3. Whale milk fat is more unsaturated than the blubber fat; the reverse is true for lactating seals. It is suggested that this is due to selective mobilization of blubber fat for milk production.

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