VITAMIN A in SELECTED, PALE-COLORED LIVERS of ALASKA FUR SEALS, 1948

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VITAMIN A IN SELECTED, PALE-COLORED LIVERS OF ALASKA FUR SEALS, 1948

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Abstract

Fifty-one livers selected for pale color were found, on the average, to weigh 1,060 grams and to contain 2.4 million "spec" units of vitamin A per pound and 3.9 percent oil. The vitamin A potency of the liver oil ranged from 4,170 to 634,000 units [2000 x E (1 percent 1 cm, 328 m mu, isopropanol)] per gram. The average potency of the liver oil was 137,000 "spec" units per gram. It appears from the present and from earlier work that paleness of liver is directly correlated with high vitamin A potency and with high oil content. It is apparently not associated with size of the seal or other readily observable characteristics. The data on vitamin A potency of the oil do not resemble a normal distribution. The data can be fitted by the formula: $f(X) = \frac{23.46}{4{,}150 + X}$, where X stands for the vitamin A potency of the oil and f (X) for the number of individuals having X as a potency.

Introduction

In 1946 the livers of eight Alaska fur seals (*Callorhinus ursinus*) were collected on the Pribilof Islands and analyzed for oil and vitamin A in Seattle (Miyauchi and Sanford 1947). The vitamin A potency was high enough in certain of the livers to warrant commercial exploitation even in such a remote area as the Pribilof Islands. Consequently, a search was made for a means of segregating the livers of high from those of low potency at the source. In 1947 it was found in a sample of 196 livers that the pale-colored ones were richer in vitamin A than the darker, maroon-colored ones (Sanford, Kenyon, and Scheffer 1949). In 1948, 51 pale-colored livers were sampled selectively. The results of the analyses are given in this report.

Collecting the Samples

The fresh, warm livers from male fur seals approximately 3 to 4 years of age were collected. The carcasses of the seals had been laid out by the sealing gang on the killing fields of St. Paul Island, Alaska, on July 12 and 13, 1948. The livers of about 500 animals were examined, and the 51 among them that appeared to be palest were selected for testing.

The color of the fur seal liver ranges from maroon (as in beef liver) to pale tan (as in cod liver). By far the greatest number of livers are shades of maroon. In selecting a sample of the palest 10 percent the color sense of the observer, rather than instruments, was relied upon.

The 1948 samples were handled in the same way as those collected in 1947. That is, each liver was washed in cold water, placed in a waxed-paper bag having a cellophane liner, and stored in a refrigerator at approximately 20° F. until they were analyzed in the fall of 1948.

As a separate operation, on July 18th, a study was made of the relation between the size of a given seal and the paleness of its liver. This was done as follows: One hundred carcasses of known length were sampled at random. (The body length of every male fur seal killed on the Pribilof Islands is measured routinely to the nearest inch.) From these were selected the 10 having the palest livers. It was found that the mean length of the 10 seals having the pale livers was virtually the same as the mean length of the 90 seals having the darker livers (41.9 inches versus 42.0.) Thus, in this sample there was no perceptible difference in size between seals having pale and those having dark livers.

Analytical Procedure

Each liver was ground in a meat chopper and a representative fraction was stored in a screw-cap jar at -20° F. About 42 hours before analysis, the sample was thawed at 35° F. The sample was blended in a Waring Blendor, and about 10 grams of the resulting material was accurately weighed into a square shaking bottle of 180-milliliter capacity. A heaping teaspoon of powdered pumice, exactly 50 milliliters of ethyl ether, and two heaping teaspoons of anhydrous sodium sulfate were then added. In a shaking device, the bottles were subjected to 144 one-inch strokes a minute for one hour. They were then centrifuged and aliquots were removed for oil and vitamin A determinations. All samples were run in duplicate.

To estimate the oil concentration, a 10-milliliter aliquot portion of the ether extract was pipetted into a tared, 50-milliliter beaker, and the ether was evaporated on an air bath. Three minutes after the disappearance of the ether, the beaker was removed and allowed to come to room temperature. The weight of the beaker and its contents then gave the remaining information necessary for the calculation of the oil concentration in the liver.

To determine the vitamin A potency, a 1-milliliter aliquot portion of the ether extract was diluted with isopropanol, and the optical density of the solution was measured at 328 m mu, by means of a Beckman spectrophotometer. The vitamin A potency was calculated as "spec" (spectrophotometric) units using the formula 2000 x E (1 percent, 1 cm, 328 m mu, isopropanol). It was recognized that this gave only a gross estimate of vitamin A, but it was thought adequate for the present purpose.

Results

The results of the analyses are presented in Tables 1 and 2. On the average the livers weighed 2.3 pounds and contained nearly 4 percent oil and 2.4 million "spec" units of vitamin A per pound. The range in potency was 4,170 to 634,000 "spec" units per gram of oil, and 0.146 million to 26.6 million "spec" units per liver. (The potency of 634,000 "spec" units per gram of oil is the maximum thus far encountered in our three-year study of fur seal livers.) The richest liver contained 182 times as much vitamin A as the poorest. About one-half of the livers yielded an oil having a vitamin A potency of less than 50,000 "spec" units per gram, and about one-third of the livers yielded an oil having a potency in excess of 100,000 "spec" units per gram. (The liver of the average 3-year-old male fur seal contributes about 4 percent of the weight of the body and 5 percent of the weight of the skinned carcass.)

Discussion

The prime objective in 1948 was to find a means of identifying, in the fresh bodies, the livers of potential value. In this we have partially succeeded. It appears from the present and our earlier work that paleness of liver is fairly indicative of high vitamin A potency. Thus, for the sample of 51 pale livers taken in 1948 and reported here, the mean vitamin A potency of the liver oil was 137,000 "spec" units per gram of oil. For the random sample of 95 livers taken in 1947, the mean potency was 57,400 "spec" units.

Although the animals sampled were of the same age and sex, they were killed a year apart. It is barely possible that the observed difference in vitamin A potency was due to a difference in the 1947 diet and the 1948 diet of the study animals. Considering, however, the wide extent of the feeding range of the fur seal herd, the probability is great that the diet from one year to the next is fairly uniform. Hence the difference in vitamin A potency probably stems from some source other than annual variation in food.

Granted that paleness of the liver and high vitamin A potency are directly correlated, the next move is to find out what factors contribute to paleness. The light color is uniform throughout the liver and is not limited to the surface. It may, to a slight extent, be caused by an increase in fat content. Thus, in the 1948 sample of pale livers, the oil concentration was 3.91 percent, while in the 1947 random sample of livers it was 2.99 percent.

The livers having a high vitamin A potency seem to contain more oil. If the 51 livers are divided into two groups, the first (with 35 livers) having a potency of less than 100,000 "spec" units and the second (with 16 livers) having a potency of more than 100,000 "spec" units per gram of oil, it is found that the mean concentration of oil in the liver of the first group is 3.63 percent and in the second, 4.55 percent. A similar relationship has been observed by Braekkan (1948) in whale liver oil. In fin, blue, and sperm whales he states that "the potency is usually highest in the samples having the highest content of fat."

Of all the livers available on the killing field, the palest one-tenth might be used commercially. These are worth, at 16 cents a million units of vitamin A, about $0.88 each, f.o.b. Seattle. Furthermore, among the palest one-tenth there is a still smaller fraction, representing about three percent of all the livers, which are worth about $2.72 each. Further observations of carcasses on the killing fields are planned in an attempt to segregate the livers of high vitamin A potency.

The wide variation in vitamin A content of fur seal liver oil poses an interesting problem. In outward appearance and behavior the animals are alike. They are juvenile males, about 3 years of age, appearing on land at the same time. They are in a resting or semi-resting stage after a sojourn of many months at sea. They are, as has been shown, fairly uniform in body length. Why, then, the vitamin A potency in their livers should vary so greatly is difficult to explain at the present time. That the variation is caused by great differences in the diet of the individual seal, is one of the more plausible explanations.1/

Perhaps the variation depends upon the length of time between the most recent meal of the seal and the time of sampling. That is, perhaps the vitamin A reserve tends to change as the male seal continues to fast on the breeding grounds. It is known that the adult male seals may go two months or more without food. How long the juvenile males, like those in our sample, habitually fast in the summer season has not been determined. It can be deduced, however, from study of the annuli or growth rings on the teeth that the deposition of calcium is interrupted, hence there is probably an annual fasting period for the subadult as well as the adult males.

Theoretical Considerations

The data on vitamin A potency (Table 1) do not resemble a normal distribution. When the observed range is divided into ten equal classes, 62 percent of the values fall within the lowest class. When the individual values are arrayed in order, equidistant on the x-axis, while their logarithms are plotted on the y-axis, the plotted points fall nearly on a straight line. Dr. Z. W. Birnbaum, of the Laboratory of Statistical Research, University of Washington, has kindly examined our data. He states that he does not know of any model to which they conform, although they can be quite well fitted by a distribution of the type

$$f(X) = \frac{M}{L + X}$$

where X stands for vitamin A potency and f (X) for the number of individuals having potency X. The parameters M and L will be positive constants which can be fitted by the method of least squares. The two constants can then be used to characterize the distribution. (Miss Elizabeth Vaughan, Statistician, Alaska Fisheries Investigations, Fish and Wildlife Service, has kindly computed the parameters for our data. She finds that L = 4,150 and M = 23.46.) Dr. Birnbaum suggests, further, that the distribution is bimodal and the superimposition of two normal distributions. All evidence from the field, however, points to a homogenous sample.

1/ A tabulation by Victor B. Scheffer (in press) of the contents of 1,300 seal stomachs from the North Pacific Ocean and Bering Sea shows that the following items are of most frequent occurrence; squid, pollack, herring, crustacea (chiefly from the fish stomachs), seal fish (Bathylagus), salmon, eulachon, and rockfish.

Table 1.--Oil and Vitamin A in Selected, Pale-Colored Livers of Male Fur Seals, Summer of 1948:

Analyses of Individual Livers

Sample No.	Weight of liver Grams	Oil in liver Percent by weight	Vitamin A potency of liver oil "spec" units per gram of oil1/
34	909	3.66	4,170
38	905	2.98	5,600
6	946	3.85	5,650
41	1101	4.16	6,300
7	921	3.25	6,700
42	948	3.29	10,300
37	1132	3.27	10,600
45	1264	3.90	10,800
9	895	3.47	11,100
11	1283	4.76	11,300
50	1363	3.13	11,300
23	969	3.88	13,400
1	1384	3.36	13,500
33	1040	3.68	15,100
49	1046	4.00	17,500
3	963	4.99	18,800
27	959	4.74	23,900
24	998	3.42	25,800
39	924	2.88	28,400
22	1260	3.95	29,500
20	1071	3.77	38,600
43	859	3.18	41,800
25	1150	2.76	42,500
40	1273	2.89	42,900
46	1046	4.38	46,400
47	981	3.26	47,000
26	1563	3.10	48,600
12	1174	4.41	53,400
16	1018	3.16	53,800
31	860	3.34	58,500
4	878	3.14	59,800
29	1127	3.15	63,000
18	1209	4.38	86,200
28	1113	3.92	91,700
5	1157	3.42	92,900
51	827	3.67	137,000
21	1499	3.92	140,000
14	994	5.16	144,000
36	1031	3.17	182,000
17	1255	4.45	251,000
15	1200	4.90	318,000
8	1032	4.48	340,000
13	1124	2.76	413,000

1/ 2000 x E (1 percent 1 cm, 328 m mu, isopropanol)

Table 1.--Oil and Vitamin A in Selected, Pale-Colored Livers of Male Fur Seals, Summer of 1948: (Continued)

Analyses of Individual Livers

Sample No.	Weight of liver Grams	Oil in liver Percent by weight	Vitamin A potency of liver oil "spec" units per gram of oil[1/]
32	822	5.31	413,000
2	849	5.26	419,000
19	1167	5.00	429,000
35	756	4.37	430,000
10	1266	4.85	470,000
48	843	5.64	508,000
30	847	5.13	628,000
44	892	4.70	634,000
Mean	1060	3.91	137,310

1/ 2000 x E (1 percent 1 cm, 328 m mu, isopropanol)

Table 2.--Summary of Data for 1948

Variate	Observed range	Arithmetic mean
Weight of liver, grams	756 to 1,563	1,060
Oil in liver, percent	2.76 to 5.64	3.91
Vitamin A potency of liver oil, "spec" units per gram	4,170 to 634,000	137,000

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Fur seal carcasses at byproducts plant, St. Paul Island, Alaska, July 15, 1948.
(Photo VBS 2409)

Byproducts plant, St. Paul Island, Alaska, July 26, 1948. (Photo VBS 2414)

Liver of bachelor fur seal 3-5 years old, St. Paul Island, Alaska, June 30, 1947. Weight of liver with gall bladder 1,381 grams (3.04 pounds). (Photo VBS 2191)