

# FATTY ACID COMPONENTS OF BLACK RIGHT WHALE OIL BY GAS CHROMATOGRAPHY

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## INTRODUCTION

There have been a number of studies on whale oil. However, there are a few studies on black right whale oil. As to the study on black right whale oil, we can find the following reports; Studies on the oil of black right whale in the Northern Pacific Ocean (Tsuyuki and Naruse, 1963), Studies on the lipids in brain of black right whale in the Northern Pacific Ocean (Tsuyuki and Naruse, 1964), Studies on liver oil of black right whale (Tsuyuki, Naruse, Mochizuki and Itoh, 1964).

So far as these works concerned with chemical properties of oils and fatty acid components by fractional distillation, minute examinations of fatty acid components have not been reported yet.

So the purpose of the present work is a minute examination of the fatty acid components of black right whale oil by gas-liquid chromatography using a hydrogen ionization detector.

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## MATERIAL AND METHOD

### *Sample used*

Material is the black right whale, *Eubalaena glacialis*, (male, body length: 17.1 m, presumed age: more than 12 years old) which was caught at the southern sea of Kodiak Island in the Northern Pacific Ocean in 1962 (Tsuyuki and Naruse, 1963).

The oils contained in 9 parts of blubbers were obtained by boiling these blubbers with water and those in 3 kinds of organs were extracted with acetone in an atmosphere of nitrogen gas. The oils used in the present report were stocks used in previous reports (Tsuyuki and Naruse, 1963, 1964). The bottles of sample oils have been filled up with nitrogen gas and preserved in refrigerator at low temperature.

Used sample oils are the oils contained in 3 kinds of organs (stomach, liver and tongue), and 9 parts of blubbers (middle back, thoracic, abdominal, brain, hind part of blow-hole, umbilicus, anterior abdominal, fore part of genital aperture and posterior back). The properties of 9 blubber oils and 3 organ oils are shown in Table 1.

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TABLE 1. PROPERTIES OF THE OILS CONTAINED IN VARIOUS BLUBBERS AND ORGANS OF BLACK RIGHT WHALE

Kinds of blubber and organ	Acid value	Saponification value	Iodine value	Unsaponifiable Matter (%)
Stomach	0.8	192.6	131.5	1.02
Liver	2.5	189.5	131.4	1.45
Tongue	2.1	195.4	115.1	1.18
Middle back blubber	1.2	196.6	126.6	0.77
Thoracic blubber	1.1	191.8	123.8	1.05
Abdominal blubber	0.7	187.6	130.5	0.94
Brain blubber	1.1	182.4	134.0	0.80
Blubber of hind part of blow-hole	1.5	194.1	127.1	1.14
Umbilicus blubber	1.6	190.4	128.6	1.05
Anterior abdominal blubber	1.6	190.7	134.9	0.80
Blubber of fore part of genital aperture	1.9	193.7	132.6	0.91
Posterior back blubber	1.8	190.0	129.7	0.70

#### *Preparation of methyl ester of fatty acid*

The methyl esters of the fatty acids of sample oils were prepared by a semi-micro methanolysis adapted to the method of Gauglitz and Lehmann (1963) for use in gas-liquid chromatography analysis. Then, to remove cholesterol, coloring materials, impurities and others, the methyl esters were refined by passing through in glass column packed with silicic acid.

#### *Gas-liquid chromatography*

The methyl esters of the fatty acids of the black right whale oils were analyzed with a Shimadzu Gas Chromatograph Apparatus, Model GC-1 C. The instrument was equipped with a hydrogen ionization detector. The column used was composed of 3 mm in diameter by 225 cm U shaped stainless steel column containing 20% diethylene glycol succinate polyester (DEGS from Shimadzu Seisakusyo Co.) supported on 60-80 mesh Shimalite. Operating conditions were as follows; column temp. 210°C, injector temp. 260°C, detector temp. 240°C. A column inlet pressure of 1.80 kg/cm<sup>2</sup> N<sub>2</sub> was used, which measured 70-74 ml/min. at the flow rate.

Each peak was identified by comparing retention time with those in a known mixture of standard fatty acid methyl esters (C<sub>10</sub> to C<sub>24</sub> as saturated fatty acids, and C<sub>16</sub> monoenoic acid and C<sub>18</sub> mono-, di- and trienoic acids as unsaturated fatty acids), and semilogarithmic plots of carbon number *vs* relative retention time were used for identification by the method of Nelson and Freeman (1960). Also, for the purpose of identification of odd carbon chain length fatty acids, the hydrogenation was operated as follows; the *n*-hexanate solution of methyl esters was added a pinch of palladium on activated carbon as a catalyst. The mixture was shaken in a small flask for 5-6 hours under hydrogen atmosphere (approximate 1.5 kg/cm<sup>2</sup>) at room temperature, and then filtered. The hydrogenated methyl esters were operated by gas chromatograph at the same condition.

TABLE 2. FATTY ACID COMPONENTS OF OILS CONTAINED IN VARIOUS BLUBBERS AND ORGANS OF BLACK RIGHT WHALE

Fatty acid chain length	No. C atoms	Double bond	Stomach	Liver	Tongue	Middle back blubber	Thoracic blubber	Abdominal blubber	Brain blubber	Blubber of hind part of blow-hole	Umbilicus blubber	Anterior abdominal blubber	Blubber of fore part of genital aperture	Posterior back blubber	Weight per cent of total fatty acids	
															No. per molecule	
10	0	1.21	0.63	0.34	0.78	0.40	0.54	0.66	0.33	0.81	0.78	0.37	0.82			
12	0	0.72	0.16	0.12	0.19	0.35	0.26	0.53	0.15	0.26	0.21	0.17	0.28			
13	0	0.01	trace	0.03	trace	0.18	trace	0.14	trace	0.03	0.12	trace	0.12			
14	0	5.48	6.22	6.40	6.60	5.37	5.76	6.61	5.24	5.83	6.93	8.11	6.10			
14	1	1.51	1.39	1.52	0.49	1.02	0.68	0.76	0.38	0.82	1.30	0.72	2.04			
14	2	1.02	0.81	0.31	0.17	0.64	0.65	0.51	0.45	0.46	1.08	0.34	1.06			
15	0	0.26	0.21	0.16	0.21	0.24	0.35	0.09	0.19	0.33	0.17	0.13	0.11			
16	0	6.26	6.69	6.90	8.85	6.51	6.26	8.37	5.95	6.50	6.49	6.96	5.20			
16	1	6.09	4.80	5.53	4.05	8.40	5.15	7.04	3.60	4.57	5.81	5.03	6.75			
16	2	2.66	2.48	2.10	1.16	1.63	1.12	1.45	1.13	1.91	2.53	1.30	1.79			
17	0	1.22	0.90	0.80	1.37	1.31	0.81	1.36	1.03	1.06	1.07	1.40	1.05			
18	0	1.08	1.21	1.27	2.93	1.92	1.14	1.26	1.81	1.19	1.15	1.54	1.63			
18	1	17.74	18.93	18.97	17.79	22.62	21.26	17.61	21.55	17.96	18.51	19.56	18.50			
18	2	1.64	1.34	1.33	1.96	1.99	1.30	1.64	1.16	2.01	1.75	1.41	1.72			
18	3	2.42	2.36	2.31	3.12	1.80	1.32	2.43	1.61	2.44	2.18	1.99	2.37			
19	0	1.11	1.90	1.29	1.01	0.87	0.65	1.39	1.15	0.97	0.93	1.17	1.50			
20	0	0.90	1.82	1.07	2.56	2.26	1.81	1.25	2.31	1.37	1.26	1.63	1.53			
20	1	19.03	21.83	21.41	21.44	19.39	23.39	18.23	21.15	21.26	18.91	20.90	20.36			
20	2	0.75	0.94	0.65	0.82	0.21	1.73	1.22	1.18	0.97	1.22	1.34	1.66			
20	3	2.29	0.73	0.90	0.73	0.19	1.30	0.57	1.37	1.02	2.54	1.50	1.94			
20	4	1.51	1.65	1.00	1.46	2.01	2.52	1.46	2.01	1.10	1.76	2.21	2.32			
20	5	18.62	16.64	17.98	16.65	16.26	15.56	17.66	18.47	18.67	16.94	15.17	16.76			
22	1	1.34	0.85	1.25	1.14	—	1.17	1.06	2.62	1.05	1.41	1.91	0.98			
22	5	1.83	1.86	2.01	1.68	1.20	1.03	1.78	1.37	3.15	1.89	1.26	1.11			
22	6	3.30	3.67	4.35	2.84	3.23	4.16	4.92	3.79	4.26	3.06	3.88	2.30			

The each peak was quantitated by the method of Magidmann *et al* (1962). All fatty acids were calculated as weight percentages of the total known fatty acids present.

### RESULTS AND DISCUSSION

In this investigation, we confirmed about 25 kinds of fatty acids in the black right whale oil, as the results of the analysis are reported in Table 2. There are as saturated fatty acids, C<sub>10</sub>, C<sub>12</sub>, C<sub>13</sub>, C<sub>14</sub>, C<sub>15</sub>, C<sub>16</sub>, C<sub>17</sub>, C<sub>18</sub>, C<sub>19</sub> and C<sub>20</sub>, and as unsaturated fatty acids, C<sub>14</sub> monoenoic, C<sub>14</sub> dienoic, C<sub>16</sub> monoenoic, C<sub>16</sub> dienoic, C<sub>18</sub> monoenoic, C<sub>18</sub> dienoic, C<sub>18</sub> trienoic, C<sub>20</sub> monoenoic, C<sub>20</sub> dienoic, C<sub>20</sub> trienoic, C<sub>20</sub> tetraenoic, C<sub>20</sub> pentaenoic, C<sub>22</sub> monoenoic, C<sub>22</sub> pentaenoic and C<sub>22</sub> hexaenoic.

There is no remarkable difference in the fatty acid components of oils contained in various parts of the black right whale body. As the main component fatty acids belong to unsaturated fatty acids, these are C<sub>20</sub> monoenoic 18.23-23.46% (average 20.7%), C<sub>18</sub> monoenoic 17.74-22.62% (av. 19.25%) and C<sub>20</sub> pentaenoic 15.17-18.67% (av. 17.12%). The next prominent fatty acids are C<sub>16</sub> saturated 5.20-

TABLE 3. EACH FATTY ACID CONTENT OF OILS IN VARIOUS BLUBBERS AND ORGANS (in order of high percentages)

Order	Fatty acid chain length No. C atoms	Double bond No. per molecule	Weight per cent of total fatty acids	Average percentages
1	20	1	18.23-23.46	20.70
2	18	1	17.74-22.62	19.25
3	20	5	15.17-18.67	17.12
4	16	0	5.20- 8.85	6.75
5	14	0	5.24- 6.93	6.22
6	16	1	3.60- 3.40	5.57
7	22	6	2.30- 4.92	3.65
8	18	3	2.32- 3.12	2.20
9	16	2	1.12- 2.66	1.77
10	20	4	1.00- 2.52	1.75
11	22	5	1.03- 2.01	1.68
12	20	0	0.90- 2.56	1.65
13	18	2	1.16- 2.01	1.60
14	18	0	1.08- 2.93	1.51
15	20	3	0.19- 2.29	1.26
16	22	1	0.85- 2.62	1.23
17	19	0	0.65- 1.90	1.16
18	17	0	0.80- 1.37	1.12
19	20	2	0.21- 1.73	1.12
20	14	1	0.38- 1.52	1.06
21	14	2	0.17- 1.08	1.05
22	10	0	0.33- 1.21	0.61
23	12	0	0.12- 1.21	0.28
24	15	0	0.09- 0.35	0.20
25	13	0	trace- 0.18	0.05

TABLE 4. A COMPARISON OF SATURATED AND UNSATURATED FATTY ACID OF BLACK RIGHT WHALE OIL

Fatty acid chain length No. C atoms	Weight per cent of total fatty acids			
	Saturated	Averages	Unsaturated	Averages
10	0.33-1.21	0.61	—	—
12	0.12-0.72	0.28	—	—
13	trace-0.18	0.05	—	—
14	5.24-6.93	6.22	0.38- 1.52	1.05
15	0.09-0.35	0.20	—	—
16	5.20-8.85	6.75	4.60-10.92	7.34
17	0.80-1.37	1.12	—	—
18	1.08-2.93	1.51	10.02-27.29	23.05
19	0.65-1.90	1.16	—	—
20	0.90-2.56	1.65	34.83-48.16	41.89
22	—	—	4.05-10.10	6.53
Total		19.55		79.86

8.85% (av. 6.75%), C<sub>14</sub> saturated 5.24-6.93% (av. 6.22%) and C<sub>16</sub> monoenoic 3.60-8.40% (av. 5.57%). The total of the above mentioned fatty acids holds really 64.18-88.93% (av. 75.61%) of all total fatty acids. (Table 3)

In comparison with saturated and unsaturated fatty acids, the proportions of total saturated fatty acids are 19.55% (average), and those of total unsaturated fatty acids are 79.86% (average) as shown in Table 4. In view of these facts, the principal fatty acids of the black right whale oil are monoenoic and polyenoic unsaturated fatty acids.

### SUMMARY

1. Fatty acid components of oils contained in 9 parts of blubbers and 3 kinds of organs of black right whale, *Eubalaena glacialis*, caught in the Northern Pacific Ocean were analyzed by gas-liquid chromatograph using a hydrogen ionization detector on a DEGS column.

2. Fatty acid components of the above mentioned sample oils were as follows;

C <sub>20</sub> monoenoic	18.23-23.46% (av. 20.70%)
C <sub>18</sub> monoenoic	17.74-22.62% (av. 19.25%)
C <sub>20</sub> pentaenoic	15.17-18.67% (av. 17.12%)
C <sub>16</sub> saturated	5.20- 8.85% (av. 6.75%)
C <sub>14</sub> saturated	5.24- 6.93% (av. 6.22%)
C <sub>16</sub> monoenoic	3.60- 8.40% (av. 5.57%)
C <sub>22</sub> hexaenoic	2.30- 4.92% (av. 3.65%)
C <sub>18</sub> trienoic	2.32- 3.12% (av. 2.20%)
C <sub>16</sub> dienoic	1.12- 2.66% (av. 1.77%)
C <sub>20</sub> tetraenoic	1.00- 2.52% (av. 1.75%)
C <sub>22</sub> pentaenoic	1.03- 2.01% (av. 1.68%)
C <sub>20</sub> saturated	0.90- 2.56% (av. 1.65%)

C <sub>18</sub> dienoic	1.16– 2.01% (av. 1.60%)
C <sub>18</sub> saturated	1.08– 2.93% (av. 1.51%)
C <sub>20</sub> trienoic	0.19– 2.29% (av. 1.26%)
C <sub>22</sub> monoenoic	0.85– 2.62% (av. 1.23%)
C <sub>19</sub> saturated	0.65– 1.90% (av. 1.16%)
C <sub>17</sub> saturated	0.80– 1.37% (av. 1.12%)
C <sub>20</sub> dienoic	0.21– 1.73% (av. 1.06%)
C <sub>14</sub> monoenoic	0.38– 1.52% (av. 1.05%)
C <sub>14</sub> dienoic	0.17– 1.08% (av. 0.63%)
C <sub>10</sub> saturated	0.33– 1.21% (av. 0.61%)
C <sub>12</sub> saturated	0.12– 0.72% (av. 0.28%)
C <sub>15</sub> saturated	0.09– 0.35% (av. 0.20%)
C <sub>13</sub> saturated	trace– 0.18% (av. 0.05%)

3. A substantial part of the saturated acids were hexadecanoic (5.20–8.85%) and tetradecanoic (5.24–6.93%). On the other hand, that of the unsaturated acids were nonadecamonoenoic (18.23–23.46%), octadecamonoenoic (17.74–22.62%) and nonadecapentaenoic (15.17–18.67%).

4. The difference in the fatty acid components of various blubbers and organs of the black right whale was not found clearly.

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