DET KONGELIGE INDUSTRI-, HÅNDVERK-
OG SKIPSFARTSDEPARTEMENT

NORSK POLARINSTITUTT
(Formerly Norges Svalbard- og Ishavs-undersøkelser)

SKRIFTER

Nr. 91

VITAMIN SOURCES IN ARCTIC REGIONS

BY

KÅRE RODAHL

OSLO
I KOMMISJON HOS JACOB DYBWAD
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NORSK POLARINSTITUTT
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A. W. BRØGGERS BOKTRYKKERI A/S

Contents.

Preface.

This paper contains the results of a scientific expedition to the sealing field off Newfoundland in 1941, as well as some of the results of a scientific winter expedition to North East Greenland 1939—40.

Due to war conditions it has not been possible to publish these data at an earlier date, and for practical purposes, the results — although slightly different in nature, have now been included in the same publication.

The purpose of the first mentioned expedition was to examine the vitamin A contents of Arctic seals. The work was carried out during the tenure of a full-time grant from the Royal Norwegian Government, to whom the author wishes to express his gratitude. I am also indebted to Dr. Thomas Moore, Dunn Nutritional Laboratories, Cambridge, for his ready assistance and encouragement throughout this work, and to Mr. Alan Davies for his valuable technical assistance during the expedition. My thanks are also due to Mr. John Giæver, for his great interest and help during the planning of the expedition.

The chief purpose of the expedition to North East Greenland in 1939—40 was to study the presence of vitamins in Arctic flora and fauna, and to undertake a dietary survey among Norwegian trappers in Greenland. My thanks are due to A/S Arktisk Næringsdrift, Oslo, for placing facilities at the trapping station Revet, N. E. Greenland, at my disposal during the expedition. Furthermore my thanks are due to the following Scientific Funds: Det Medisinske Fakultets Videnskapelige Fond, Nansenfondet, Norsk Varekrigsforsikrings Fond, and Freiafondet, — with whose assistance the expedition came into existence.

I am greatly indebted to Professor dr. med. Einar Langfeldt, Head of the Institute of Physiology, University of Oslo, for his help in planning

the expedition, for furnishing laboratory facilities for the continuation or this research, and for his valuable advice and criticism during the preparation of this paper.

Finally I wish to express my sincere gratitude to Norsk Polarinstitutt for granting me the necessary funds to enable me to complete this work.

Institute of Physiology, Oslo, November 1st 1948.

Kåre Rodahl.

I. Vitamin A in Arctic Seals.

A Report on the Results of the Expedition to the Sealing Fields East of Newfoundland and Labrador 1941.

Introduction.

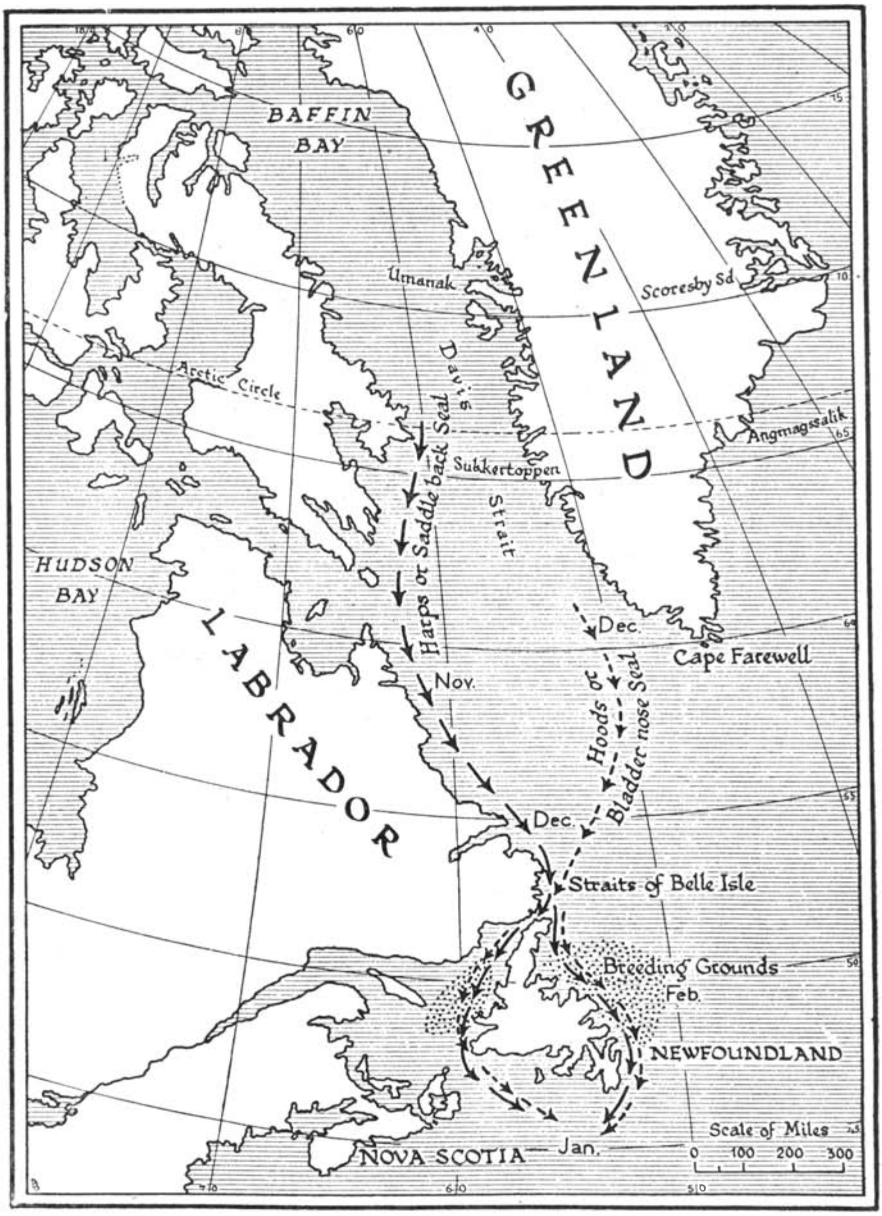
During an expedition to North-East Greenland in 1939—40 a large number of specimens of Arctic mammalian organs were collected by the author for a survey of the vitamin content and for the study of the toxic effect of the livers of certain Arctic animals, in particular polar bear and bearded seal. After the invasion of Norway in 1940 this material was brought to England where the author was given the necessary facilities to continue the research at Dunn Nutritional Laboratories, Cambridge.

Investigations carried out on these specimens showed the liver of polar bear (*Ursus maritimus*) and bearded seal (*Erignathus barbatus*) in particular to contain a high vitamin A potency. (K. Rodahl & T. Moore: "The Vitamin A Content and Toxicity of Bear and Seal Liver". Biochem. J., 1943, 37, 166). In two samples of polar bear liver 18000 I. U. vitamin A per gram liver was found, and the two samples of bearded seal liver contained 12000 and 15000 I. U. respectively. A later investigation of the liver of a third polar bear collected by Commander Ullring showed a vitamin A content of 13000 I. U. per gram liver.

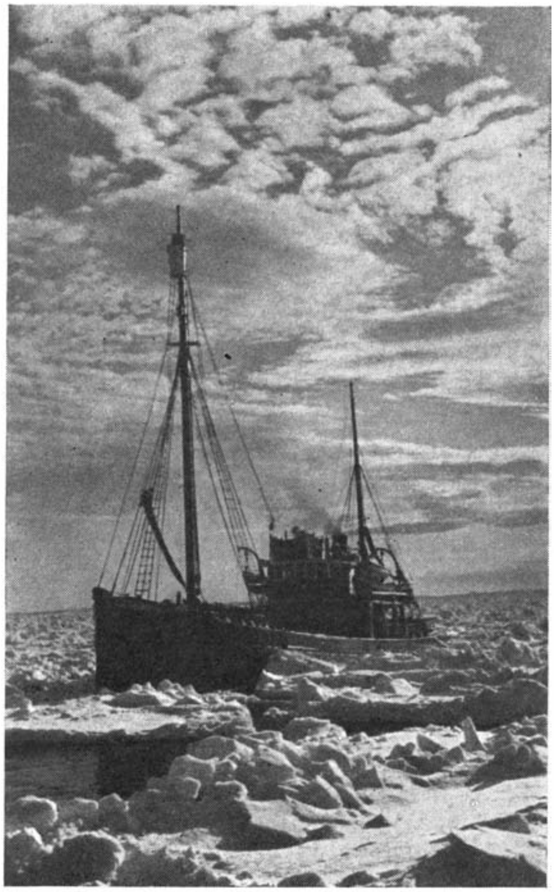
A sample of seal liver oil was examined with regard to the content of vitamin D, and was found to contain 60 I. U. vitamin D per gram, while liver oil from polar bears contained no vitamin D.

Further investigations of the livers of other Arctic mammals showed a relatively high vitamin A potency, such as liver of ringed seal (*Phoca hispida*), which contained 2000 I.U. per gram liver, and it was considered likely that livers of other Arctic seals such as Greenland seal (*Phoca groenlandica*) and hood seal (*Cystophora cristata*) might have a comparatively high vitamin A reserve.

Although the habits of seals are not yet fully understood, it is known that they ingest large quantities of herring, cod and other marine organisms prior to migration to the breeding grounds where little or no food is consumed. It appeared feasable, therefore, to assume that a seal accumulates a high vitamin A reserve and that the seal liver might provide an additional source of vitamin A supply.



Approximate migration routes of seals.
(From J. Colman, The Polar Record, No. 16, 1938.)



M/S "Polaris" in the sealing field.

In view of the importance of obtaining new sources under the then existing war conditions when the supply of whale liver was seriously hindered, and to make a closer study possible, an expedition to the sealing grounds off Newfoundland and Labrador was made during the period March 5th—May 19th 1941, under the auspices of the Royal Norwegian Government.

Two of the Norwegian sealing vessels — "Polarbjørn" (commanded by Captain Marø) and "Polaris" (commanded by Captain Brandal) which had left Norway prior to the German invasion, were to partake in the sealing off Newfoundland and Labrador, and it was arranged that the three members of the scientific expedition, — Mr. John Giæver (The Government representative), Mr. Alan Davies (technical assistent) and the author (leader) should establish a laboratory on board one of the vessels — "Polarbjørn" — where the investigations could be carried out during the sealing expedition.

We left the United Kingdom on February 9th 1941 on board the Norwegian merchantman M/S "Dagrunn" and reached Nova Scotia in Canada on February 22nd 1941.

The necessary scientific equipment was purchased in Montreal while the vessels were being prepared for the expedition.

On the evening of March 5th, we sailed from Halifax proceeding northwards along the coast of Nova Scotia. Already the following day we met drifting ice from the Gulf of St. Lawrence. The ice became more packed as we proceeded and at midnight on March 6th we were forced to turn southwards and came out of the ice belt on March 7th.

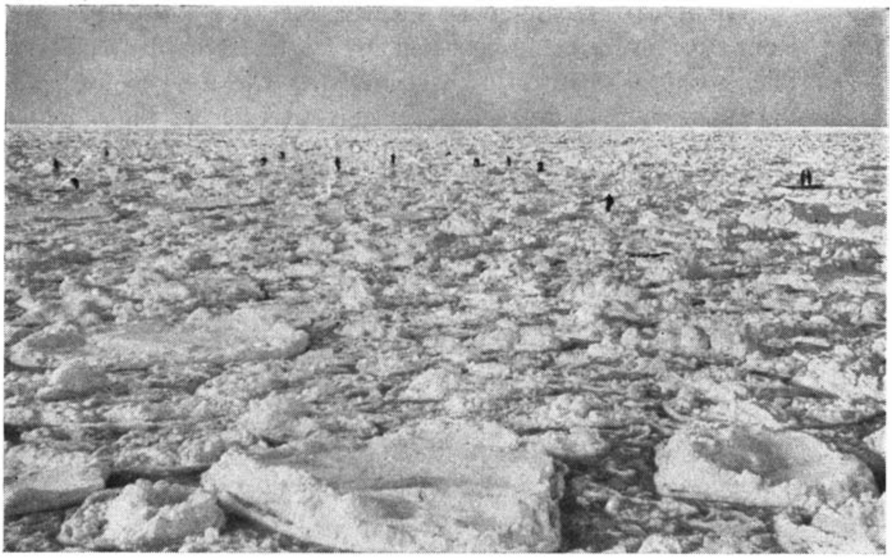
In spite of the heavy seas we commenced the preparation of the laboratory on board the ship. This work continued with several interruptions caused by rough seas and heavy gales, until March 12th when the laboratory was completed, and the equipment was found to function satisfactorily.

The laboratory was installed in the ship's saloon and contained the necessary equipment for the determination of vitamin A by the Carr-Price method. Special racks were made for the glassware to avoid breakage in heavy seas, but actual laboratory work could only be carried out while the ship was in the ice.

As much ice was expected that year, the original plan of the sealing captain was to proceed northwards, east of the icebelt, and to penetrate the ice at the latitude of Bell Island where the largest breeding grounds are usually found. It was discovered, however, that there was very little ice that year so we continued to sail northwards along the east coast of Newfoundland.

As a result of various reports, Captain Marø decided to turn southwards in search of the young seals on March 14th. That day we sighted three of the Newfoundland sealers and later on the same day we communicated with the Norwegian sealer "Polaris" which was approaching our position. The following day we went side by side with the four Newfoundland sealers, S/S "Eagle", "Neptune", "Terra Nova" and "Ranger". We penetrated thin new ice approaching the Bay of Notre Dame, where seals were observed in the water and on the ice at great distances.

On March 16th the Newfoundland sealers proceeded towards land, where seals had been observed in large quantities from the shore. Captain Marø did not find it advisable, however, to go further in as he feared to be caught in the pack ice, which was steadily moving towards land by an easterly wind. He decided to sail northwards instead, hoping to find newborn seals on the breeding grounds off Groais Island and Bell Island. The ice was jammed and we were caught several times in the pack ice. The following day we continued northwards in scattered



Seal catch in scattered ice.

ice and the first family of hood seals were shot that day and the livers were examined.

In the afternoon the first catch of newborn seals took place. It was a large gathering of white-coats and all available men went on the ice. At nightfall we had 300 seals on board but the pelts were mostly of a poor quality.

Livers from practically all the killed animals were collected in the following manner:

The livers were quickly removed as the animals were skinned on the ice. When the seal was skinned on one side, the abdomen was opened, the liver was grasped with the left hand and removed with a knife in a single cut. It was then either thrown into heaps together with the fur and blubber, and later picked up by the ship, or carried in special canvas bags prepared for this purpose.

It has been suggested that the collecting of the livers might interfere with the transport of the pelts from the place where the seal is killed on the ice to the ship, and that it, therefore, might be impracticable to collect the livers from the seals skinned on the ice. This is not in accordance with our experiences on this expedition, where livers from nearly 10,000 seals were collected by the two vessels.

In all circumstances, the livers were kept together with the rest of the catch during transport on the ice. The bags containing the livers were attached to the hook on the rope by which the pelts were dragged across the ice, and gathered in heaps where they were later collected by the ship.

In the case of the young seals, their livers were smaller and a larger number of livers could consequently be transported in the bag. When only a single seal was transported over the ice, the liver was simply hooked onto the rope, It is mainly livers from the old fully grown seals that are worth collecting, while livers from baby seals are of less value from the standpoint of vitamin A. It is, therefore, of less importance that all livers from these animals should be collected.

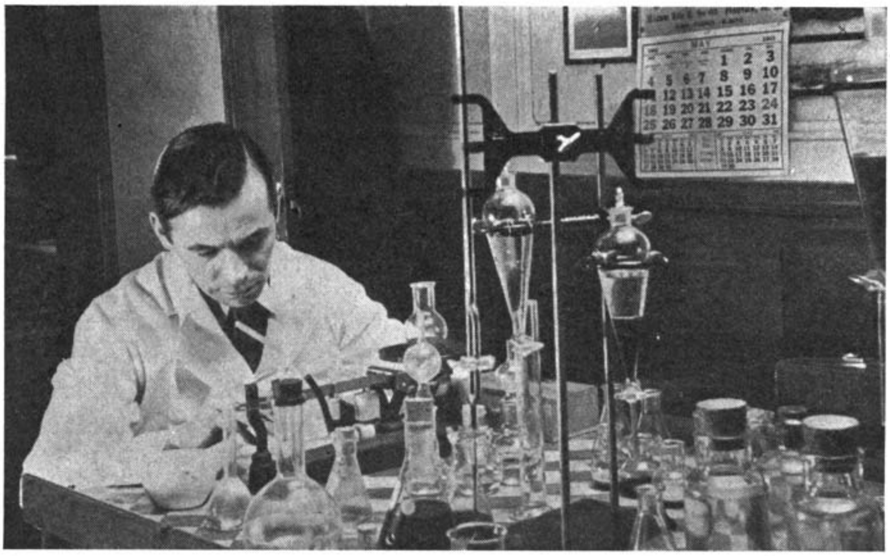
The original plan for preserving the collected seal liver had been to keep it frozen. But owing to the unusally high temperatures encountered that year, this was found impossible without a refrigeration plant. We succeeded in keeping a small quantity of livers frozen for a short period in wooden barrels, but during a few days of mild weather the ice melted. It would probably have been possible to keep the liver on ice in large double-walled zinc-lined ice chests, but as no material to build such chests was available we were forced to preserve the livers in brine. The livers were placed in small tanks in the hold, with salt sprinkled liberally between each layer and at intervals brine was added. Although this method preserved the liver successfully, it is probably not to be recommended, as it hardened the liver to a marked degree, impairing the digestion for solvent extraction.

On March 18th weather was bad with snow and rain. The seals were found in scattered patches and only 300 animals were caught in the course of the day. There was a heavy swell under the ice which made the laboratory work difficult. The following day a considerable number of hood seals were caught on scattered ice, including an unusually large male hood seal measuring 267 cm.

Analysis of the vitamin A content of the livers of several hundred hood seals and Greenland seals, both fully grown and baby seals, were carried out. Simultaneously an unsuccessful attempt was made to extract the fat from the livers on a large scale. The livers were minced, 0,5 % KOH was added until the mixture had a pH of 8 to 9. The mixture was treated with live steam under great pressure 30 to 90 min. The mixture was then kept at a temperature of approximately 45° C in 48 hours during which time the oil should have gathered on the top, but owing to the low fat content of the liver (2,5 to 10 %) the amount of oil was practically negligible, nor did we succeed in breaking down the liver tissue completely with this concentration of KOH. The yield of oil was, therefore, much less than the fat percentage of the liver.

Later on other methods were applied, by which we succeeded in extracting 80 % of the fat content of the liver, and the oil was found to contain approximately 600 000 I. U. vitamin A per gram.

The following days we had rough weather with snow and gale, and only a small number of seals were caught. During this period essays



The laboratory onboard "Polarbjørn".

of vitamin C content of the organs of the seals were made, and samples of seal livers were procured for check tests of vitamin A content by biological methods. Furthermore, organs of seals were preserved for a later determination of the content of vitamin B1, and nicotinic acid.

During this time, a comparatively large number of hood seals were killed. According to Captain Marø it is unusual to find so many hood seals on this particular sealing field. The proper breeding grounds for hood seals are not known, if any such exist at all. Some hood seals whelp in scattered groups off Newfoundland and some in the Gulf of St. Lawrence. Captain Marø was of the opinion that the majority of the hood seals have their breeding grounds somewhere north of the coast of Labrador, and that the families of hood seal we found east of Newfoundland were only scattered groups of seals in the periphery of the proper breeding grounds.

Shortly after whelping (3 to 4 weeks) the fully grown hood seals leave the Newfoundland sealing grounds and migrate to the straits between Greenland and Iceland where large gatherings of hood seals, mostly older animals, are found in the early summer.

It is remarkable that practically all the hood seals found at the Newfoundland sealing fields are fully grown. Thus for instance, 3 years old hood seals are seldom seen at this particular sealing field. It is generally believed that the young hood seals are to be found further north along the coast of Labrador in the Baffin Bay and in the Davis Strait.

From our observations in 1941 it was apparent that the hood seals whelped later than the Greenland seals.

We continued to sail northwards hoping to find the main patch of baby seals, but the chance of finding valuable pelts became less as the days passed towards the end of March.

We came out of the ice, which at some places only formed a narrow line along the coast. One day we had a heavy gale, and twice the sea broke over the ship and a number of pelts and a considerable quantity of liver was lost. Some of the laboratory glassware was broken, but considerable damage was avoided, thanks to eager assistance from the crew.

On March 22nd we reached Cape Bauld, but no seals were sighted. It was decided to turn southwards again to search the area round White Bay. That day we passed two Newfoundland sealers which were sailing northwards. The weather was favourable, and we could see how the ice was smashed against the rocky shore in the heavy seas.

The following day we continued to sail southwards in heavy snow and high sea. An easterly wind pressed the ice against the coast, and it was necessary to go out towards the edge of the icebelt in order to prevent being carried ashore.

On March 28th we reached the mouth of White Bay where a large number of various types of seals were killed, thus furnishing us with a most valuable material for our laboratory investigations. For the first time a great number of old Greenland seals were examined. The ice was very scattered and the seals were caught from the boats.

In the following days a small number of scattered seals were shot. The swell was constantly high and the ice consisted of scattered but hard winter ice. The temperature was invariably above freezing point.

We then proceeded northwards again in bad weather and only 200 to 300 seals were killed daily. On April 4th it was reported from the radio station at St. Johns that a large number of seals were sighted on the Bay of Notre Dame, and it was decided to go there. We were met with heavy pack-ice, however, and it was impossible to penetrate the edge of the icebelt. Two of the Newfoundland sealers were caught in the ice, and we could see that they had killed a large number of seals.

We sailed along the edge of the icebelt in heavy seas and a strong easterly wind. It became colder and the temperature dropped to —10° C.

In the following days a few hundred Greenland seals were killed daily, and on April 9th the removal of the blubber from the skins was commenced.

At that time we were in the ice off Belle Isle, and much ice had, in the course of a few days, come from the north, and on April 17th the ice belt was so broad that open water could not be seen from our position. We had at that time 3800 pelts and 7500 kg. blubber on board M/S "Polarbjørn".

The liver is removed.

During the days April 19th to 25th up to one thousand seals were killed daily. A large number of livers were examined, as well as other organs of the seals. The stomach content and the general condition of the seals was studied in an endeavour to find an explanation of the observed considerable individual variations of the vitamin content of the livers, and the variation in relation to age and sex.

At the end of April and the beginning of May, we had constantly bad weather with rain, snow and gale, which made further work impossible. M/S "Polaris" was considerably damaged by the sea.

From May 4th a small number of seals were killed daily a few miles off Groais Island. The weather was still unfavourable and the seals were scattered. For several days we were drifting along in heavy fog, and when the fog lifted on May 6th we discovered that we were close to shore, but the exact position could not be determined. We sailed NNE, and in the evening of that day we sighted Belle Isle.

On May 7th the weather improved and we sailed south of Belle Isle, but met heavy ice in the strait which could not be penetrated.

On May 8th, it rained again, but in spite of this, we sailed northwards along the coast of Labrador in a last attempt to find seals, as we had only little provisions left. The weather became gradually worse, however, and made further attempts impossible.

On May 12th we reached Battle Harbour on the coast of Labrador and 300 seals were killed that day. On May 14th the catch was discontinued, the total number of seals being 7150 on board "Polarbjørn". The laboratory experiments were completed and in the afternoon we sailed for Canada through the Strait of Belle Isle and the Gulf of St. Lawrence. In the afternoon of May 17 we sighted Nova Scotia and on May 19th we reached Halifax with approximately 12 tons of seal livers on board the two vessels.

Results of Observations.

Technique. For the determination of vitamin A in organs of seals, the Carr-Price Method modified by Davies, (1933) was used. 5 grams tissue was taken, digested with 5 % potash, and extracted by ether and alcohol. The fat was taken up in chloroform, 2 ml. antimony trichloride was added, and the vitamin A was determined colorimetrically using a Lovibond tintometer (British Drug Houses). This method was compared with biological methods prior to the expedition.

All determinations were carried out in the laboratory on board the expedition ship.

Some duplicate samples were conserved in toluene (or in brine water) for check tests after the return of the expedition. Larger samples of the salted livers were extracted by various laboratories in Canada, U. S. A. and England and the vitamin A content was determined for control (see pages 24—26).

Hood Seal (*Cystophora cristata*). A large number of livers from hood seal were weighed and assayed in March and April with the results shown in Tables 1 and 2.

Table 1.

Average Liver Weights.

Age and Sex	Mean Weight in gms.	Variation
Baby seal — approximately 7 days...	1494	1000—2100
Female — fully developed	2929	2200—3750
Male — fully developed	4136	3600—5000

From table 2 it appears evident that the vitamin A reserve in the males is higher in March than in April and generally higher than in the females at this time of the year. The females show a higher reserve in April than in March.

The individual variation in the vitamin A is considerable, however, as is evident from our observations. A much larger material is therefore necessary to decide whether the observed seasonal variation in the vitamin A content might be accepted for seals in general.

There is certain evidence which seems to indicate that the vitamin A reserve varies at the different breeding grounds. A further investigation

Table 2.

Vitamin A Content of Liver of Hood Seal at Different Stages of Development and at Different Periods of the Breeding Season.

Specimen	No. of Animals Examined	Mean Vitamin A Reserve I. U. per g Liver		
		March	April	March & April
Baby seals.				
Foetus	1	120	-	-
1 hour after birth	1	150	-	-
7 days. (approx.)	1	300	-	-
14 days. (approx.)	4	1500	-	-
21 days. (approx.)	9	-	300	-
Young seals.				
1 year	2	-	-	2400
2 years	2	-	-	1200
Fully developed.				
Males above 4 years	26	5180	4320	4934
Females above 4 years	14	1370	2742	2110

of a larger material should therefore be carried out at other breeding grounds and at other periods of the year.

The reason for the higher concentration in March might be explained by the fact that the seal on arrival at the breeding grounds at the end of February has spent a considerable time on the fishing banks ingesting large quantities of herring, cod and other marine organisms rich in vitamin A or carotene, thus accumulating a high vitamin A reserve. It is interesting to note that from this time to the end of the breeding season there is evidence of little or no food being eaten. This points to a continuous decrease in stored body fat and a rapid dissipation of vitamin A from the liver during the months of March, April and May.

Following the birth of the young, mating takes place. A few weeks following mating the animals show a marked loss of hair and, according to sealing captains of many years' standing, it is not until after this period that the seal begins to look for food.

The females show a lower reserve in March, which is the month when the majority of them bear their young. It is particularly noticeable during the lactation period. A considerable amount of vitamin A seems to be transmitted to the young through the mother's milk. As a point of interest, a sample of milk collected from a female with a baby seal one or two weeks old had a potency of 10 I. U. per gram. The vitamin A content in livers of newborn seals seems to increase during the first two weeks of lactation, reaching a maximum at the end of the second week. During the third week the young are left and have to utilize the reserve accumulated from the mother's milk. This seems to explain the lower reserve found at the age of three weeks.

The vitamin A content of the liver of females was found to be higher in April than in March. If little or no food is consumed by the females during this period an increase of the vitamin A reserve of the liver seems unlikely, and the difference in the vitamin content from March to April might therefore depend on a coincidence, as the figures refer to 14 animals only.

The oil content of the livers of *Cystophora cristata* up to the age of three weeks is usually around 9 per cent. After this age the oil content remains fairly constant at approximately 2.4 per cent.

There is reason to believe that seasonal variation in the vitamin A reserve takes place in most types of seals. It is known that the seals in all the more important sealing fields, such as the White Sea, the edge of the winter ice to the east and north of Jan Mayen, and Newfoundland are fattest in the months of March and lose weight until the end of May. In this period the seal takes little or no food. Later the seal increases in fatness in the course of the Spring and Summer. It is therefore to be expected that the vitamin A reserve of the liver should be generally on a higher level in livers of hood seals which are caught in the Greenland Strait in the months of June, July and August. A similar condition may be found in livers of bearded seal caught off Svalbard during the Summer months.

Greenland Seal (*Phoca groenlandica*). During the period March 12th to May 13th a similar investigation was made on the above type of seal to compare the findings with regard to hood seal.

Table 3.

Average Liver Weights.

Age and Sex	Mean Weight in gms.	Variation
Baby Seal		
Newborn	361	—
8—10 days	814	—
Young Seal		
Males — 1 year	1142	769—1600
Females — 1 year	1050	900—1200
Fully developed		
Male	1783	1600—2250
Female	1681	850—2180

Table 4.

Vitamin A Content of Livers of Greenland Seal at Different Stages of Development.

Age and Sex	No. of Animals Examined	Mean Vitamin A I. U. per g Liver	Variation
Newborn			
Foetus	2	2400	—
8—10 days	6	340	120— 600
28 days (approximately)	10	3000	—
Young seal			
Males — 1 year	24	1620	600—4500
Females — 1 year	23	1560	600—1800
Females — 3 years..........	10	5000	—
Fully developed			
Males above 4 years........	47	6570	3000—12,000
Females above 4 years......	23	2542	600— 4,500

From table 4 it will be seen that the vitamin A content of the livers of Greenland seals is of the same order as that of hood seals and similar variations with age and sex are found.

Table 5.

Age and Sex in Relation to the Fat Content of the Liver.

Sex	Age	Mean % Fat	Variation
Females ...	Above 4 years	3.2	3.0—4.5
Males	Above 4 years	2.8	2.0—5.0
Males	2 years	3.6	—
Males	1 year	3.4	2.4—4.4
Females ...	1 year	2.3	2.0—3.0
Females ...	8—10 days	10.0	—

Table 5 indicates the mean fat content of all livers examined during the period of investigation. It will be seen that the fat content is higher (10 %) in very young animals until reaching maturity, at which time the fat per cent appears to remain fairly constant.

It will be seen from table 6 that the vitamin A reserve in the liver from a normal Greenland seal examined on May 4th was only moderate and below the mean value for this type of seal. Under these circumstances only small amounts were detected in the retina, kidney, lung and subcutaneous fat. The pancreas gave a positive reaction but the concentration of vitamin A was too small to permit an accurate determination being carried out. The figures are in agreement with similar

Table 6.

Distribution of Vitamin A in Organs of a Normal Greenland Seal Killed May 4th, 1941.

Organs	I. U. per g.	Organs	I. U. per g.
Liver	2400	Heart	0
Kidney	6	Thyroid	0
Lung	3	Epididymis	0
Spleen	0	Subcutaneous fat	12
Pancreas	trace	Lymph gland . . .	0
Testicles	0	Corpus vitreum .	0
Muscle	0	Lens crystalina. .	0
Cerebellum	0	Retina	4
Cerebrum	0		

findings in organs from bearded seals (*Erignathus barbatus*) collected during a previous expedition to North East Greenland. The results were as follows:

Liver:	12 000 I. U.	vit. A. pr. gram
Subcutaneous fat:	7 I. U.	—»—
Meat:	0 I. U.	—»—
Kidney:	9 I. U.	—»—

Distribution of Vitamin A and Its Relation to Physiological Factors.

Distribution in the Liver. Vitamin A was determined in samples from different parts of the liver.

(1) lobus hepatis dexter
(2) lobus hepatis sinister
(3) lobus caudatus
(4) lobus quadratus

No variation in vitamin concentration could be observed in parts determined and it is therefore suggested that the vitamin is evenly distributed throughout the liver.

Distribution of Vitamin A in Organs of Seal Preserved in Toluene. Vitamin A was determined in August 1941 in organs of hood seal (*Cystophora cristata*) and Greenland seal (*Phoca groenlandica*) gathered in the sealing fields east of Newfoundland in the month of April 1941. The organs were preserved in toluene. The sample was weighed before being placed in toluene. It was found by later experiments that some of the vitamin A was removed from the tissue by the toluene. In order to keep within the limit of experimental error, the tissue was weighed and a proportionate volume of toluene preservative was added to the test sample.

The pelts are hauled to the ship. The livers are kept in canvas bags as shown in the photograph.

Table 7.

Distribution of Vitamin A in Organs of Seal Preserved in Toluene.

Organs	I. U. Vitamin A per gram	
	Cystophora cristata	Phoca groenlandica
Muscle	0	0
Brain	0	-
Kidney	9	traces
Udder	traces	-
Spleen	0	-
Subcutaneous fat	-	12
Cerebrum	-	0
Cerebellum	-	0
Liver	-	1500

It will be observed that the figures shown in table 7 are in agreement with the findings made in the laboratory on board the ship during the expedition (see p. 20).

Vitamin A in Relation to Physiological Factors. On the days of April 19th and 26th a series of specimens of liver from various batches of Greenland seal were taken and supplied with an index card showing information regarding age, stomach contents and thickness of subcutaneous fat, together with any abnormalities observed. In all cases the stomach was found to be empty. The results of the investigations are shown in the following tables:

Table 8.

Vitamin A Content of Livers from Greenland Seals with Reference to Physiological Conditions Observed April 19th and 26th, 1941.

Sex	Age	Blubber in cm.	Stomach Contents	Liver Wt.	% Oil	I.U. per g. Liver	I.U. per g. oil	Total I.U. in Whole Liver
April 19th								
Male	Above 4 years	2.5	Empty	1900	3.0	750	25.000	1.425.000
—	» 4 »	3.5	»	1900	2.0	3.000	150.000	5.700.000
—	» 4 »	3.3	»	1800	2.8	3.000	104.300	5.400.000
—	» 4 »	2.3	»	1800	2.8	1.800	64.300	3.240.000
—	» 4 »	3.5	»	-	2.4	750	31.250	-
—	» 4 »	3.4	»	-	2.0	300	15.000	-
—	» 4 »	2.3	»	-	2.0	1.500	75.000	-
—	» 4 »	3.5	»	2100	5.0	12.000	240.000	25.200.000
—	Approx. 4 years	3.8	»	2250	5.0	15.000	300.000	33.750.000
—	» 4 »	3.5	»	1500	4 0	240	6.000	90.000
—	» 4 »	3.5	»	2250	3.6	1.200	33.500	2.700.000
Female	» 4 »	4.2	»	850	4.0	2.400	60.000	2.040.000
—	» 4 »	4.3	»	1850	3.0	1.500	50.000	2.775.000
—	» 4 »	3.8	»	-	3.0	900	30.000	-
Male	» 1 year	1.8	»	1250	4.4	900	20.450	1.125.000
—	» 1 »	3.1	»	1250	2.4	1.200	50 000	1.500.000
—	» 1 »	2.1	»	1600	3.0	240	8.000	384.000
—	» 1 »	2.5	»	-	4.0	750	18.750	-
Female	» 1 »	2.5	»	1000	2.0	1.500	75.000	1.500.000
April 26th								
Male	» 5 years	3.2	»	1750	2.0	1.500	75.000	2.625.000
—	» 5 »	3.3	»	1900	2.0	12.000	600.000	22.800 000
—	» 5 »	4.3	»	1750	3.0	1.500	60.000	2.625.000
—	» 5 »	4.0	»	1700	4.0	2.400	60.000	4.080.000
—	» 5 »	2.8	»	1600	2.0	1.200	60.000	1.920.000
Female	» 5 »	3.5	»	1750	3.0	3.000	100.000	5.250.000
—	» 5 »	3.8	»	1650	2.0	750	37.500	1.237.500
—	» 5 »	4.5	»	1500	3.0	1.200	40.000	1.800.000
—	» 5 »	3.0	»	2000	4.0	1.200	30.000	2.400.000
—	» 5 »	4.1	»	2000	4.4	2.400	54.545	4.800.000
Male	» 2 »	3.0	»	1250	3.6	300	8.333	375.000
Female	» 4 »	2.8	»	1350	3.0	1.200	40.000	1.620.000
—	» 3 »	4.8	»	1450	3.6	900	25.000	1.305.000
Male	» 1 year	2.8	»	1000	3.6	2.400	66.000	2.400.000
—	» 1 »	2.3	»	1350	3.0	1.500	50.000	2.025.000
Female	» 1 »	4.4	»	1100	3.0	3.000	100.000	3.300.000
—	» 1 »	3.0	»	1200	2.0	600	30.000	720.000

Table 9.

Showing Average Figures of Previous Table.

Sex	Age	Blubber in cm	Stomach	Liver Wt.	0/0 Oil	Vitamin A I. U.		
						per g Liver	per g Oil	Whole Liver
Male	Approx. 5 years	3.2	Empty	1820	2.7	3208	151.588	7.975.000
—	» 4 »	3.3	»	2000	4.2	5480	113.166	12.146.667
—	» 1 »	2.4	»	1090	3.4	1165	39.023	1.486.800
Female	» 5 »	3.8	»	1780	3.3	1710	52.309	3.097.500
—	» 4 »	4.1	»	1350	3.3	1600	55.000	2.407.500
—	» 1 »	3.3	»	1100	2.3	1700	68 333	1.840.000

No distinct correlation could be found in the vitamin content of the liver and physiological factors observed.

Table 10.

Oil Content of Greenland Seal and Hood Seal in Relation to Vitamin A Potency.

Group	g Oil per 100 g Liver	Number Animals	Mean I.U. Vitamin A per g Liver	Mean I.U. per g Oil
1.	2.0—2.4	20	3675	134.687
1.	2.5—2.9	3	2000	104.300
3.	3.0—3.4	10	1459	51.444
4.	3.5—3.9	4	1200	53.374
5.	4.0—4.4	7	1470	38.500
6.	5.0—5.4	8	6900	270.000
7.	9.0—9.4	8	300	-

Table 10 shows, with one exception, a distinct relationship between the amount of oil in the liver and vitamin A potency. It appears evident that the lower the oil content the higher the potency of the same.

Vitamin A Content of Seal Liver Oil.

Potency Yield and Appearance of Oil. From a representative sample of seal liver (52 livers of various kinds) oil was extracted by solvent methods. The oil had a mean potency of 251,600 I. U. per gram, varying from 30,000 to 375,000 I. U. per gram. In a few cases oil of a potency of 600,000 I. U. per gram was obtained, but as this was from a few livers only, the value could not be considered as fully representative.

The Effect of Preservatives on the Vitamin A Content. A 5 gram sample of liver was assayed March 18th from a whole liver taken from a young Greenland seal. The remainder of the liver was placed in saturated brine and assayed at 14-day intervals over a period of 130 days. No deterioration took place. Although the salt prevented deterioration it hardened the liver tissue, thus impairing the digestion to a slight extent.

In livers preserved in dry salt a marked hardening of the tissues was observed and it is therefore not to be recommended.

During the expedition duplicate samples were also preserved in toluene for later control purposes. The samples were taken at intervals, weighed and kept in toluene in sealed bottles. It was later found that part of the fat and the vitamin A was dissolved into the toluene. In one case more than 50% of the vitamin A content of the liver was transferred to the toluene.

Check of the Carr-Price Method. Before leaving Cambridge, England, the figures obtained from the determination of vitamin A in livers of polar bear and bearded seal were checked against biological tests. The results agreed favourably.

After the return of the expedition a representative sample of seal liver from the various types of animals was extracted on August 7, 1941. The oil was examined and found to contain 187,500 I. U. per gram. The remainder of the oil sample was equally divided, and nitrogen bubbled through each sample. One sample was sent to Dr. T. Moore, Cambridge, England, and a duplicate sample was sent to Dr. Young, Professor in biochemistry, Dalhousie University, Halifax.

Assay was made by Dr. Moore on August 26th, by the Carr-Price method, and he reported the result 160,000 I. U. per gram.

The same oil was determined by Dr. Young at the Department of Biology, Halifax, by the spectrophotometric method on August 30th and by this method he found 150,000 I. U. per gram.

Another assay was made by us in Toronto on the same oil returned to us by Dr. Young on October 16th, and 150,000 I. U. per gram was found, showing a slight deterioration during the period from August 7th to October 16th.

Seal Liver Oil Extracted and Checked by Various Other Laboratories. Representative samples of salted seal liver collected during the expedition were sent to various laboratories for extraction and check-tests. The results were as follows:

1. July 10th 1941. Marden Wild Corporation.
   Oil extracted by Centrifugal Method. The results were unsatisfactory regarding percentage recovery.
   Results from 70 lbs. liver:

   Total fats 2.06%
   Free fatty acids.. 28.99%

   Potency 59,400 U. S. P. units per g.

The pelts and livers are collected in heaps on the ice, where they were later collected by the ship.

2. July 12th 1941. Ayerst McKenna & Harrison Ltd., Montreal, Que. Liver extracted with cold acetone. Acetone extractions filtered and distilled in vacuum and oil clarified by centrifuging. Oil dark brown in colour. Yield 2,2 %.
Potency 57,000 I. U. per g.

3. July 15th 1941. Marden Wild of Canada Ltd., Sommerville Station, Boston, Mass. U. S. A.
Oil extracted from liver by digestion with potash and extraction with ether.
Potency 50,460 U. S. P. units per g.

4. July 15th 1941. Marden Wild of Canada Ltd., Sommerville Station, Boston, Mass. U. S. A.
Extracted by digesting the liver with potash and extracting with ether in the presence of alcohol.
Potency 253,100 I. U. per g.

5. July 28th 1941. Collett Corporation, New York.
   Oil extracted by solvent method but no information available regarding the solvent used. Yield 4.5 %.
   Potency 55,000 U. S. P. units per g.

6. July 30th 1941. Distillation Products Inc., Rochester, New York.
   Method of extraction not stated.
   Yield of oil approximately 3 %.
   Potency 118,000 I. U. per g.

7. July 1941. Dunn Nutritional Laboratory, Cambridge, England. (Dr. T. Moore).
   Oil extracted by solvent method.
   Potency 100,000 I. U. per g.

8. July 1941. Glaxo Laboratories, England.
   Oil extracted by solvent method.
   Potency 260,000 I. U. per g.

It will be observed that the average potency of the oil is approximately 100,000 I. U. per gram.

Simultaneously one barrel of seal livers was sent to Crooks Laboratories, London, England. Operating on two selected livers from which 500 grams were taken for each extraction, the oil present was found to be 1,5 % and 1,8 % respectively. The potency of the oil in these two samples was 230,000 I. U. A. and 190,000 I. U. A. respectively.

The whole barrel of livers was then processed in a small works plant from which 5 lbs of oil was obtained. (1,8 %). The oil was of an excellent quality and had the following characteristics:

Unsaponifiable matter...	50,4 %
Iodine value...........	191,7
E. value	116,0 (195,000 I. U. A.).

Extraction Methods.

In an attempt to ascertain the most suitable method for extraction of the liver, several experiments were carried out.

Alkali Digestion Method (1)- (Carried out on board ship). Aqueous potassium hydroxide, 0,5 %, was added to the minced liver, the pH adjusted to 8 to 9 and the whole transferred to a conical vessel constructed by the ship's engineer. The solution was then treated with live steam for 30 minutes and allowed to cool. The solution was kept at a temperature of approximately 45° overnight. It was observed that the liver tissue had not completely broken down and little cream had risen to the surface. The solution was then treated with live steam for a further 60 minutes and allowed to cool. The temperature of the solution was kept at 45° overnight. The following morning a negligible amount of cream appeared on the surface. This was skimmed off and separated by the addition of alcohol and water. The amount of oil obtained did not correspond reasonably with that found by the chemical solvent method and the procedure was abandoned.

Alkali Digestion Method (II). Minced liver was digested by adding 5 % aqueous KOH and heating in a steam oven until complete solution had taken place. The solution was then extracted with ether in the presence of alcohol. The aqueous layer was discarded and the ether layer, after washing and filtering through a sintered glass funnel containing anhydrous sodium sulphate, was evaporated off on a water bath. The oil obtained was deep yellow in colour and solidified on cooling. It appeared to be partially saponified.

Soxhlet Extraction (I). Minced liver was ground with anhydrous sodium sulphate, transferred to a soxhlet thimble and extracted with ether in the usual way. The liver was extracted for 2 hours. The oil obtained was dark brown in colour but proved palatable.

Soxhlet Extraction (II). Minced liver was dried in a steam oven at a temperature of 100° C. The dried liver was then ground to a fine powder and transferred to a soxhlet thimble and extracted for 3 hours with ether. The resultant oil was dark brown as in the sample above.

Centrifugal Method. Minced liver in the presence of 5 % aqueous KOH was digested by heating in a steam oven. The solution was then centrifuged at 2000 R. P. M. No oil was obtained.

Peptization and Centrifugation. A method for the production of oils from fish livers of low oil content described by Brocklesby and Green was tried on salted seal livers. The livers were minced and diluted with an equal volume of water and sufficient 25 % HCl added to reduce the pH to between 1,22 and 1,5. The pH was maintained within this range during the digestion process. Commercial pepsin to the amount of 0,05 % of the weight of the livers was added. The mixture was then maintained at a temperature of 110—120° F. for 36 hours during which time it was occasionally stirred. At the end of this time a quantity of saturated sodium carbonate solution was added and the mixture heated to approximately 175° F. for five minutes. It was seen that the liver tissues had not completely broken down. A quantity of the solution was centrifuged but no oil was visible. In view of the low rating of the centrifuge available — 2000 R. P. M. — it could not be said that the method had altogether failed.

Steaming and Centrifugation. At a later date, oil of good appearance was obtained by digestion with alkali and passing the resultant solution through a Sharples centrifuge (15,000 R. P. M.) at Vitamin Oil Producers' plant in Port Saxon, Nova Scotia.

The livers were chopped and treated with live steam for 30 minutes. Alkali was added (2 to 4 %) and the mixture steamed for a further 30 to 60 minutes until the complete solution had taken place. The pH was adjusted to 8 and the liquid passed through a Sharples centrifuge. The 'sludge' which was of the consistency of rubber was redigested and run through the centrifuge a second time. The clarified oil had a bright yellow colour and contained no free fatty acids.

Statistical Outlook.

The following tables are taken from official Norwegian statistics:- "Undersøkelser av nye fangstfelter". November 1936, by Thor Iversen. The calculations are based on these statistics and the observations from the Newfoundland sealing grounds, and may only be regarded as rough estimates, as conditions found at the Newfoundland sealing grounds may not be similar to those of other sealing grounds.

(*A*) *Sealing Fields.* Approximately 500,000 seals are caught annually. We know at the present time three main sealing fields in the drifting ice:

(*1*) *White Sea.* The only type of seal caught in this area is Greenland seal *(Phoca groenlandica).* The catch takes place during the breeding season, at the end of February and the beginning of March to May. The majority of the catch consists of baby seal. Usually Norwegian and Russian sealers take part in this catch. (The last statement applies to conditions prior to 1936 as at present Norwegian sealers do not operate in the White Sea).

(*2*) *Jan Mayen*, where both Greenland seals and hood seal are present in large quantities. The catch takes place during the months of March to May. Only Norwegian ships used to take part in this catch.

(*3*) *Newfoundland and Labrador* (Gulf of St. Lawrence). Both Greenland seal and hood seal are present, but the hood seal is in the minority. The catch starts on March 5, and goes on to April and May. Seals are not killed on Sundays, according to a Newfoundland law. Until recently only Newfoundland sealers have taken part in the catch. Since 1937 some Norwegian sealers have also been taking part in the catch, and there is reason to believe that the number will increase in the future, as the prospects are favourable.

The Norwegian sealers also follow the seals on their wanderings during the summer time, in the drift ice around Spitsbergen, and in the strait between Iceland and Greenland.

Spitsbergen Area. The catch consists mainly of Greenland seal, but hood seal, bearded seal, fjord seal, walrus, and polar bears are also hunted.

Denmark Strait. Mainly old hood seals are caught in this area by Norwegian sealers during the months of June and July. In recent years a combined catch of seal and Arctic sharks has taken place here.

(B) Output of the Sealing Industry. During the period 1928—36, 489,323 seals (434,022 Greenland seals and 55,301 hood seals) were caught annually from sealing vessels in the sealing fields mentioned above.

The annual catch of seals from the shores of Newfoundland, Labrador, Greenland and Russia is calculated at 100,000 or 150,000 seals.

Figures showing the annual catch from sealing vessels from different countries and at different areas are given in tables below. The figures are taken from official Norwegian statistics (Iversen, 1936).

(C) The Sealing Fleets. (1) Newfoundland. The Newfoundland sealing fleet consisted on an average of 10 ships during the period 1928—36, with a total tonnage of 5,810 net tons. The average number of crew totalled 1,643 men.

(2) Norway. Norway had during the same period an average of 85 sealing vessels, with a total net tonnage of 4,015 tons. The average number of crew totalled 1,245 men.

(3) Russia. Exact figures are not available. In 1932 twelve ships were operating in the White Sea. Total tonnage was 3,674 tons, and the crew was 982 men.

(D) Variations in the Seal Catch. There are marked annual variations in the seal catch from all the sealing fields.

(1) Newfoundland. During the period 1906—36 the highest figure was obtained in 1906 (342,000 animals). The catch was gradually decreasing until 1920 (34,000 animals). There has been no decrease in the catch during recent years.

Table 11.

Showing the Average Number of Seals Caught per Ship — 1928—36.

Year	No. of Ships	Seals per Ship
1928	12	18.919
1929	14	14.418
1930	18	13.402
1931	10	8.787
1932	4	12.153
1933	6	29.341
1934	10	22.739
1935	10	14.303
1936	8	22.961

(2) Norway. The number of seals killed annually increased from 1906 to 1925 (59,000—409,000).

(*E*) *Vitamin A Obtainable from Seal Livers.*

Table 12.

Approximate Liver Weight and Vitamin A Content (Estimated).

Animal	Liver Weight in g	I.U. vitamin A per g Liver
Greenland Seal		
Baby seal.............	1000	2000
Young seal	1000	3000
Old seal..............	2000	5000
Hood Seal		
Baby seal & Young seal	1500	1000
Old seal..............	4000	4000

Table 13.

Number of Seals at Different Sealing Grounds for the Period 1928—36.

Sealing Ground	Phoca groenlandica			Cystophora cristata		Total
	Baby Seal	Young Seal	Old	Baby & Young	Old	
White Sea	106.314	37.324	92.434	-	-	236.072
Jan Mayen ...	23.027	2.517	4.547	20.852	7.691	58.634
Denmark Strait	-	-	-	7.274	16.594	23.868
Newfoundland .	139.761	19.498	8.600	2.066	824	170.749
Total	269.102	59.339	105.581	30.192	25.109	489.323

Table 14.

Million I. U. Vitamin A Obtainable from Seal Livers According to Figures in Table II (Estimated).

Sealing Ground	Phoca groenlandica			Cystophora cristata		Total
	Baby	Young	Old	Baby & Young	Old	
White Sea	212.628	111.972	924.240	-	-	1.240.840
Jan Mayen ...	46.054	7.551	45.470	31.278	123.056	253.409
Denmark Strait	-	-	-	10.911	265.504	276.415
Newfoundland .	279.522	58.494	86.000	3.099	13.184	440.299
Total	538 204	178.017	1.055.710	45.288	401.744	2.219.963

Table 15.

Average Annual Distribution of the Seal Catch, 1928—36.

Country	Phoca groenlandica			Cystophora cristata		Total Number of Animals
	Baby	Young	Old	Baby & Young	Old	
Norway.......	78.977	23.171	35.280	28.126	24.285	189.839
Russia	50.364	16.670	61.701	-	-	128.735
Newfoundland .	139.761	19.498	8.600	2.066	824	170.749
Total	269.102	59.339	105.581	30.192	25.109	489.323

Table 16.

Distribution of the Vitamin A from the Seal Catch, Million I. U. Based on Table IV (Estimated).

Country	Phoca groenlandica			Cystophora cristata		Total
	Baby	Young	Old	Baby & Young	Old	
Norway.......	157.954	69.513	352 800	42.189	388.566	1.011.022
Russia	100.728	50.010	617.010	-	-	767.748
Newfoundland .	279.522	58.494	86.000	3.099	13.184	440.299
Total	538.204	178.017	1.055.810	45.288	401.750	2.219.069

Summary.

Vitamin A was assayed by the antimony trichloride method in livers of hood seal *(Cystophora cristata)* and Greenland seal *(Phoca groenlandica)* during the breeding period March until late May, 1941.

Throughout this period the concentration of vitamin A in the livers of the male animals showed a higher level than those of the females in both types of seal studied and higher in older animals.

The livers of the males had a higher concentration of vitamin A in March than in April.

The lower the yield of oil the higher the concentration of vitamin.

No correlation could be found between the amount of subcutaneous fat and vitamin potency of the liver.

The viscera of several hundred animals were examined during the breeding season and found to be devoid of food.

The maximum concentration of vitamin A observed in the liver of hood seal was 24,000 I. U. per g, the mean value being 3,000 I. U. per g. A similar observation on Greenland seal showed a maximum level of 15,000 I. U. per g and a mean value of 3,400 I. U. per g.

The oil content of very young animals was high (10 %), the livers of mature animals remaining fairly constant (3,0—4,0 %),

From a representative sample of seal livers, oil was extracted by a rough method of semi-commercial scale and found to have a potency of 251,000 I. U. per g.

Only very small amounts of vitamin A were found in kidney, lung, retina, subcutaneous fat and other tissue.

Methods for extraction of the salted liver have been investigated.

Of the various methods tried the centrifugal method using a very high rotation gave the oil of best appearance.

According to official statistics, approximately half a million seals are caught annually — corresponding to an amount of vitamin A of more than 2 billion I. U., assuming that the conditions found at the Newfoundland sealing grounds are similar to those of other sealing grounds. Of the total amount of vitamin A available from the seal catch, 50 per cent would, under normal conditions, go to Norway.

References.

Davies, A. W. (1933), "The Colorimetric Determination of Vitamin A by the Alkali Digestion Method". Biochem. J. *27*, 1770.

Rodahl, K., and Moore, T., (1943), "The Vitamin A Content and Toxicity of Bear and Seal Liver". Biochem. J. *37*, 166.

II. Sources of Vitamin C in Arctic Regions.

Introduction.

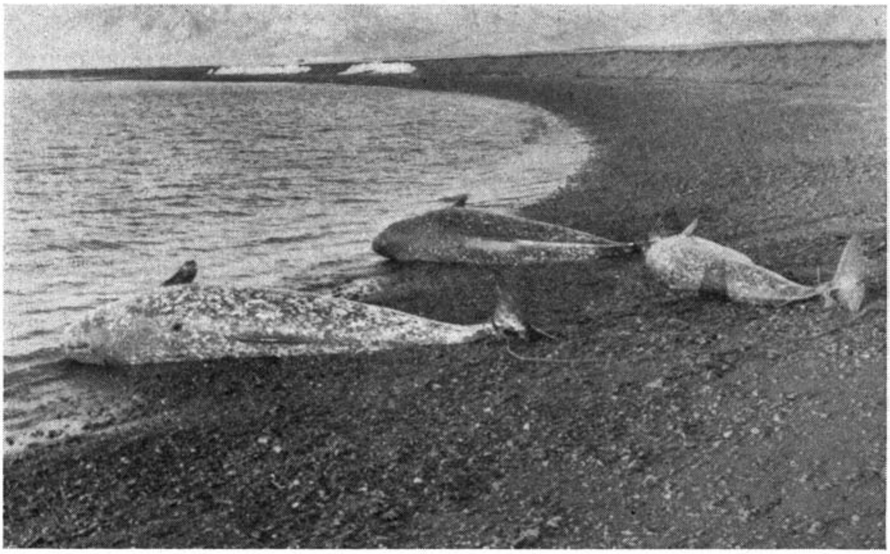
In a previous paper (1) it has been shown that vitamin C (l-ascorbic acid) is well distributed through the more common Arctic flora. The fact that no vitamin deficiency is known among the East Greenland Eskimos, who for a greater part of the year are living entirely on the organs of Arctic animals, indicates that these animals contain sufficient vitamins to satisfy the normal requirements of these people. Stefansson, (2) who first directed attention to this fact, cured three cases of scurvy with fresh meat. In view of this, and as an extension of the previous work, an investigation was carried out during the period from July 1939 to August 1940 on an expedition to North East Greenland. This paper contains the results of chemical determinations of ascorbic acid in organs of the more common types of Arctic animals and birds, as well as the more important European foodstuffs consumed by the trappers in N. E. Greenland.

Observations and Discussions.

Technique: For determination of vitamin C in animal organs a modification of the method of Tillman's (3) was used. 5—10 grams of the organ were ground in a mortar, adding sand and 10 % trichloracetic acid for extraction of the ascorbic acid. The liquid was filtered through a Buchner funnel and the colourless solution titrated against 2,6-dichlorophenol-indophenol to a faint pink colour. In some cases the method of Emmerie and Van Eekelen was used (4). (After extraction with trichloracetic acid the liquid was neutralised with calcium carbonate, mercury acetate was added, and the extract was filtered through a Buchner funnel. The solution was saturated with hydrogen sulphide and allowed to stand over night. The hydrogen sulphide was removed by bubbling nitrogen through the liquid and the colourless solution titrated against 2,6-dichlorophenol-indophenol.) A series of analyses was carried out on each specimen.

The trapping station and the laboratory at Revet, North East Greenland, lat. 74° 30′ N.

The laboratory at Revet, North East Greenland.



Narwhale at Myggbukta. (Photo: E. Bird.)

The technique mentioned above required a rather well-equipped laboratory, which had to be established in the Arctic. For this purpose the trapper's hut at Revet, Clavering Island, East Greenland, latitude 74° 30′N, was placed at my disposal by the Norwegian Corporation A/S Arktisk Næringsdrift, Oslo. The room was built with double panel walls and covered with tarred wall-paper. The outside walls were protected by earth from the ground to the roof. Special equipment suitable for the Arctic conditions had to be made, such as hand centrifuges, hand pumps etc. The main difficulty was to protect the chemicals and solutions from the extremely low temperature in the middle of the winter (sometimes —50°C), when the room temperature at times went down to—25°C during the night.

The results are tabulated as follows (tables 17, 36—38).

Arctic Mammals and Fish.

From table 17 it is evident that of the organs examined, such internal organs as liver, brain and kidneys of the Arctic mammals, which constitute the main source of food supply in the Arctic, musk oxen and seals were rich in vitamin C.

It is interesting to note that some of the organs which are eaten by the Eskimos but not by the European trappers, such as testicles of musk ox and fjord seal, had a relatively high content of ascorbic acid. (Testicles of musk ox 14—20 and testicles of fjord seal 9—30 mg ascorbic acid per 100 g). It was found that the ascorbic acid was unevenly distributed throughout the organ, the central part of the testicles being richest in ascorbic acid.

Table 17.

Distribution of Ascorbic Acid in Organs from Arctic Animals.

Animal	Organ	Mg Asc. Acid per 100 g Substance		
		Max.	Min.	Mean
Musk ox (Ovibos moschatus)	*Muscles*, fresh	1.5	0.4	0.8
	— stored 3 months, frozen	0 3	0.2	0.3
	— "gassed"	0.0	0.0	0.0
	— salted (In brine 40 days)	-	-	0.0
	Cooked meat, roast leg	1.2	0.4	0.8
	— boiled meat	1 8	0.6	1.4
	— boiled meat cakes	0.0	0.0	0.0
	Milk, fresh	3.4	3.4	3.4
	Heart muscle	1.5	1.4	1.5
	Diaphragm muscle	-	-	0.4
	Oesophagus	0.5	0.4	0.5
	Tongue	1.1	1.0	1.0
	Brain tissue	13.9	11.6	12.8
	Peripheral nerves from plexus brachialis	-	-	0.0
	Liver, fresh	15 8	5.7	10.4
	— stored 12 days, frozen	-	-	8.2
	— fried	11.7	6.9	9.3
	Kidney, fresh	8.3	4 3	5.9
	Spleen	11.4	3.1	6.0
	Udder	5.1	5.0	5.8
	Testicles	20.5	14.8	18.2
	Epididymis	8.1	2 2	4.2
	Lymph gland	29.2	16.3	20.7
	Thyroid gland.	-	-	3.8
	Pancreas	6.1	4.9	3.9
	Adrenals	-	-	39.2
	Bile	1 3	0.6	1 0
	Lung tissue	12.1	5.4	8 1
	Eye, whole organ	0.8	0.5	0.7
	Ventricle wall	2.3	2.1	2.2
	Small intestine	-	-	7.4
	Content of ventricle	0.7	0.2	0 4
	Content of small intestine	3.5	1.3	2.4
	Suet	0 0	0 0	0.0
	Subcutaneous fat	0 0	0.0	0.0
	Uterus with foetus	7.0	7.0	7.0
	Amniotic fluid	-	-	0.4
	Fluid from foetal bladder	-	-	0.0
	Penis, pars cavernosa	-	-	1.3
Ringed seal (Phoca hispida)	Liver	15.0	9.7	11.9
	Muscles	0.9	0.5	0.7
	Large intestine	-	-	1 0
	Small intestine	6.4	0.8	3.3
	Content of small intestine	2.7	1.8	2 1
	Blubber	0.0	0.0	0.0
	Abdominal blubber	0.0	0.0	0.0
	Axillary lymph gland	-	-	15.8
	Kidney	2.0	2.0	2.0
	Testicles, average	-	-	9.4
	— central part	-	-	30.4
	Testicles and epididymis	-	-	7.6

Animal	Organ	Mg. Asc. Acid per 100 g. Substance		
		Max.	Min.	Mean
Ringed seal (Ph. hispida) (cont.)	Epididymis	2.0	1.8	1.9
	Urinary bladder	-	-	1.9
	Skin	-	-	1.0
Bearded seal (Erignathus barbatus)	Brain substance	16.8	4.3	10.6
	Muscle, trunk	0.6	0.4	0.5
	Heart muscle	-	-	0.9
	Liver	14.4	14.1	14.3
	Kidney	4.0	3.6	3.8
	Kidney, glomeruli	-	-	2.9
	Lung tissue	0.5	0.5	0.5
	Blubber, subcutaneous	0.0	0.0	0.0
	Eye, crystalline lens	-	-	2.1
	— vitreous body	-	-	3.5
	— pigmented retina	-	-	6.3
Hood seal[1] (Cystophora cristata)	Liver (of baby seal)	-	-	21.0
	Liver (of adult female with baby)	-	-	7.5
	Liver (of unborn seal)	-	-	8.5
	Meat (muscles from neck) of baby seal	-	-	0.9
	Meat (muscles from neck) of adult females	-	-	0.5
	Milk from udder	-	-	5.0
	Udder	-	-	2.5
	Brain	-	-	9.0
	Heart	-	-	1.1
	Diaphragm	-	-	1.0
	Kidney	-	-	9.9
	Spleen	-	-	12.9
	Pancreas	-	-	28.4
	Ventricle	-	-	3.0
	Thymus	-	-	4.7
Greenland seal[1] (Phoca groenlandica	Liver (of baby seal)	-	-	26.6
	Meat (muscles from neck)	-	-	0.3
	Heart	-	-	0.7
	Diaphragm	-	-	0.4
	Brain: cerebrum	-	-	8.0
	cerebellum	-	-	12.0
	Kidney	-	-	3.9
	Spleen	-	-	4.6
	Pancreas	-	-	7.4
	Lung	-	-	1.1
	Testicles	-	-	24.4
	Epididymis	-	-	7.2
	Eye: lens crystallina	-	-	1.8
	corpus vitreum	-	-	3.0
	retina	-	-	7.9
Snow hare (Lepus variabilis glacialis)	Muscles, neck	-	-	1.3
	Liver	5.1	4.4	4.8
	Kidney	-	-	2.9
	Content of stomach	13.4	7.7	10.6
Shark (Somniosus microcephalus)	Liver	3.2	2.5	2.9
	Meat	0.3	0.2	0.3

[1] Two specimens of hood seal and Greenland seal were determined in the sealing field east of Newfoundland in the spring of 1941.

Animal	Organs	Mg Asc. Acid per 100 g Substance		
		Max.	Min.	Mean
Narwhale (Monodon monoceros)	Epidermis — "Mattaq"	34.0	29.5	31.8
	— corneus layer	-	-	14.5
Salmon (Salmo salar)	Liver	9.2	8.7	8.9
	Roe	-	-	25.1
	Meat	1.4	1.3	1.4
	Meat salted, boiled	0.0	0.0	0.0

Spleen and lymph glands from musk ox and seals which are eaten by the Eskimos, but carefully avoided by the trappers who consider them inedible, contained up to 29 mg ⁰/₀ ascorbic acid.

It was found that fresh meat of musk ox, which forms the most important source of food supply to the European trappers, contained approximately 1 mg ⁰/₀ ascorbic acid. When stored or salted, the meat lost its vitamin C content, while fresh meat of musk ox cooked in the usual trapper manner, maintained its vitamin C content. When fried as meat cakes the meat was found to contain no ascorbic acid.

Heart muscle and the tongue of musk ox and seals had approximately the same ascorbic acid content as ordinary trunk muscle.

The liver of musk ox and seals contained an average of approximately 10—25 mg ascorbic acid per 100 g. In the case of seals, the baby seals had a higher vitamin C content than adult seals. A slight deterioration of the vitamin C content of the liver of musk ox took place when fried or stored frozen during a period of 12 days.

Of the other internal organs, the adrenals were rich in vitamin C, while only small amounts were found in the rest of the internal organs.

In the stomach content of musk ox consisting of grass and buds of Arctic willows, only small amounts of ascorbic acid were detected (0,5 mg ⁰/₀). Stomach content of snow hare contained approximately 10 mg ⁰/₀ ascorbic acid.

"Mattaq", — the epidermis of narwhale, which has long been known as an excellent antiscorbuticum among Arctic people, contained approximately 30 mg ascorbic acid per 100 g. It is frequently eaten by the Eskimos, who keep it stored in seawater.

The liver of Arctic shark (Somniosus microcephalus) contained small amounts of ascorbic acid and only traces could be found in the meat, which causes diarrhæa when eaten raw by men or dogs.

Of the organs of salmon, the roe was found to be rich in ascorbic acid (25 mg ⁰/₀).

From table 18 there is no evidence to suggest any definate seasonal variation in the ascorbic acid content of tissue examined.

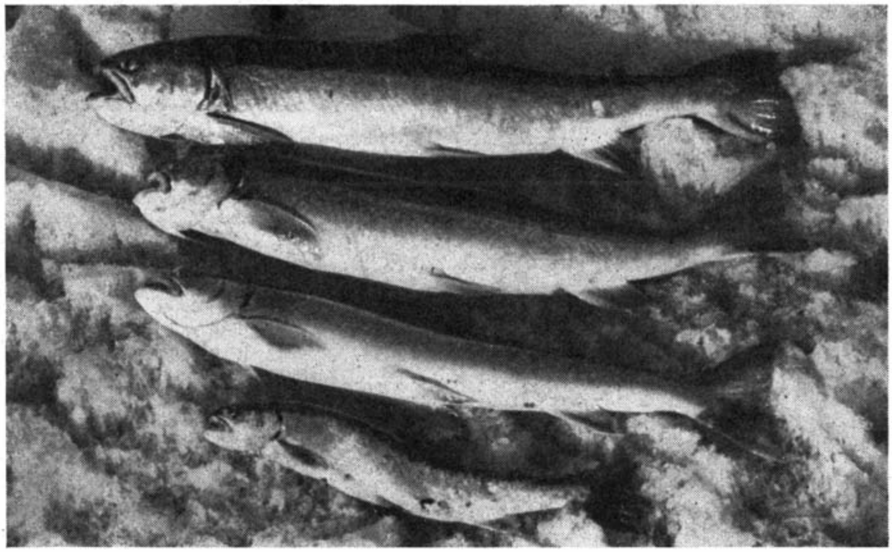
Table 18.
Comparison of Ascorbic Acid Content of Organs of Arctic Animals at Different Seasons of the Year.

Animal	Organ	Date Killed for Analysis	Mg Ascorbic Acid per 100 g. Mean
Musk ox (Ovibos moschatus)	Muscles, fresh.	28. 9.39	0.5
	— —	7.10.39	0.6
	— —	3. 1.40	0.8
	— —	24. 5.40	1.5
	Liver, fresh.	2. 9.39	9.9
	— —	28. 9.39	13 4
	— —	5. 3.40	5.7
	— —	25. 4.40	10.4
	— —	1. 7.40	10.4
	Kidney, fresh.	7.10.39	4.7
	— —	23.10.39	8.3
	— —	5. 3.40	6.0
	Spleen, fresh.	7.10.39	7.7
	— —	26.10.39	11.4
	— —	5. 3.40	4.0
	— —	28. 6.40	3.1
	Testicles, fresh.	7.10.39	20.0
	— —	5. 3.40	18.2
	Lung, fresh.	28. 9.39	7.2
	— —	12. 5.40	7.0
	— —	28. 6.40	12.1
	Content of ventricle	28. 9.39	0.5
	— — —	25. 4.40	0.3
	— — —	12. 5.40	0.7
Ringed seal (Ph. hispida)	Liver, fresh.	18. 9.39	11.2
	— —	3.10.39	11.2
	— —	11.10.39	15.0
	Muscles, fresh.	18. 9.39	0.6
	— —	6.10.39	0.7
	Content of small intestine	18. 9.39	1.8
	— — —	3.10.39	2.7

From table 19 it will be observed that the average-sized musk ox (including internal organs) provides approximately 1500 mg ascorbic acid.

Of this amount, the internal organs, which are all eaten by the Eskimos, provide 500 mg.

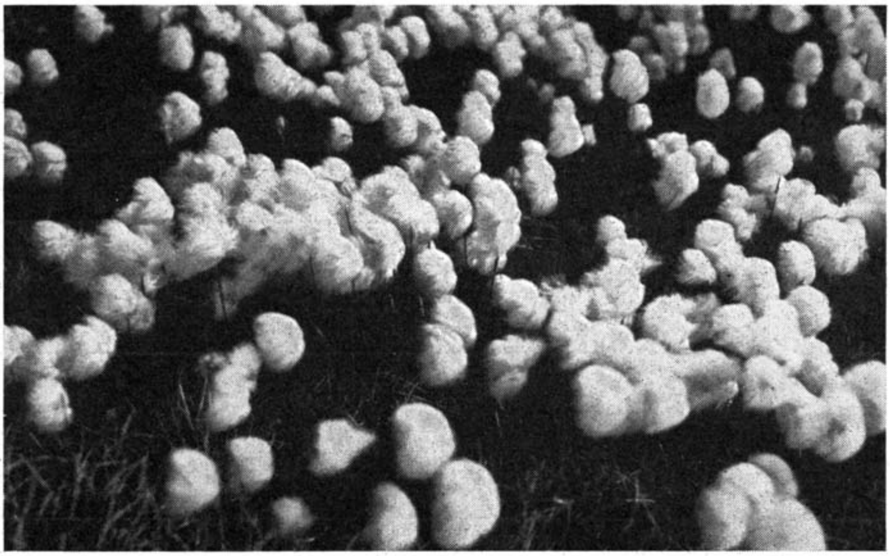
Based on a daily requirement of 25 mg which is believed sufficient under Arctic conditions (Høygaard, 1939), the internal organs alone would provide one man's ascorbic acid requirement for a period of 20 days. Of the internal organs, the European trappers ingest only the liver, kidney, heart, tongue and some brain. The total amount of ascorbic acid obtainable from these organs, 334 mg, would fulfil the requirement of one man for a period of 16 days.



Salmon caught at Strindberg, North East Greenland.
(Photo: E. Bird.)

Table 19.
Ascorbic Acid Available from Meat and Organs of one Average-Size Musk Ox.

	Weight of Organ in g	Ascorbic Acid Content per 100 g (mg %)	Total Amount Ascorbic Acid in mg.
Thyroid.	24	4	1.0
Liver	2 500	10	250.0
2 kidneys	458	6	27.5
2 adrenals	8	40	3.2
Pancreas	85	4	3.4
Spleen	385	6	23.1
2 testicles	180	18	23.4
2 epididymus	40	4	1.6
Tongue	485	1	4.9
2 eyes	32	1	0.3
Brain	250	13	32.5
Heart	1 000	2	20.0
Other organs (approx.)	-	-	100.0
Muscles (approx.)	100 000	1	1 000.0
Total	-	-	1 499.9



Cotton grass at Revet. (Photo: Antonsen.)

Table 20.

Comparison of Fully Grown and Young Musk Oxen in Relation to Their Ascorbic Acid Content.

Organ	Mg Ascorbic Acid per 100 g	
	Young Musk Ox Calf (8—14 Days Old)	Fully Developed Musk Ox.
Brain	12.8	12.8
Adrenals	25.1	39.2
Spleen	2.2	6.0
Kidney	1.4	5.9
Liver	1.4	10.4
Trunk muscle ..	0.4	0.8

The figures for young musk ox refer only to one animal but are apparently lower, with the exception of brain, than the figures for fully grown animals.

Arctic Birds.

Table 21.

Distribution of Ascorbic Acid in Organs of Arctic Birds.

Species of Bird	Organs	Mg Ascorbic Acid per 100 g
Rock ptarmigan (Lagopus rupestris)	Breast muscle	0.9
	Liver	21.8
	Heart	1.9
	Small intestine	15.2
Parasitic jaeger (Stercorarius parasiticus)	Brain	19.1
	Liver	12.8
	Eye (whole organ)	2.1
	Heart muscle	1.4
	Breast muscle	1.0
	Small intestine	11.5
Glaucous-gull (Larus hyperboreus)	Brain	19.4
	Liver	16.5
	Eye (whole organ)	2.7
	Heart muscle	0.9
	Breast muscle	0.5
	Small intestine	8.1
Old squaw (Clangula hyemalis)	Brain	8.2
	Liver	12.3
	Eye (whole organ)	3.1
	Breast muscles	1.2
	Heart muscles	1.7
	Small intestine	17.4
	Crop	1.9
Loon (Gavia immer)	Brain	29.3
	Liver	19.2
	Eye (whole organ)	2.1
	Heart muscle	1.1
	Small intestine	8.0
Eider-duck (Somateria mollissima)	Liver	30.0
	Liver, cooked	8.7
	Heart muscles, fresh	2.3
	Heart muscles, cooked	2.4
	Breast muscles, fresh	1.3
	Subcutaneous fat	0.0
	Small intestine	24.8
	Crop	2.6
	Eggs, new-laid	7.0
	Eggs, boiled, white	1.6
	Eggs, boiled, yolk	0.9

Snow hare.

Rock ptarmigan in North East Greenland.

Table 22.

Comparison of Content of Ascorbic Acid in Organs from Arctic Birds — Mg %.

Organ	Rock Ptarmigan (Lagopus rupestris)	Parasitic Jaeger (Stercorarius parasiticus)	Glaucous-gull (Larus hyperboreus)	Old-squaw (Clangula hyemalis)	Loon (Gavia immer)	Eider-duck (Somateria mollissima)
Brain	-	19.1	19.4	8.2	29.3	-
Liver	21.8	12.8	16.5	12.3	19.2	30.0
Eye (whole organ) ...	-	2.1	2.7	3.1	2.1	-
Heart muscle	1.9	1.4	0.9	1.1	1.1	2.3
Breast muscle	-	1.0	0.5	1.2	-	1.3
Small intestine	15.2	11.5	8.1	17.4	8.0	24.8
Crop	-	-	-	1.9	-	2.6

Table 23.

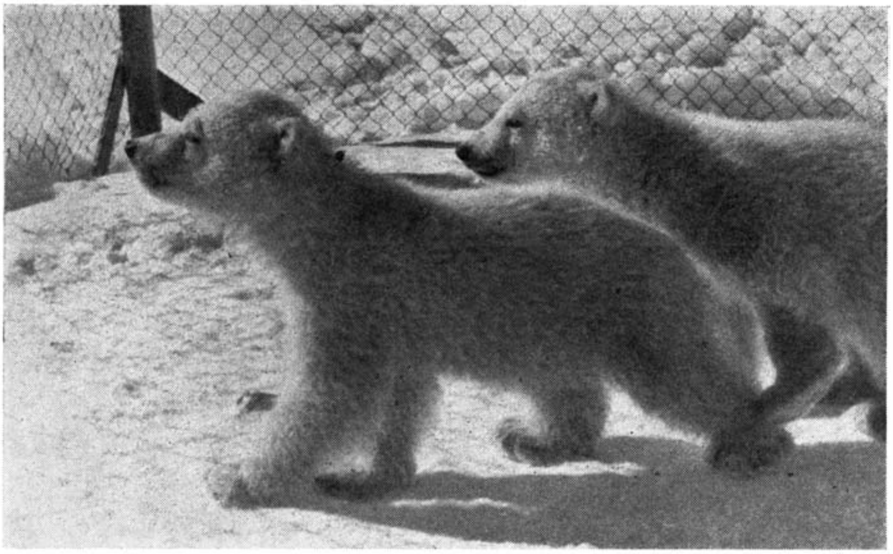
Total Mg Ascorbic Acid Obtainable from Arctic Birds.

	Parasitic Jaeger	Glaucous-gull	Old-squaw
Brain	0.50	0.76	0.40
Liver	0.75	8.50	1.86
Eyes	0.08	0.29	0.12
Heart	0.04	0.10	0.10
Breast muscle	0.30	1.69	2.00
Intestine	3.60	-	6.80
Crop.	-	-	0.16
Total	5.28	11.30	11.44
Mg ascorbic acid per g body-weight	0.01	-	0.01

The results of ascorbic acid determinations carried out on organs of Arctic birds are given in Tables 21, 22 and 23. It will be observed that considerable amounts of ascorbic acid were detected in the liver, brain and intestines of the birds examined. Small amounts were found in other organs.

These findings with regard to the distribution of ascorbic acid in Arctic fauna and flora (1) are in agreement with the facts stated by Høygaard (5) that the East Greenland Eskimos secure 50 % of their vitamin C requirements from marine algae, the other 50% being obtained from organs of mammals, birds and fish.

The Arctic birds form an important food supply in the spring, at which time scurvy used to be most common among European trappers in the Arctic.



Bear cubs at Myggbukta. (Photo: E. Bird.)

The above stated figures for the vitamin C content in Arctic animals together with the results of determination of vitamin C in the more important Arctic plants (1) indicate that when the natural sources of this vitamin are properly utilised there should be no reason to suffer from scurvy in Arctic regions, even without supplies of fruits or other sources of ascorbic acid from more temperate zones.

In this connection it is of interest to compare the vitamin C content in natural foodstuffs with the European foodstuffs brought up to Greenland by the trappers.

European Foodstuffs. The results of determination of ascorbic acid in the laboratory at Revet by the same method, in the more important European foodstuffs consumed by the Norwegian trappers in N. E. Greenland, are given in table 24.

From this table it will be observed that a number of the imported foodstuffs used by the European trappers in Greenland were seriously lacking in vitamin C content, such as frozen potatoes, pickles, dehydrated travelling provisions (pork and peas, pork and beans, and apple jam), mixed fruit salad, dried patent food ("Reserveproviant") and salted or dried meat and fish.

Other European foodstuffs consumed by the same trappers, such as potatoes and dried vegetables had appreciable amounts of antiscorbutic vitamin.

Concentrated commercial lemon juice, which is considered by the trappers as a legal antiscorbutic medicine on winter expeditions, and is usually taken as such, had no vitamin C content when examined after a few months storage in Arctic conditions.

Table 24.

Ascorbic Acid Content of More Important European Foodstuffs Consumed by Norwegian Trappers in North East Greenland, as Determined by Tillman's Method.

	Mg 0/0 *Vitamin C* (ascorbic acid)		*Mg* 0/0 *Vitamin C* (ascorbic acid)
Potatoes, frozen	0.7	Tinned pears	1.0
— — boiled	2.6	— pear juice	2.3
— dried	4.9	Condensed milk, full cream, unsweetened	3.8
— — boiled	1.8		
Onion, frozen	4.5	Lemon (frozen for 3 months)	14.0
Dried vegetables (Julienne)	2.9	"Citronal" (antiscorbutic medicine)	0.0
— cabbage	42.1		
Pickles, onion	0.0	Butter	0.0
— gherkins	0.0	Margarine	0.0
Pickled cabbage	0.0	Cheese	0.0
Dried spinach	16.8	Dried patent foods	0.5
Fish cakes	0.0	Biscuits	0.0
Meat cakes, boiled (musk ox meat)	0.0	Salted meat	0.0
		Smoked pork (bacon and ham)	0.0
Dried travelling provision			
— pork and peas	0.7	Salted pork	0.0
— pork and beans	0.5	Salted salmon	0.0
— apple jam	0.6	Salted herring	0.0
— pancakes	0.0	Dried cod	0.0
Mixed fruit salad	1.8	Salted cod	0.0

Summary.

Employing a modification of the method used by Tillman, the vitamin C (l-ascorbic acid) content was assayed in organs from musk ox, various types of seals, snow hare, Arctic shark, narwhale, salmon, and a variety of Arctic birds, in a laboratory at Revet, Clavering Island, N. E. Greenland throughout the whole year. In animals of most importance from the view point of food supply, all available organs have been examined under different conditions, such as before and after cooking, frying, freezing etc.

It is shown that some of the internal organs of these animals are rich in vitamin C and when fully utilized they would form an important source of vitamin C supply to the European trappers in Greenland.

A number of the European foodstuffs consumed by the Norwegian trappers in Greenland were found to be seriously lacking in vitamin C content, while other foodstuffs, such as potatoes and dried vegetables had appreciable amounts of antiscorbutic vitamin when stored under Arctic conditions.

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III. A Dietary Survey Among Norwegian Trappers in North East Greenland.

Introduction.

Problems of Arctic diet have confronted us for many years, but little attention has been focussed on this all important subject. Lack of proper knowledge regarding the presence of vitamins in the flora and fauna of the Arctic regions has prevented the European trappers from fully utilizing the natural resources. Consequently, even up to recent years, many cases of vitamin deficiency diseases, more notably scurvy and beriberi, have been recorded among the Europeans trappers in Greenland.

During the dark period of the year, November to February, the trappers generally show a lack of initiative, and complain of feeling lazy and show symptoms of debility. It is suggested that this may be due to a mild form of avitaminosis C.

In a preliminary work by Høygaard and Rasmussen (1) who examined the crew of a Norwegian hunting vessel, who had spent the previous winter in North East Greenland, it was found that the whole crew of 12 men suffered from avitaminosis A, and 10 of the men from hypovitaminosis C. The captain suffered from manifest beriberi. The importance of a sufficient supply of vitamin A was emphasized, in view of the fact that the ability of a hunter depends upon the power of night distinction of his eye. In a later work by Høygaard, Holm and Rodahl (2) it was shown that hemeralopia occurred very frequently among navigators from our merchant marine.

With a view to ascertaining to what extent vitamin deficiency might apply to the health of the Arctic hunters, a comprehensive study of the diet dur.ng four periods of the year was made by the author during a scientific expedition to North East Greenland (1939—40), the chief purpose of which was to study the sources of vitamins in the Arctic. The survey was made among a group of Norwegian trappers during the year 1939—40. The expedition arrived at Clavering Island, North East Greenland lat. 74°30′N at the end of July, 1939, where a chemical laboratory was established. Thirteen Norwegian trappers spent the following winter at the coast from Kong Oscars Fjord to Peters Bay, divided into 6 groups.

The food supply in each group was very similar, and was secured by A/S Arktisk Næringsdrift, Oslo. A preliminary investigation showed that the food consumption in the different groups was fairly equal, and this fact was verified by checking the total food consumption during the whole year at the different groups. A representative group of three trappers (including the author) stationed at our base was therefore investigated during the four seasons of the year (summer, autumn, winter and spring). None of the individuals investigated suffered from any illness.

Observations and Calculations.

Method of Collecting and Calculating Data. During the surveys the author was living with the individuals examined. The food served at each meal was weighed before and after the meal and the individual food intake recorded. Corrections were made for edible and inedible wastage. In each period the food consumption was usually recorded during two weeks. The data of food consumption were calculated in terms of the recognized nutritive elements — protein, fat, carbohydrate, calcium, phosphorus, iron, the vitamins and energy value. The figures for the content of protein, fat, carbohydrate, calcium, phosphorus, iron and energy value of the consumed foodstuffs were taken from "Tables of Food Value, Canadian Council of Nutrition". The figures for the vitamin C content of foodstuffs consumed by the European trappers were obtained by own determinations by a modification of Tillman's method in the laboratory at Revet, North East Greenland.

Results. The results of these studies are given in the following tables.

Table 25.

Nutritive Value of the European Foodstuffs Consumed.

Foodstuff	per 100 grams						
	Calories	Proteins	Fat	Carbo-hydrates	gms. Ca	gms. P	mg. Fe
Bread, wheat, average	265	9.3	1.2	52.7	0.03	0.10	0.80
Bread, whole wheat 100 %	269	9.2	1.7	52.6	0.04	0.16	1.70
Biscuits	300	7.4	10.0	41.0	0.07	0.09	0.65
Rice, boiled	96	1.8	0.1	21.3	-	-	-
Oatmeal	410	16.1	7.2	67.5	0.07	0.39	4.80
Wheat, cream of	368	11.8	2.4	72.5	-	0.02	0.11
Butter	795	1.0	85.0	-	0.02	0.02	0.20
Margarine	-	-	-	-	-	-	-
Milk, condensed, unsweetened	145	6.9	8.2	9.9	0.32	0.24	0.70
» » sweetened	340	7.9	9.0	54.6	0.30	0.24	0.60
» dried	372	37.7	1.4	49.9	0.32	0.24	0.70
Chocolate, sweet	568	8.0	35.0	51.1	0.04	0 07	0.36
Cheese, goats	443	27.6	34.9	1.3	1.09	0.81	1.20
» cream	393	2.2	40.0	3.0	0.51	0.40	1.30

Foodstuff	per 100 gram						
	Calories	Proteins	Fat	Carbo-hydrates	gms. Ca	gms. P	mg. Fe
Eggs, boiled	135	11.9	9.3	-	0.06	0.22	3.13
» dehydrated	570	40.0	43.7	-	-	-	-
Meat	448	13.3	42.3	-	0.01	0.20	3.00
» salted, smoked (beef)	172	26.4	6.9	-	0.02	0.32	6.20
Tongue, fresh, pickled	227	11.9	19.2	-	0.03	0.23	6.90
Meat, sausage	342	10.9	29.3	5.9	0.05	0.12	1.98
Tenderloin	198	18.9	13.0	-	-	-	-
Ham, smoked, boiled	291	20.2	22.4	-	0.01	0.22	1.70
Duck, breast muscle	252	18.3	19.0	-	-	-	-
Suet	780	4.7	81.8	-	-	-	-
Liver, ground, boiled	174	26.7	6.0	2.1	0.01	0.37	8.20
Anchovy	103	15.3	3.6	1.7	-	-	-
Cod fish, salted	107	25.4	0.3	-	0.03	0.29	0.52
» » cakes	213	7.3	15.0	10.7	0.01	0.19	0.40
» roes	-	-	-	-	0.02	0.50	1.60
Salmon, salted	150	19.5	7.5	-	0.02	0.25	1.20
Salmon, smoked,	209	22.0	12.8	-	0.01	0.25	0.90
Sardines, canned	278	23.0	19.7	-	0.04	0.37	1.80
Herring, kippered	276	19.8	20.9	-	0.32	0.35	12.50
Potatoes	69	1.8	0.1	14.7	0.01	0.05	1.20
» boiled	97	2.5	0.1	20.9	-	-	-
Peas, green	57	3.6	0.2	9.8	0.02	0.13	2.07
» dried, boiled	52	5.0	-	7.7	0.01	0.08	1.22
Cabbage (dried vegetables)	32	1.6	0.3	5.6	0.05	0.03	0.45
Beans	57	3.2	0.3	9.9	0.03	0.13	2.40
Onions, fresh	50	1.6	0.3	9.9	0.04	0.05	0.48
Macaroni	367	13.4	0.9	74.1	0.02	0.14	1.20
Cranberries	48	0.4	0.6	10.0	0.01	0.01	0.44
Apple sauce	102	0.3	0.3	24.0	0.01	-	0.34
Lemons	32	0.7	0.5	5.9	0.02	0.01	0.60
Marmalade	320	0.4	0.8	76.0	0.05	0.01	0.56
Raisins	353	2.6	3.3	76.1	0.06	0.13	2.99
Fruit salad, mixed	135	1.3	0.3	30.9	0.07	0.12	7.60
Pears	52	0.5	0.1	12.0	0.01	0.01	0.15
Lime juice	34	0.5	-	7.1	-	-	-

The above figures are taken from "Tables of Food Value, Canadian Council of Nutrition". The ingestion of proteins, fat, carbohydrates and minerals of the trappers was calculated on the basis of figures set out in the above table.

Table 26.

Ingestion of Proteins, Fat, Carbohydrates, and Minerals per Man per Day in the Period 3/10/39—18/10/39.

Foodstuffs	gms. consumed per man per day	Calories	Proteins	Fat	Carbohydrates	gms. Ca	gms. P	mg. Fe
Bread, wheat, average	185	491	17	2	98	0.05	0.18	1.48
Bread, whole wheat, 100 0/0	98	264	9	2	52	0.03	0.16	1.67
Biscuits	11	34	1	1	5	0.01	0.01	0.07
Rice	3	3	0	0	1	-	-	-
Oatmeal	11	47	2	1	8	0.01	0.04	0.55
Groats	6	-	-	-	-	-	-	-
Wheat, cream of	5	17	1	0	3	-	0.00	0.01
Sugar	3	14	-	-	3	-	-	-
Coffee	43	-	-	-	-	-	-	-
Tea	0	-	-	-	-	-	-	-
Pancakes	2	-	-	-	-	-	-	-
Butter	72	574	1	61	-	0.01	0.01	0.14
Margarine	15	117	0	13	-	0.00	0.00	0.03
Milk, condensed, unsweetened	91	132	6	7	9	0.29	0.22	0.64
» » sweetened	9	29	1	1	5	0.03	0.02	0.05
Chocolate	8	48	1	3	4	0.00	0.01	0.02
Cheese, goats (1)	41	184	11	14	1	0.45	0.34	0.50
» » (2)	2	7	0	1	0	0.01	0.01	0.02
» » cream	3	12	0	1	0	0.02	0.01	0.04
Eggs, boiled	31	42	4	3	-	0.02	0.07	1.00
Musk ox meat	90	405	12	38	-	0.01	0.18	2.71
Meat cakes (musk ox)	26	115	3	12	-	0.00	0.05	0.76
» canned	30	101	3	9	2	0.01	0.04	0.59
Ham, smoked	17	49	3	4	-	0.02	0.04	0.29
» salted	9	26	2	2	-	0.00	0.02	0.15
Sardines	2	5	0	0	-	0.00	0.01	0.03
Salmon, salted	34	71	8	4	-	0.00	0.09	0.31
Cod fish cakes	68	145	5	10	7	0.01	0.13	0.27
Potatoes	207	143	4	0	30	0.02	0.10	2.48
Peas, green	2	1	0	0	0	0.00	0.00	0.05
» dried, boiled	11	6	1	-	1	0.00	0.01	0.14
Beans, brown	7	4	0	0	1	0.00	0.01	0.16
Onions	5	2	0	0	5	0.00	0.00	0.02
Macaroni	12	44	2	0	9	0.00	0.02	0.14
Apple jam	1	1	0	0	0	0.00	-	0.00
Cranberries	13	6	0	0	1	0.00	0.00	0.06
Lemon	7	2	0	0	0	0.00	0.00	0.04
Raisins	1	4	0	0	1	0.00	0.00	0.03
Fruit salad	10	14	0	0	3	0.01	0.01	0.78
	1191	3159	97	189	249	1.00	1.79	15.23

Table 27.

Ingestion of Proteins, Fat, Carbohydrates, and Minerals Per Man Per Day in the Period 31/12/39—17/1/40.

Foodstuffs	gms. consumed per man per day	Calories	Proteins	Fat	Carbohydrates	gms. Ca	gms. P	mg. Fe
Bread, wheat, average	46	121	4	1	24	0.02	0.05	0.37
Bread, whole wheat, 100 %	112	301	10	2	59	0.04	0.18	1.90
Rice	5	5	0	0	1	-	-	-
Oatmeal	9	39	2	1	6	0.01	0.04	0.45
Wheat, cream of	9	35	1	0	7	-	0.00	0.01
Coffee	40	-	-	-	-	-	-	-
Tea	1	-	-	-	-	-	-	-
Butter	48	385	0	41	-	0.01	0.01	0.10
Margarine	7	52	0	6	-	0.00	0.00	0.01
Milk, condensed, unsweetened	92	133	6	8	9	0.29	0.22	0.64
» » sweetened	3	12	0	0	2	0.01	0.01	0.02
Chocolate	4	21	0	1	2	0.00	0.00	0.01
Cheese, goats	2	8	1	1	0	0.02	0.02	0.02
Meat, musk ox	86	385	11	36	-	0.01	0.17	2.58
Meat, sausage	22	76	2	7	1	0.01	0.03	0 44
Tongue, pickled	2	4	0	0	-	0.00	0 00	0.13
Meat cakes, canned	28	97	3	8	2	0.01	0.03	0.50
Ham, smoked	8	22	2	2	-	0.00	0.01	0.05
Ham, salted	17	49	4	4	-	0.00	0.04	0.29
Sardines	1	3	0	0	-	0.00	0.00	0.02
Cod fish roe	19	-	-	-	-	0.00	0.09	0.30
Salmon, salted	37	55	7	3	-	0.01	0 09	0.44
Cod fish cakes	15	32	1	23	2	0.00	0.03	0.06
» » dried	17	18	4	0	-	0.01	0.05	0.09
Potatoes	43	30	1	0	6	0.00	0.02	0.52
» dried	58	40	1	0	9	0.01	0.03	0.70
Peas, dried	9	5	1	-	1	0.00	0.01	0.12
Beans	15	9	1	0	2	0.00	0.02	0.36
Onions	4	2	0	0	0	0.00	0.00	0.02
Macaroni	11	42	2	0	8	0.00	0.02	0.14
Apple jam	5	48	0	0	1	0.00	-	0.02
Cranberries	1	0	0	0	0	0.00	0.00	0.00
Fruit salad	28	38	0	0	9	0.02	0.03	2.14
Lemons	8	2	0	0	0	0.00	0.00	0.05
Marmalade	1	4	0	0	1	0.00	0.00	0.01
Peas, canned	38	20	0	0	5	0.00	0.00	0.06
	851	2093	64	144	157	0.48	1.20	12.63

Table 28.

Ingestion of Proteins, Fat, Carbohydrates, and Minerals per Man per Day in the Period 28/4/40—17/5/40.

Foodstuffs	gms. consumed per man per day	Calories	Proteins	Fat	Carbohydrates	gms. Ca	gms. P	mg. Fe.
Bread, white	34	90	3	0	18	0.01	0.03	0.27
Bread, whole wheat, 100 %	127	342	12	2	67	0.05	0.20	2.16
Wheat, cream of	60	219	7	1	43	-	0.01	0.07
Coffee	20	-	-	-	-	-	-	-
Tea	1	-	-	-	-	-	-	-
Butter	54	427	1	46	-	0.01	0.01	0.10
Margarine	30	237	0	25	-	0.01	0.01	0 59
Milk, condensed, unsweetened	94	137	7	8	9	0.30	0.23	0.66
Cheese, goats	34	149	9	12	0	0.37	0.27	0.40
Chocolate	7	42	1	3	4	0.09	0.01	0.03
Meat, musk ox	7	33	1	3	-	0.00	0.01	0.22
Meat, various kinds	228	1021	30	96	-	0.02	0.46	6.84
Meat cakes (musk ox)	22	75	2	6	1	0.01	0.03	0.44
Ham salted, boiled	10	30	2	2	-	0.00	0.02	0.17
Ham, smoked	26	77	5	6	-	0.00	0.06	0 45
Tongue, musk ox	7	15	1	1	-	0.00	0.01	0.46
Liver, ground, boiled	5	9	1	0	0	-	0.02	0.41
Salmon, salted	4	7	1	0	-	0.00	0.01	0.05
Potatoes	121	83	2	0	18	0.01	0.06	1.45
» dried	81	56	1	1	12	0.01	0.04	0.97
Vegetables, dried	26	8	0	0	1	0.01	0.01	0.07
Onions	29	15	0	0	3	0.01	0.01	0.14
Macaroni	35	130	5	0	26	0.01	0.05	0.42
Cranberries	12	6	0	0	1	0.00	0.00	0.05
Fruit salad	29	40	0	0	9	0.02	0.04	2.24
Marmalade	20	64	0	0	15	0.01	0.00	0.11
	1123	3312	91	212	227	0.86	1.60	18.77

Table 29.

Ingestion of Proteins, Fat, Carbohydrates, and Minerals per Man per Day in the Period 15/6/40—30/6/40.

Foodstuffs	gms. consumed per man per day	Calories	Proteins	Fat	Carbohydrates	gms. Ca	gms. P	mg. Fe
Bread, white	135	356	13	2	71	0.04	0.13	1.08
Bread, whole wheat, 100 %	46	124	4	1	24	0.02	0.07	0 78
Wheat, cream of	25	92	3	1	18	-	0.01	0.03
Oatmeal	6	26	1	0	4	0.00	0.02	0.31
Rice	41	39	1	0	9	-	-	-
Sugar	37	149	-		37	-	-	-
Coffee	34	-	-	-	-	-	-	-
Tea	2	-	-	-	-	-	-	-
Butter	70	558	1	60	-	0.01	0.01	0.10
Margarine	25	199	0	21	-	0.01	0.01	0.05
Milk, dehydrated	55	205	21	1	28	0.18	0.13	0.39
» condensed, sweetened	47	159	4	4	26	0.14	0.11	0.28
Pancakes	35	-	-	-	-	-	-	-
Cheese, goats	37	164	10	13	0	0.40	0.30	0.44
Eggs (eider duck)	3	3	0	0	-	0.00	0.01	0.08
Eggs, dehydrated	1	4	0	3	-	-	-	-
Chocolate	12	69	1	4	6	0.00	0.01	0 04
Meat cakes	36	88	3	8	2	0.01	0.03	0 51
» bearded seal	38	169	5	16	-	0.00	0.08	1 13
» salted	63	102	17	4	-	0.01	0.20	3.93
Fat, musk ox	1	12	-	1	-	-	-	-
Breast muscles, eider duck	68	171	12	13	-	0.01	0.16	0.16
Entrails » »	2	-	-	-	-	-	-	-
Breast muscles, clangula hyemalis	13	22	2	2	-	0.00	0.03	0 22
Breast muscles, loon	10	26	2	2	-	0.00	0.02	0.18
Liver, ground, boiled	5	9	1	0	0	0.00	0.02	0.42
Ham, smoked	27	78	5	6	-	0.00	0.06	0.46
Anchovy	5	5	1	0	0	-	-	-
Sardines	3	7	1	1	-	0.00	0.01	0.05
Salmon, smoked	3	5	1	0	-	0 00	0.01	0.02
Herring, salted	10	28	2	2	-	0.03	0.04	1.28
Cod fish, salted	10	11	3	0	-	0.00	0.03	0.05
Cod fish cakes	51	109	4	77	5	0.01	0.10	0.21
Potatoes	71	49	1	0	10	0.01	0.04	0.85
Potatoes, dried	87	60	2	0	13	0.01	0 04	1.08
Vegetables, dried	3	1	0	0	0	0.00	0.00	0.01
Onions	10	5	0	0	0	0.00	0.00	0.05
Pickles	1	-	-	-	-	-	-	-
Peas, dried	10	5	1	-	1	0.00	0.01	0.13
Macaroni	22	79	3	0	16	0.00	0.03	0.26
Salt	13	-	-	-	-	-	-	-
Lemons	18	6	0	0	1	0.00	0.00	0.11
Marmalade	24	48	0	0	19	0.01	0.00	0.14
Fruit juice, mixed	12	4	0	-	1	-	-	-
Fruit salad	29	40	0	0	9	0.02	0.04	2.24
Pears, canned	26	13	0	0	3	0.00	0.00	0.04
Cranberries and apple sauce	3	2	0	0	0	0.00	0.00	0.01
	1275	3311	123	242	303	0.92	1.76	18.07

Table 30.

Ingestion of Proteins, Fat, Carbohydrates, and Minerals per Man per Day at Different Periods of the Year.

Period	Food intake per man per day gms	Calories	Proteins	Fat	Carbo-hydrates	gms. Ca	gms. P	mg. Fe
I (October 3, 1939—October 18, 1939)	1191	3159	97	189	249	1.00	1.79	15.23
II (December 31, 1939—January 17, 1940)	851	2093	64	144	157	0.48	1.20	12.63
III (April 28, 1940—May 17, 1940)	1123	3312	91	212	227	0.86	1.60	18.77
IV June 15, 1940—June 30, 1940)	1275	3311	123	242	303	0.92	1.76	18.07
Mean	1110	2969	94	197	234	0.82	1.59	16.17

Table 31.

Vitamin Content of Foodstuffs Consumed by European Trappers in North East Greenland.

Most of the figures with regard to vitamin C content were obtained by own determinations. The majority of the rest of the figures are taken from *Nutritional Abstracts and Reviews*, Vol. 9, No. 4, April, 1940.

Foodstuffs	Own Figures	According to Available Literature			
	Vitamin C mg. 0/0	Vitamin C mg. 0/0	Vitamin B_1 I. U. per 100 gr.	Vitamin A I. U. per 100 gr.	Vitamin D I. U. per 100 gr.
Bread, whole wheat, 100 0/0 ..	0.0	0	26-60	-	-
Bread, white	0.0	0	24-87	-	-
Butter	0.0	0	-	2000	36-54
Egg, boiled	0.4	-	100	8800	220
Cheese, Goat (1)	0.0	-	0	1000	-
Cheese (2)	0.0	-	0	1000	-
Cheese, cream	0.0	-	0	2000	-
Cranberries	-	5	-	-	-
Apple jam	0.6	-	-	-	-
Travelling provisions	0.5	-	-	1000	-
Liver sausages	-	-	-	-	-
Biscuits	0.0	0.0	-	-	-
Milk, condensed	3.8	-	10	300	2.4
Milk, dried	-	-	-	300	-
Sardines	-	-	30	800-6400	7000-14000
Anchovy	-	-	-	3000	-
Milk, condensed, sweetened ..	-	-	-	300	-
Pancakes	0.0	-	-	-	-
Sugar	-	-	-	-	-
Lemon	14.0	-	-	-	-

Table 31 (continued).

Foodstuffs	Own Figures	According to Available Literature			
	Vitamin C mg. %	Vitamin C mg. %	Vitamin B_1 I. U. per 100 gr.	Vitamin A I. U. per 100 gr.	Vitamin D I. U. per 100 gr.
Coffee	-	-	-	-	-
Chocolate	-	-	-	-	-
Marmalade, orange	2.1	1.14	-	-	-
Tea	-	-	-	-	-
Potatoes, frozen, boiled	2.6	5-23	30-60	-	-
Vegetables, dried	42.1	-	-	-	-
Potatoes, dried, boiled	1.8	-	-	-	-
Tongue, musk ox	0.5	-	95	-	-
Meat, musk ox	0.8	-	-	-	-
Meat, sausage	0.0	-	-	-	-
Meat, cake	0.8	-	-	-	-
Meat, salted	0.0	-	-	-	-
Ham, smoked	0.0	-	357	0	-
Fat	0.0	-	-	80	-
Pork, salted	0.0	-	-	0	-
Pork	0.0	-	-	0	-
Salmon salted	0.0	-	-	-	300
Salmon, smoked	-	-	-	-	-
Rice	-	-	-	0	-
Raisins	-	-	75	-	-
Herring, salted	0.0	-	-	2300-6000	107
Fish cakes	0.0	-	-	-	-
Cod roe, canned	-	-	300	-	-
Meat cakes, canned	0.0	-	-	-	-
Cod, dried	0.0	-	-	-	-
Peas, dried	-	-	-	-	-
Meat, game	1.0	-	49	-	-
Peas, green	-	30-170	40-100	-	-
Cod, salted	0.0	-	-	-	-
Macaroni	-	-	-	-	-
Egg powder	-	-	-	10-900	-
Onion, frozen	4.5	2.6-15	40	-	-
Pickles	0.0	-	-	-	-
Margarine	0.0	-	-	2000	30
Brown beans, dried	0.5	7.0-26.1	15-120	-	-
Fruit salad, mixed	1.8	1.0	90	-	-
Pears, canned	1.0	-	-	-	-
Flour, white	-	0	-	-	-
Oats	-	0	325	-	-
Groats	-	-	-	-	-
"Citronal" (lemon juice)	0	-	-	-	-
Fruit juice, mixed	0	-	-	-	-

The vitamin intake of the trappers was calculated on the basis of figures set out in the above table.

Table 32.

Vitamin Ingestion per Man per Day in the Period 3/10/39 to 18/10/39.

Foodstuffs	gms. consumed per man per day	Vitamin C mg.	Vitamin B_1 I. U.	Vitamin A I. U.	Vitamin D I. U.
Bread, whole wheat, 100 % ..	98	0	42.2	-	-
Bread, white	185	0	92.6	-	-
Butter	72	0	-	1443	33
Eggs	31	0.13	31.8	2800	70
Cheese, goat (1)	41	0.00	0	415	-
» » (2)	2	0.00	0	18	-
Cheese, cream	3	0.00	0	61	-
Cranberries	13	0.67	-	-	-
Jam, apple	1	0.00	-	-	-
Travelling provisions	11	-	-	-	-
Biscuits	10	0.00	-	-	-
Milk, condensed	-	-	-	-	-
» unsweetened	91	3.45	9.1	273	2
Sardines	2	-	0.5	58	179
Milk, condensed, sweetened ..	9	-	-	26	-
Pancakes	2	0.00	-	-	-
Sugar	3	-	-	-	-
Lemon	7	0.96	-	-	-
Coffee	43	-	-	-	-
Chocolate	9	-	-	-	-
Tea	0	-	-	-	-
Peas, green	2	0.07	1.6	-	-
Potatoes	207	5.37	93.0	-	-
Potatoes, dried	-	-	-	-	-
Meat, musk ox	90	0.72	-	-	-
Pork, smoked	17	0.00	60.1	0	-
Pork, salted	9	0.00	-	0	-
Rice	3	-	-	-	-
Salmon, salted	34	0.00	-	-	-
Raisins	1	-	0.9	-	-
Fish cakes	68	0.00	-	-	-
Meat cakes, tinned	30	0.00	-	-	-
Peas, yellow	11	0.08	-	-	-
Macaroni	12	-	-	-	-
Onion	5	0.31	1.8	-	-
Margarine	15	0.00	-	295	4
Beans, brown, dried	7	0.03	4.6	-	-
Fruit salad, mixed	10	0.18	9.2	-	-
Flour, white	5	-	0	-	-
Oats	11	-	14.8	-	-
Groats	6	-	-	-	-
Consumed per man per day ..	1176	11.97	362.2	5380	288

Table 33.

Vitamin Ingestion Per Man Per Day in the Period 31/12/39 to 17/1/40.

Foodstuffs	gms consumed per man per day	Vitamin C mg.	Vitamin B_1 I. U.	Vitamin A I. U.	Vitamin D I. U.
Bread, whole wheat, 100 % ..	112	0	48.1	-	-
Bread, white	46	0	22.9	-	-
Butter	48	0	-	968	22
Eggs	-	-	-	-	-
Cheese, goat	2	0.00	0	19	-
Margarine	7	0.00	-	132	2
Cranberries	1	0.05	-	-	-
Jam, apple	5	0.03	-	-	-
Biscuits	-	0	-	-	-
Milk, condensed, unsweetened	92	3.50	9.2	176	2
Sardines	1	-	0.4	42	124
Milk, condensed, sweetened ..	4	-	-	11	-
Meat, sausage	22	-	-	-	-
Tongue, musk ox	2	-	1.8	-	-
Marmalade	1	0.11	-	-	-
Sugar	-	-	-	-	-
Lemon	8	1.06	-	-	-
Chocolate	4	-	-	-	-
Coffee	40	-	-	-	-
Tea	1	0	-	-	-
Potatoes	43	1.13	19.5	-	-
Potatoes, dried	58	1.04	-	-	-
Meat, musk ox	86	0.69	-	-	-
Cod roe	19	-	56.6	0	-
Pork, smoked	8	-	27.0	0	-
Pork, salted	17	0.00	-	-	-
Salmon, salted	37	0.00	-	-	110
Macaroni	11	-	-	-	-
Fish cakes	15	0.00	-	-	-
Meat cakes, tinned	28	0.00	-	-	-
Rice	5	-	-	-	-
Fruit salad, mixed	28	0.46	26.4	-	-
Cod, dried	17	0.00	-	-	-
Pears, canned	38	0.38	-	-	-
Peas, yellow	9	0.07	-	-	-
Beans	15	0.08	10.1	-	-
Onions	4	0.17	1.5	-	-
Oats	9	0	30.7	-	-
Flour, white	9	-	0	-	-
Consumed per man per day ..	852	8.77	254.2	1348	260

Table 34.

Vitamin Ingestion per Man per Day in the Period 28/4/40 to 17/5/40.

Foodstuffs	gms. consumed per man per day	Vitamin C mg.	Vitamin B_1 I. U.	Vitamin A I. U.	Vitamin D I. U.
Bread, whole wheat, 100 % ..	127	0	54.7	-	-
Bread, white	34	0	16.9	-	-
Butter	54	0	-	1074	24
Cheese, goat	34	0	-	335	-
Pork, salted, boiled	10	0	-	0	-
Marmalade	20	0.42	-	-	-
Jam, cranberry	12	0.69	-	-	-
Tongue, musk ox	7	0.03	6.3	-	-
Cheese	-	0.00	-	-	-
Meat	7	0.06	-	-	-
Liver, canned	5	-	-	-	-
Milk	94	3.58	9.4	283	2
Coffee	20	-	-	-	-
Chocolate	7	-	-	-	-
Tea	0	-	-	-	-
Potatoes	121	3.14	54.3	-	-
Potatoes, dried	81	0.16	-	-	-
Meat	228	1.82	-	-	-
Meat cakes	22	0.18	-	-	-
Pork	26	0.00	93.5	0	0
Salmon	4	-	-	-	13
Macaroni	35	-	-	-	-
Vegetables, dried	26	11.14	-	-	-
Margarine	30	0.00	-	597	9
Fruit salad	29	0.53	26.5	-	-
Onions	29	1.32	11.8	-	-
Flour, white	60	-	0	-	-
Consumed per man per day ..	1122	23.07	273.4	2289	48

Table 35.

Vitamin Ingestion per Man per Day in the Period 15/6/40 to 30/6/40.

Foodstuffs	gms. consumed per man per day	Vitamin C mg.	Vitamin B_1 I. U.	Vitamin A I. U.	Vitamin D I. U.
Bread, whole wheat, 100 % ..	46	0	19.8	-	-
Bread, white	135	0	67.3	-	-
Eggs, eider duck	3	-	2.6	46	-
Butter	70	0	-	1403	30
Cheese, goat	37	0	0	371	-
Marmalade	24	0.51	-	-	-
Salt	13	0	-	0	0
Margarine	25	0	-	500	8
Milk, dried	55	-	-	165	-
Milk, condensed, sweetened ..	47	-	-	140	-
Pancakes	35	0	-	-	-
Liver paste	5	-	-	-	-
Pork, smoked	27	0	96.1	0	-
Sardines	3	-	0.8	92	269
Anchovy	5	-	-	154	-
Salmon, smoked	3	-	-	-	-
Sugar	37	-	-	-	-
Lemon	18	2.51	-	-	-
Chocolate	12	-	-	-	-
Coffee	34	-	-	-	-
Tea	2	-	-	-	-
Fruit juice, mixed	12	0	-	-	-
Meat, salted	63	0	-	-	-
Potatoes	71	1.85	32.0	-	-
Potatoes, dried	87	1.57	-	-	-
Peas, yellow	10	0.07	-	-	-
Beef, bearded seal	38	0.19	-	-	-
Meat cakes	26	0.21	-	-	-
Macaroni	22	-	-	-	-
Fat	1	0.00	-	1	-
Herring, salted	10	0.00	-	426	11
Vegetables, dried	3	1.08	-	-	-
Onions	10	0.43	3.9	-	-
Pickles	1	0	-	-	-
Eider duck	68	1.59	33.3	-	-
» liver	2	0.08	-	-	-
Loon, muscles	10	0.10	5.0	-	-
Clangula hyemalis, muscles ..	13	0.13	6.3	-	-
Cod, salted	10	0.00	-	-	-
Fish cakes	51	-	-	-	-
Flour	25	-	0	-	-
Rice	41	-	-	0	-
Groats	6	-	-	-	-
Fruit salad	29	0.53	26.5	-	-
Pears, canned	26	0.26	-	-	-
Eggs, powdered	1	-	-	3	-
Cranberry and apple jam	3	0.09	-	-	-
Consumed per man per day ..	1276	11.2	293.6	3300	318

Table 36.

Vitamin Intake per Man per Day at Different Periods of the Year.

Period	Food intake per man per day gms.	Vitamin C mg.	Vitamin B_1 I. U.	Vitamin A I. U.	Vitamin D I. U.
I. (October 3, 1939—October 18, 1939)	1176	12.0	362	5389	288
II. (December 31, 1939—January 17. 1940)	852	8.8	254	1348	260
III. (April 28, 1940—May 17, 1940)	1122	23.0	273	2289	48
IV. (June 15, 1940—June 30, 1940)	1276	11.2	294	3300	318
Mean	1106	13.8	296	3082	229

Calories. The figures presented in the previous tables indicate the gross-consumption of calories, and represent the maximum values. In other words, the consumption of calories, proteins, fat and carbohydrates as well as minerals does not exceed the figures stated in the previous tables.

The average consumption per man was 2969 calories per day, varying from 3311 in the summer to 2093 in the middle of the winter.

If 10 % is deducted from these figures as indigestible material excreted through faeces, the average figure for the nett calories is found to be 2672 varying from 2980 in the summer to 1887 in the middle of the winter.

This result is surprising in view of the fact that many Arctic travellers have suggested that at least 5000 calories would be necessary under Arctic conditions. However, real hard work is only done occasionally, for instance, during travelling by skis under difficult conditions.

During the dark period of the year, when the food intake and calory consumption is at a very low level, the weather conditions usually prevent any exercise taking place. At times the trappers are confined indoors for several weeks, during which periods they rest in their sleeping bags for the greater part of the day. They are adequately protected against loss of heat by well heated houses.

In the autumn and early spring the trappers travel by sledge and dogs along the fjord ice, and as the going is usually good, they are able to sit on the sledge during the journey, and they are well protected by warm fur clothing.

During the late spring when the fjord ice is breaking up and the snow is melting on the land, the trappers are again confined to the hut. In the summer, they usually travel by motor boats, which consequently does not entail hard work.

This may well explain the surprisingly low calory consumption.

Proteins, Fat, and Carbohydrates. Compared with the Canadian Dietary Standard, the consumption of proteins is slightly higher, and of fat, much higher than the standard. The consumption of carbohydrates is comparatively low. The trappers' diet is more a fat diet than a carbohydrate diet.

Calcium, Phosphorus, and Iron. The average consumption of calcium, phosphorus and iron is higher than the Canadian Standard.

Vitamins.

(1). Vitamin A. From the tables it will be observed that the vitamin A during Period I was obtained through the ingestion of eggs (50 %), butter (25 %), cheese (10 %), milk (6 %), and margarine (6 %). Based on the generally accepted daily requirements of 3000—4000 I. U., the intake of vitamin A is above normal requirements. During the second period — midwinter — at which time there is practically no daylight, the intake falls much below normal requirements. There is no consumption of eggs, approximately 67 % of their vitamin A intake is obtained from butter, milk and margarine forming the other main sources. In the spring and summer (Periods III and IV) the vitamin A consumption still remains at a low level. The more important sources consisted at that time of butter, milk, margarine, herring and cheese.

(2). Vitamin B1. If 400 I. U. vitamin BI (as recommended by Rose (1933)) is considered the normal requirement of average adults, the European trappers in Greenland are on a B1-deficient diet during all four periods. This may explain the marked loss of appetite which usually occurs in the course of the winter.

(3). Vitamin C. The consumption of vitamin C during all four periods was less than the figures considered as normal human requirement. In the middle of the winter the intake was less than 10 mg. ascorbic acid per day per individual. No symptoms of manifest scurvy were observed. These findings are in agreement with observations made by Høygaard (3), who, during sledging journeys of long duration in the Arctic, subsisted on less than 15 mg ascorbic acid per day without any ill effect.

(4). Vitamin D. Vitamin D is of less importance in this connection, as the European trappers in North East Greenland are all male adults.

Discussion.

Vitamin deficiency is unknown among East Greenland Eskimos as for the greater part of the year they subsist entirely upon meat from Arctic animals and birds. The muscles and internal organs of these birds and animals have been shown to contain an adequate amount of vitamins and when utilized in the Eskimos' manner fulfil their normal requirements. Furthermore a number of the more important Arctic plants which are consumed by the Eskimos, were found to be rich in vitamin C (4).

A point worthy of note is the fact that all the internal organs, which have been shown to be rich in ascorbic acid, are eaten by the Eskimos, but few by the European trappers among whom, up to recent years, scurvy has been prevalent.

A number of the foodstuffs used by the European trappers were seriously lacking in vitamin C content. Other European foodstuffs consumed by the same trappers, such as potatoes and dried vegetables, have appreciable amounts of the antiscorbutic vitamin, but these did not furnish sufficient ascorbic acid to fulfil the amount hitherto considered by nutritional workers as a normal human requirement.

There is a marked decrease in the consumption of vitamin C during the dark period (December to January) attributed to a decreased food-intake. During this period the trappers show a loss of appetite, and inertia and lack of initiative was observed.

In this connection it is interesting to note that Dr. H. U. Sverdrup relates (personal communication) that during the Maud expedition they endeavoured to maintain normal appetite during the dark period of the year by regular and sufficient physical exercise. He also relates that in the spring of 1924 he had symptoms which he himself interpreted as slight scurvy, — but by consuming 1 to 2 tins of condensed, unsweetened milk daily the symptoms disappeared within a week.

It was found that commercial concentrated lemon juice in bottles, which is considered by the trappers as a legal antiscorbutic medicine on winter expeditions, and is usually taken as such, had no vitamin C content after a few months storage in Arctic conditions.

Practically all winter expeditions are now provided with tablets of ascorbic acid (50 mg per tablet). The tablets are not popular with the trappers and are often discarded. It seems advisable to provide vitamin C in a more palatable form that would be taken regularly. From the author's experience, lemon, the ascorbic acid content of which has been shown to remain stable when stored in air-tight bottles in a cool place, provided an attractive source. By this means fresh lemonade can be prepared daily without loss of ascorbic acid content A lemon stored for three months under Arctic conditions contained approximately 25 mg ascorbic acid. A lemon per day should, therefore, be made available to each trapper.

In view of dried potatoes and other vegetables being more conveniently transported and stored without serious deterioration to the ascorbic acid content over a period of years, these food commodities should be made available in preference to canned foods which lose a considerable proportion of their ascorbic acid during the canning process. The foodstuffs, in all instances, should constantly be stored below freezing point to prevent any deterioration occurring.

Summary.

The vitamin C content of the more common European foodstuffs consumed by the Norwegian trappers in Greenland was determined by a modification of the method of Tillman during a scientific expedition to North East Greenland 1939—1940. A large number of these foodstuffs were found to have no vitamin C content.

A dietary survey was made among a group of Norwegian trappers during four periods of the year at the trappers' station Revet, North East Greenland.

The average daily gross consumption per man was 2969 calories varying from 3311 in the summer to 2093 in the middle of the winter.

Compared with the Canadian Dietary Standard, the consumption of protein and fat was higher than the standard, while the consumption of carbohydrates was comparatively low.

The average consumption of calcium, phosphorus and iron was higher than the Canadian Standard.

The daily intake of vitamin A was above normal requirements during the month of October (Period I) while it was much below normal requirement in December (Period II). In the spring and summer (Periods III and IV) the vitamin A consumption still remained at a low level.

If 400 I. U. vitamin Bl is considered the normal daily requirement of average adults, the Norwegian trappers in Greenland are on a vitamin B_1 deficient diet during all periods of the year. However, when one takes into consideration the relatively high consumption of fat and protein by the trappers, the actual requirement of vitamin B_1 may be considerably lower than the above stated figure.

The consumption of vitamin C during all four periods was less than the figures considered as normal human requirement.

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