

Composition of Fin Whale Milk

By

KEIZO OHTA, TOSHINAO WATARAI, TETSU ŌISHI, YUKIO UESHIBA,
SHINICHI HIROSE, TōRU YOSHIKAWA, YAEKO AKIKUSA,
MICHIO SATŌ and HIDEKO OKANO

(Department of Pediatrics, Tokyo Dental and Medical University)

Introduction

In studying the relation between the rate of growth and the composition of the milk during the nursing stage of various mammals, as shown in Table I, the greater the rate of growth is, the greater is the amount of substances necessary for the organization of the body, as protein, minerals, etc., contained in the milk of the animal.¹⁾

Table I. Rate of Growth and Composition of Milk of Various Mammals

	Days required for the body weight at birth to double	Protein %	Minerals %
Human	120	1.30	0.30
Horse	60	2.14	0.35
Cow	47	3.50	0.75
Goat	22	3.76	0.85
Sheep	15	5.15	0.93
Hog	14	6.20	1.07
Cat	9½	9.08	0.51
Dog	9	9.72	0.91

From Pfaundler and Schlossmann's Handbuch der Kinderheilkunde

Of the mammals the animal with the largest body is the Cetacea. According to Peters²⁾ the length of the fin whale at birth averages 6 meters, and 6 months later (at the end of the nursing stage) it becomes 12 meters, at 1 year 15 meters, at 2 years 19 meters and at 6-8 years 21 meters. According to Nishiwaki³⁾ the male reaches the sexual maturity in 3.5 years, the female in 4 years, and it is said that it lives 25-30 years. In other words, throughout the course of life the rate of growth during the nursing stage is the greatest. In this sense the analysis of the whale milk is an interesting subject but reports on this are very few.

A report will be made in this paper on the results obtained by analyzing the milk from 3 fin whales by comparing it with the human and cow milk.

Materials

The whale milk the authors used in this study was that obtained from 3 fin whales which will be tentatively called fin whale milk A, B and C, respectively.

The fin whale milk A and B was obtained from the 2 fin whales captured by the Tonnan-maru group of ships belonging to the Nihon Suisan Kabushiki Kaisha (Japan Fisheries Co., Ltd.) in the Antarctic Ocean (near the Ross Bay), and the fin whale milk C from the fin whale captured by the Baikaru-maru group of ships organized jointly by the 3 companies, Kyokuyo Hogeï (Polar whaling co.), Nihon Suisan (Japan Fisheries co.) and Taiyo Gyogyō Co., in the Arctic Ocean (south of the Aleutian Islands), the milk being obtained at the time the whales were slaughtered after being captured, preserved in an electric refrigerator and sent to the authors through the courtesy of Dr. M. Nishiwaki of the whale Research Institute in Tokyo. The authors express their thanks to those cooperating in the collection and transportation of the fin whale milk.

The general characteristics of the fin whale A, B and C are shown in Table II.

Whale milk A was a part of about 2 liters of milk flowing out from the mammary gland of a 71-foot fin whale during dissection, and from the state of the mammary gland, uterus and corpus luteum. This fin whale was considered to be in the last half of the nursing stage. This milk was collected on Feb. 8, 1952, and 136 grams of it were sent to the authors on March 4, 1953. Whale milk B was a part of about 0.5 liter of milk flowing out from the mammary gland of a 72-foot fin whale during dissection and was considered to be in the weaning stage. This milk was collected on March 12, 1953, and 128 grams of it were sent to the authors on May 14, 1953. Whale milk C was a part of about 2 liters flowing out from the mammary gland of a 65-foot fin whale and was considered to be in the last half of the nursing stage. This milk was collected on August 29, 1953, and 130 grams of it were sent to the authors on Oct. 24, 1953.

Results

Color and external appearance: Fin whale milk A was of a cream color with a brownish yellow tone, fin whale milk B a cream color with a light red tone and fin whale milk C a milk white color, all being of the so-called cream color. According to Dr. Nishiwaki the color of the fin whale milk A and B was said to be darker than that

Table II. General Characteristics of Whales Captured in the Antarctic and Arctic Oceans (Courtesy of Dr. Nishiwaki)

	A	B	C
Name of Whaling ship group	Tonan-maru (Antarctic Ocean)	Tonan-maru (Antarctic Ocean)	Baikaru-maru (Arctic Ocean)
Date of slaughter (Capture)	05; 55, Feb. 8, 1952	18; 30, March 12, 1953	05; 45, Aug. 29, 1953
Date of beginning of treatment	19; 15, Feb. 8, 1952	20; 40, March 12, 1953	
Place of slaughter (Capture)	S. lat. 69°23'; W. long. 166°47'	S. lat. 69°48'; W. long. 163°12'	N. lat. 50°27' E. long. 162°23'
Kind of Whale	Fin	Fin	Fin
Sex	Female	Female	Female
Length	71 feet	72 feet	65 feet
Thickness of subcutaneous fat	6.0 cm.	6.0 cm.	6.0 cm.
Gastric content	(—)	(—)	(—)
Embryo	(—)	(—)	(—)
Amount of milk	About 2 lit.	About 0.5 lit.	About 2 lit.
Thickness of mammary gland	22.5 cm.	11.0 cm.	19.0 cm.
Color of mammary gland	White		Brownish yellow
Maximum width of uterus cornu	Left 14 cm Right 16 cm	Right and left almost the same	Left 20 cm Right 20 cm
Color of uterus	Grayish yellow		Brownish red
Weight of ovary	Old: right 7 left 5	Old: right 7 left 9	Left 1.2 kg. Right 1.0 kg.
Number of corpora lutea	New (—)	New (—)	Old: right 3 left 4 New (—)
Maximum diameter of corpus luteum	Left 5.5 cm. Right 4.0 cm.	Right 4.5 × 3.5 × 4.0 cm.	6.0 cm.
Stage of secretion	Latter half stage	Latter half stage (Weaning state)	Beginning of latter half of lactation stage
Date whale milk was received	March 4, 1953	May 14, 1953	Oct. 24, 1953

of the fresh milk. The external appearance of all 3 showed a very thick creamy state. (Table III)

Table III.

Color Tone				
Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
Cream color (Light brownish yellowish white color)	Cream color with light red tone	Cream color (Milk white color)	Milk white color with bluish tone	Milk white color with yellowish tone
Taste and flavor				
Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
Flavor resembles cod liver oil Taste astringent	Same as whale milk A	Somewhat fishy smell Astringent taste light	Fishy smell A little sweet	Aromatic Very slightly sweet

Taste and flavor: Both fin whale milk A and B had a flavor resembling a cod liver oil and the taste was somewhat astringent but the fin whale milk C had a somewhat fishy smell and compared to the former 2 the astringent taste was light. According to Dr. Nishiwaki the taste and flavor of the fin whale milk C were said to be close to those of the fresh milk but those of the fin whale milk A and B were stronger than those of the fresh milk. (Table III)

Specific gravity: (18°C)

Measuring method¹⁾—The specific gravity of the whale milk was determined by the copper sulfate method. In case the specific gravity was lighter than that of water, a drop of the milk was dropped into a measuring cylinder with a certain amount of water, and then alcohol was added little by little, determining the proportion of water to alcohol where this drop of milk neither sank nor rose. The specific gravity of this mixture of water and alcohol was measured and the value obtained was taken as the specific gravity of the whale milk. The specific gravity of the human and cow milk was determined by a hydrometer.

The specific gravity of the whale milk A was 1.012, whale milk B 0.994 and whale milk C 1.003, all being lighter than the specific gravity 1.032 of the human and cow milk (Table IV). This was probably due to the large amount of fat contained in the whale milk.

Surface tension: (20°C)

Measuring method²⁾—From the principle that the ratio of the surface tension between the two kinds of solutions is equal to the ratio between the specific gravity and the number of drops, the number of

drops of equal amounts of the whale milk and water was measured by using Traubes stalagmometer, and the surface tension of the whale milk was calculated with the surface tension of water (against air 72.8 dynes/cm) as the basis. As the whale milk was viscid and the surface tension could not be measured in this state, the whale milk was diluted 4-fold with distilled water and the surface tension was measured for general information. The surface tension of the whale milk A was 38.4 dynes/cm and whale milk B 39.8 dynes/cm, being far greater than that of the undiluted human and cow milk (Table IV). By the same method the surface tension of the whale milk C was measured but it could not be measured successively because the liberation of fat was rapid.

Table IV.

Specific gravity (18°C)				
Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
1.012	0.994	1.003	1.032	1.032
Surface tension (dyne/cm) (20°C)				
Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
As it was not measurable in the original state, the value is that diluted 4-fold with distilled water				
38.4	39.8	-----	44.4	51.2

Viscosity: (20°C)

Measuring method^o—The viscosity was measured by Hess' viscosimeter. As the viscosity of the whale milk was high and impossible to measure, the value was that of the whale milk diluted 4-fold with distilled water.

The value of the whale milk A was 2-6 centipoises, the whole milk B 6.4 centipoises and the whale milk C 1.2 centipoises. The viscosity of the whale milk A and B was far higher and that of the whale milk C was lower than that of the undiluted human and cow milk but it still showed that the viscosity of the whale milk A, B and C was quite high (Table V).

Boiling point:

Measuring method^o—The boiling point was measured roughly with a 200°C thermometer and accurately with Beckmann's apparatus. The boiling point of the whale milk A was 98.5°C and the whale milk B and C 98.2°C, being lower than that of the human and cow milk (Table V).

Table V.
Viscosity (centipoise) (20°C)

Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
As it was not measurable in the original state, the value is that diluted 4-fold with distilled water				
2.6	6.4	1.2	2.1	2.3
Boiling point (°C)				
Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
98.5	98.2	98.2	101.2	100.4

PH and acidity:

Measuring method—The PH was determined with the PH test paper manufactured by the Toyo Filter Paper Company, Ltd., and the acidity was measured by applying Soxhlet-Henkel's method³⁾: One to 2 drops of the alcohol solution, to which the indicator, phenolphthalein, was added at the rate of 2%, were added to 10cc of the whale milk and measured with 1/4N NaOH.

The PH of the whale milk A, B and C was 4.6, 6.2 and 6.4, respectively, all being lower than that of the human and cow milk. Especially the whale milk A and B showed a fairly high acidity, the acidity of the whale milk A being high with a value of 46.7 and that of the whale milk C being comparatively low with a value of 21 (Table VI). The reason for this was considered to be due probably to the whale milk A and B acidifying during the long period from the time of the collection of the milk to the time of analysis. As will be stated later, this fact was confirmed by the comparison of the amount of lactose contained in the 3 whale milk.

Table VI.

PH (Tōyō filter paper)				
Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
4.6	6.2	6.4	7.0	6.8
Acidity (Soxhlet-Henkel's method)				
Whale milk A	Whale milk B	Whale milk C	Human milk	Cow milk
46.7	—	21.0	5.0	7.1

Water content:

Measuring method⁹⁾⁽¹⁰⁾—The whale milk was mixed with refined white sand and dried by air bath of 98–100°C. The amount of the decrease in weight was made to represent the water content, which was expressed in %.

The water content was much less than that of the human and cow milk (Table VII) and the solid substances were about 4 times those of the human and cow milk, this naturally accounting for the creamy state of the whale milk.

Table VII.
Chemical composition (%)

	Water	Protein	Fat	Lactose	Minerals
Whale milk A	53.4	13.3	33.0	0.3	1.0
Whale milk B	55.0	12.3	31.8	0.2	0.7
Whale milk C	54.1	10.5	32.5	1.4	1.4
Human milk	87.5	1.7	3.5	7.1	0.2
Cow milk	88.1	3.4	3.1	4.7	0.7

Protein:

Measuring method¹¹⁾—Five grams of the whale milk were quantitatively measured for the total nitrogen by Kjeldahl's method, and the figure obtained by multiplying the amount of the total nitrogen by 6.38 was made to represent the amount of protein. Casein nitrogen was determined by adding 70–80 cc of water to 10 gm. of the whale milk, heating to 40–42°C., adjusting the PH to 4.5 with 1.0 cc of 10% acetic acid solution and 1.0 cc of 1 N sodium acetate solution, cooling, precipitating the casein, drying and filtrating this solution with the No. 6 Tōyō filter paper and measuring the nitrogen in the precipitate together with the filter paper by Kjeldahl's method. Noncasein nitrogen was determined by quantitatively measuring the nitrogen in 20 cc of the filtrate.

The soluble protein fractions of the whey were studied by dialyzing the filtrate of 40 cc (10gm.) of the whale milk, from which casein was removed by the same method stated above (human and cow milk was diluted to about 1:10 and the whale milk to about 1:40), in an ice room with a cellophane paper in a 50% gum arabic solution, concentrating the entire content to about 1/20 till the protein content became about 2–4% and then studying the protein fraction electrophoretically with Tiselius' apparatus.

The amount of protein was very great, being 6–8 times that of the human milk and 3–4 times that of the cow milk (Table VII).

There was less of the casein nitrogen than the noncasein nitrogen, being similar to the amount in the human milk (Table VIII). In studying the protein fractions, electrophoretically, of the whey of the whale milk C after removing the casein, as shown in Fig. I, the results of the analysis showed that the *A/G* ratio was 1.6, average albumin 61.8% and globulin 38.2%, the albumin, contrary to the human milk, being greater and that the globulin fractions were: α -globulin 2.5%, β -globulin 10.1% and γ -globulin 30.4%, γ -globulin being the greatest.

Table VIII.
Kinds of Proteins (mg%)

	Total N	Casein N	Noncasein N	N.P.N.
Whale milk A	2082	849 (41%)	1233 (59%)	—
Whale milk B	1921	660 (34%)	1266 (66%)	56.0
Whale milk C	1650	770 (46%)	880 (54%)	—
Human milk	266	118 (44%)	148 (56%)	26.3
Cow milk	537	416 (78%)	121 (22%)	71.7

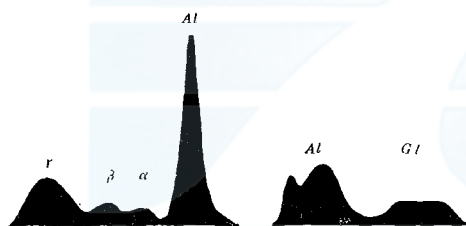


Fig. I.

Next, in order to examine the amino acid in the hydrolyzed substance of the whale milk, an equal amount of 10% hydrochloric acid or 5 N sodium hydroxide was added to the whale milk, decomposed by boiling for 24 hours at 100°C, dried by evaporation, dissolved

in distilled water and a certain amount examined by paper chromatography. For filter paper the No. 2 Toyo filter paper was used. For solvent N-butyl alcohol saturated with water, S-collidin saturated with water and phenol liquified with 0.1% ammonia water were used. For color reaction 0.25% ninhydrin-butyl alcohol solution saturated with water was used⁽¹²⁾⁽¹³⁾.

As in the human and cow milk, in both the whale milk A and B glycine, alanine, valine, leucine, isoleucine, proline, phenylalanine, lysine, arginine, histidine, tryptophan, asparaginic acid, glutamic acid, serine, threonine, tyrosine, cystine and methionine were found.

Fat:

Measuring method—The fat content was measured by Gerber's method.

The size of the fat globule was measured by measuring the diameter of the fat globule with a microscope attached with an ocular

net and expressed in per cent. The method of measuring the milk fat is as stated below.

Saponification value (Köttstorfer's method)¹⁴—Fifty cc of 0.5 N alcoholic KOH were added to 4–5 gm. of the whale milk, heated until Saponification was completed by attaching a reflux refrigerator and titrated with 0.5 N HCl, with phenolphthalein as the indicator.

Acid value¹⁵—Fifty cc of 95% neutral alcohol were added to 10 gm. of the whale milk, heated to 60–65°C and dissolved, and titrated with 0.1 N potassium hydroxide, with phenolphthalein as the indicator.

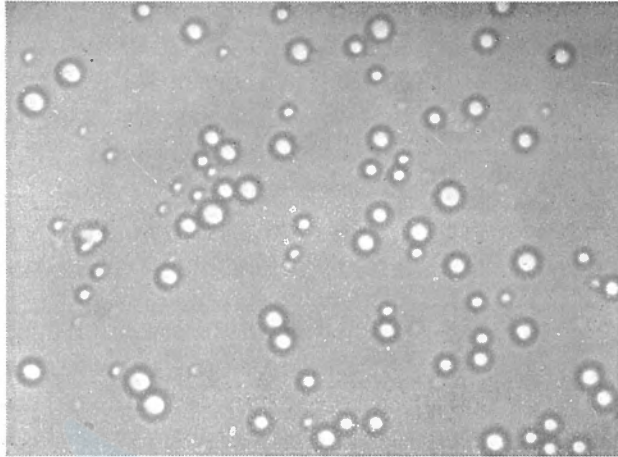
Iodine value (Heubner's method)¹⁶—Chloroform and iodine solutions were added to 0.5 gm. of the whale milk and titrated after being left standing for 6 hours with sodium thiosulfate, the corresponding iodine value of which had been tested beforehand, with starch solution as the indicator.

The fat content was very large, being about 10 times that in the human and cow milk (Table VII). There was more of the fat globules of far larger size than in the human and cow milk (Table IX, Fig. II).

Table IX.
Size of fat globules (%)

	Less than 1.48 μ	1.49– 2.85 μ	2.86– 5.70 μ	5.71– 7.18 μ	7.19– 11.40 μ	Greater than 11.41 μ
Whale milk A	27	41	22	2	6	2
Whale milk B	28	26	34	6	4	2
Whale milk C	20	38	34	5	2	1
Human milk	35	44	21	0	0	0
Cow fresh	24	56	16	2	2	0
Cow homogenized	73	27	0	0	0	0

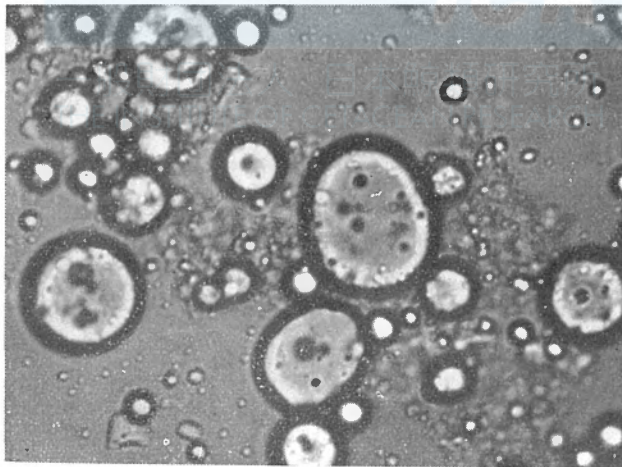
Fig. II. is a picture of the whale milk B. Besides the fat globules numerous cells are seen in the picture. According to the authors' study on the human milk large fat globules and various kinds of cells appear in the milk during the weaning stage. The whale milk B was presumed to be the milk of the weaning stage from the state of the mammary gland, corpus luteum, etc. of the whale and this microscopic finding confirmed this fact. Three kinds of characteristic values of the milk fat were measured but the saponification, acid and iodine values were all much higher than those of the human and cow milk (Table X), and in comparing the 3 whale milk they all showed generally similar values with the exception of the acid value of the whale milk A and B, which was conspicuous in being especially higher than that of the whale milk C.



Cow milk



Human milk



Fin whale milk

Table X.
Characteristic values of Milk fat

	Acid value	Saponification value	Iodine value
Whale milk A	3.7	329.0	188.5
Whale milk B	2.7	298.9	80.0
Whale milk C	0.9	389.0	101.0
Human milk	0.1	196.0	55.0
Cow milk	0.2	236.0	26.0

In comparing these characteristic values with the results obtained by Pedersen¹⁷⁾¹⁸⁾, on the milk fat of the sperm whale and humpback whale and those by Alent¹⁹⁾ on the milk fat of the white fin whale, both the saponification and iodine values were very much alike but acid value of the whale milk A and B was 6-10 times higher than that of the milk of the whales stated above, only the acid value of the whale milk C showing a slightly higher value. The reason for this was probably due to the fact that the elapse of time between the collection and analysis of the whale milk A and B was long and therefore the fat decomposing and the isolated fatty acid increasing during preservation.

Lactose:

Measuring method²⁰⁾—About 80 cc of water were added to 5 gm. of the whale milk and to this mixture 1.5 cc of Fehling's copper sulfate solution were added, heated and adjusted to neutral or to a very slight acid with N/4 alkali, after the crystallized sediment had settled, the supernatant fluid was filtered into a 100 cc measuring bottle and 100 cc of water added to this filtrate; 40 cc of the 200 cc were added to 20 cc of boiling Fehling's solution and boiled further for exactly 6 minutes; the crystallized cuprous oxide was collected being careful not to come in contact with air as much as possible, dissolved in 40 cc of ferric sulfate solution and this solution was colored to a faint red with a potassium permanganate solution; the amount of copper was calculated from the amount of KMnO_4 consumed, and the amount of the lactose was calculated from the lactose quantitative determination table.

The amount of lactose was very small, being roughly about 1/20-1/30 of that in the human milk and 1/15-1/25 of the cow milk in the case of the whale milk A and B and about 1/5 of the human milk and about 1/3 of the cow milk in the case of the whale milk C. However, that the amount of lactose in both the whale milk A and B was very small is not the essential property but it is considered that a part of the lactose decomposed during the long period of the preservation of the whale milk, as stated above in regard to the PH and acidity.

Minerals :

Measuring method²¹⁾²²⁾—The whale milk was evaporated and dried by air bath, heated for 3 hours in the electric muffle furnace keeping the temperature from rising above 550°C, the ash measured and the value expressed in per cent.

Ca.²³⁾²⁴⁾—Of the minerals the amount of calcium was calculated as follows: The carbon, silicic acid and the sand thought to be contained in a minute amount were removed from the ash obtained by the above process, ammonia water and ammonium oxalate added to the filtrate, calcium precipitated as calcium oxalate, filtered, heated for one hour in the electric muffle furnace at 1100°C, the calcium oxalate changed to calcium carbonate and further to calcium oxide and measured.

P²⁵⁾—Of the minerals the phosphorus was measured as phosphoric acid as follows: A mixed solution of hydrochloric acid, ammonium acetate and magnesia was added to the filtrate stated above from which the calcium was removed, ammonia water was added and ammonium magnesium phosphate was precipitated, the precipitate was heated for 1 hour in the electric muffle furnace at 1100°C, the magnesium pyrophosphate was measured and 0.6376 times the value obtained was the amount of the phosphoric acid.

Mg.²⁶⁾—After evaporating and concentrating by the use of the sand bath the filtrate in which the calcium was separated as calcium oxalate, the concentrated substance was transferred on to a porcelain evaporating dish and after evaporating and drying over a water bath it was heated over a Bunsen burner driving out the ammonium salts, oxalic acid, etc.; next, after cooling the residue 6 N HCl was added and the residue moistened; after adding a small amount of boiling water and dissolving the magnesium salt by heating for a while over a water bath it was filtered; then to the filtrate were added ammonium acetate and an excess of ammonium acetate and an excess of ammonium phosphate solution, and the indicator phenolphthalein was added and $MgNH_4PO_4 \cdot 6H_2O$ was precipitated, heated and measured as $Mg_2P_2O_7$; by multiplying this value by 0.3624 the weight of MgO was obtained.

The amount of the minerals was less than what the authors had imagined, being approximately of the same degree as in the cow milk. However, in the whale milk C it was about 2 times that in the cow milk. The amount of Ca and P was near to that of the cow milk in the case of the whale milk A; with the whale milk B it was slighter more than in the human milk; in the whale milk C the amount of Ca and P was large, being about several times that in the human and cow milk; magnesium was also present at the rate of 0.232% (Table XI).

Table XI.
Minerals (%)

	Total	Calcium (CaO)	Phosphorus (P ₂ O ₅)	Magnesium (MgO)
Whale milk A	1.03	0.190	0.125	—
Whale milk B	0.74	0.066	0.040	—
Whale milk C	1.37	0.323	0.409	0.232
Human milk	0.20	0.054	0.038	—
Cow milk	0.74	0.165	0.194	—

Vitamins:

Measuring Method Vitamin A and total carotenoids—First, when the whale milk was examined by Fujita-Aoyama's²⁷⁾ method for the presence of peroxides, the peroxide number was 0 for 1 gm. of the whale milk.

Next, for the purpose of quantitatively measuring the total carotenoids in the whale milk, 1 gm. of the whale milk was collected and to it 5 cc of 20% alcoholic potassium hydroxide were added, and after saponifying for 10 minutes at 60°C the contents were shaken vigorously three times, each time with 2 cc of petroleum-ether and for 10 minutes at a time, extracting the total carotenoids; for the sake of convenience it was measured with the standard solution of β -carotene and the photoelectric colorimeter, and the value obtained was taken as the value of the total carotenoids.

In regard to vitamin A, after saponifying 1 gm. of the whale milk in the same way as above it was shaken vigorously three times, each time with 2 cc of petroleum benzene and for 10 minutes each time, extracting the vitamin A; the layer of the petroleum benzene was collected and after washing three times with water it was measured on a weakly activated Al₂O₃ chromatograph (length of the column 2.5 cm; the content 0.7 cm) according to Fujita-Aoyama's method of determination of the genuine value of vitamin A, the vitamin A was extracted twice with 2 cc of benzene, each time, the benzene was evaporated and the residue was dissolved in chloroform, Carr-Price's reaction was brought about inside the photoelectric colorimeter apparatus and quantitatively measured colorimetrically. With the human and cow milk 5 cc of the material were taken and measured in the same way.

Thiamine—To 1 gm. of the whale milk distilled water was added to bring the entire content to 50 cc, shaken vigorously for 15 minutes and suspended; 10 cc of this content were taken as the material. In the case of human and cow milk 100 cc of each were used for the

study. For the removal of protein 10% meta phosphoric acid solution was used, and the measuring method was the thiochrome fluorescent method⁽²⁹⁾⁽³⁰⁾⁽³¹⁾ with permutit.

Riboflavin—Distilled water was added to 1 gm. of the whale milk to bring the content to 50 cc, shaken vigorously for 15 minutes, heated in water bath for 5 minutes at 80°C and suspended, shaken vigorously further for 15 minutes and 10 cc of it were taken as the material. In the case of human and cow milk 10 cc of each were taken as the material. For suspension the milk was heated in the same way in water bath for 5 minutes at 80°C and suspended. For the removal of protein 10% glacial acetic acid solution was used. The measuring method was the lumiflavin fluorescence method⁽³²⁾⁽³³⁾.

Ascorbic acid—The quantitative determination method (Teruuchi's modification) of vitamin C in the blood with 2, 4-dinitro-phenylhydrazine was applied. Eight cc of distilled water were added to 1 gm. of the whale milk (1 cc in the case of human and cow milk), mixed thoroughly and to this 0.2% 2, 6-dichlorophenylindophenol was added and the reduction type of ascorbic acid was changed completely to the oxidation type; then 24% tin chloride was added and the surplus dye was removed and then the protein was removed with 24% sulfosalicylic acid solution. The bis-2, 4-dinitrophenylhydrazone produced by the action of 2% dinitrophenylhydrazine on the centrifuged supernatant was dissolved in concentrated sulfuric acid and the orange-red color appearing at this time was quantitatively determined by a photoelectric colorimeter.

In the case of the whale milk A the easily destroyable vitamin A and ascorbic acid were not found at all but the total carotenoids, thiamine and riboflavin were found to the same extent, or to a greater extent, as in the human and cow milk. In the case of the whale milk C thought to be preserved better than the whale milk A, vitamin A, total carotenoids, thiamine, riboflavin and ascorbic acid were all found to a considerable amount, especially vitamin A, thiamine and riboflavin showing values considerably higher than in the human and cow milk (Table XIII).

Table XIII.
Vitamins

	Vitamin A	Total carotenoids (including carotene)	Thiamine	Riboflavin	Ascorbic acid
Whale milk A	0	25 γ %	0.093 mg%	0.084 mg%	0
Whale milk C	650 I.U. %	11 γ %	0.110 mg%	0.220 mg%	0.73 mg%
Human milk	20-138 I.U. %	25-86 γ %	0.020 mg%	0.030 mg%	4.80 mg%
Cow milk	17- 60 I.U. %	9-20 γ %	0.040 mg%	0.150 mg%	1.00 mg%

Enzymes :

Measuring method—The method of measuring diastase was by Wohlgemuth's method³⁶⁾. To a row of test tubes were added the whale milk diluted serially, the content of each test tube being the same (1 cc); to this 0.1 cc of 1% starch solution was added, and after being left standing in an incubator for 24 hours at 38°C 1–2 drops of N/10 KJ solution are added and the number of the test tube showing a yellow color, or in other words whether the digestion was up to achrodextrin, was observed.

The determination of lipase was done by Kayajima's alkali titration method³⁷⁾. 1 gm. of the whale milk, 0.2 cc of tributyrin (substrate), 1 cc of 0.5% gelatin solution and 1.0 cc of N/15 phosphoric acid buffer solution (PH 7.0) were transferred in order into a 50 cc triangular flask and after shaking vigorously for 2 minutes it was kept warm for 5 hours at 37°C; and then 25 cc of ethyl alcohol were added, shaken vigorously for 2 minutes and filtered; 20 cc of the filtrate were titrated for the amount of acid, decomposed from the tributyrin by the enzymatic action, with N/20 potassium hydroxide solution using a microbiuret and with phenolphthalein as the indicator. If this value was a cc and a' cc the value of the control, the process of which was performed without adding tributyrin at first but adding it after keeping the filtrate warm for 5 hours the acidity titrated in the same way as stated above, the consumed amount of potassium hydroxide was expressed by $a - a'$.

The amount of diastase in the whale milk C was $D_{24\text{ h}}^{38^\circ\text{C}} = 32$ and the amount of lipase was N/20 KOH titration value (37°C) 2.0, observing the presence of these enzymes.

Summary

Physicochemical studies were made on 3 kinds of whale milk collected from the fin whale of the Antarctic and Arctic Oceans and preserved in an electric refrigerator for 2–15 months, and the following results were obtained :

The external appearance was of a viscous creamy state, and the flavor was of the degree of having a slightly fishy smell in the case of a fresh milk but in the case of an old milk it had a cod liver oil-like flavor and the taste was somewhat astringent. The specific gravity and boiling point were both lower than those of the human and cow milk while the surface tension and viscosity were higher than those of the human and cow milk. Due to acidification the milk was acid and the acidity was high. The water content was lower than that of the

human and cow milk. The solid substances were about 4 times those in the human and cow milk. Protein was about 8 times that of the human milk and about 4 times of the cow milk. The amount of casein nitrogen and noncasein nitrogen was similar to that in the human milk. The ratio of albumin and globulin in the whey protein studied electrophoretically was opposite to that in the human milk, albumin being greater, and of the globulin fractions there was more of the γ -globulin. Amino acid found also in 18 kinds of human and cow milk was found. Fat was 10 times that in the human and cow milk and there were more of the large fat globules. The saponification, acid and iodine values were far higher than those of the human and cow milk. Two kinds (A, B) of whale milk showed especially a high acid value but this is not the essential property, being due probably to the decomposition of a part of the fat. Lactose was smaller in amount than that in the human milk, or 1/5-1/15-1/30 of that in the human milk. This low lactose content is not the essential property, being considered as being due to the decomposition of a part of the lactose by fermentation because of the milk being old. The minerals were 1-2 times those of the cow milk. In regard to the vitamins, in the whale milk thought to be preserved comparatively well vitamin A, total carotenoids, thiamine, riboflavin and ascorbic acid were all found in considerably large amounts but in the old milk vitamin A and ascorbic acid were not found, the amount of other vitamins being also comparatively small. The presence of the enzymes, diastase and lipase, was demonstrated. Calories per 100 gm. were 330-350, being very much higher than the 65 calories for the human milk and the 60 calories for the cow milk.

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