Some Chemical Properties of *Munida gregaria* and *Euphausia superba*

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These abundant Antarctic crustaceans were assayed for proximate composition by standard AOAC methods. Constituent fatty acids were determined by vapor phase chromatography; 19 amino acids were estimated by column chromatography, while cystine and tryptophan were assayed microbiologically. *Munida* contained 38% fat, with C_{16} and C_{18} acids predominating. The protein content of *Euphausia*, calculated from amino nitrogen determinations, was 37.8%. The amino acid composition of *Euphausia* resembles that of shrimp meat, though the protein of the former seems to be somewhat richer in phenylalanine, tryptophan, and tyrosine. Euphausids can be ground into a fine powder having pleasant organoleptic properties and nutritive values comparable with shrimp.

The small shrimp-like *Euphausia superba*, commonly called "krill," has been regarded as the most important zooplankton organism in Antarctic waters (Hardy and Gunther, 1935). This euphausid is eaten by penguins and crabeater seals and, around South Georgia, forms practically the sole diet of blue and fin whales. The euphausids generally rise to the surface at night and sink to some 200 meters in the daytime. The galatheid decapod *Munida gregaria* superficially resembles a very small lobster and occurs in great numbers in shallow sub-Antarctic waters—for example, around Tierra del Fuego. It apparently enters into the food chain of marine fishes, sea birds, and sea lions in the Beagle Channel and other similar localities. Because of the importance of these crustaceans in the nutrition of life in the southern ocean, and because of the possibility that greater human uses may be found, the authors decided to study their chemical composition.

The galatheid *Munida gregaria* Fabricius was obtained aboard the Argentine research vessel, *A.R.A. Zapiola*, on February 26, 1966, in Bahia Aguirre, Tierra del Fuego. A triple-O net, 1 meter in diameter and having a mesh size of 0.042 inch, was towed at slow speed for 4 minutes at a depth of 30 meters to obtain 120 kg. of wet material. *Euphausia superba* Dana was gathered in the same way during the first week of March 1966, at various locations in the Drake Passage and Bransfield Strait near the South Shetland Islands. The amounts of krill caught in the net varied with the location, time of day, depth of sampling, etc. A typical krill catch of 12 kg. was obtained on March 8 in waters 460 fathoms deep, at 62°55′ S, 59°20′W, by towing the triple-O net at a speed of 4 knots from the surface to a depth of 30 meters. The samples were washed in clean fresh water and then frozen at −10° C., in the ship's meat freezer. The materials were freeze-dried in an industrial dryer, and kept in plastic bags in a refrigerator until chemical analyses could be performed.

Whole dried animals were ground in a Wiley cutting mill in preparation for the chemical analyses. The galatheids formed an oily paste, and the euphausids made a dry powder, upon grinding and sieving through a fine-mesh strainer. The proximate composition was determined according to AOAC official methods (1960). Amino acid composition was estimated for 19 acids by the method of Moore *et al.* (1958). Cystine and tryptophan were assayed microbiologically. Cystine was liberated by hydrolysis according to the techniques of Horn and Blum (1956), and tested in the medium of Steel *et al.* (1949). Tryptophan samples were prepared by alkaline hydrolysis, according to the method of Green and Black (1944), modified by use of a hydrolyzate prepared by refluxing for 2 hours with 10*N* potassium hydroxide. Amino acid nitrogen was determined by hydrolyzing samples in 1 to 1 HCl for 16 hours, followed by reaction with 1,2-naphthoquinone-4-sulfuric acid in alkaline solution. The fatty acid distribution in the galatheid sample was determined in the lipids extracted with ethanol-ether, then methylated according to standard methods (Vogel, 1962) and examined on a Perkin-Elmer Model 154 vapor fractometer equipped with a 2-meter diethylene glycol succinate column operated at a temperature of 200° C.

Revised estimates of the per cent protein, based upon determinations of amino acid nitrogen, gave a value of 13.19 for *Munida* and 37.75 for *Euphausia*. Using these revised figures for protein content together with the analyses for fat, the authors found that the "carbohydrate," etc., by difference amounted to 44.98 and 57.92% of the dry matter.

The proximate composition of the galatheid and euphausid materials is shown in Table I. Galatheids

Table I. Proximate Composition of *Munida gregaria* and *Euphausia superba* on a Dry Weight Basis

Determination	Results	
	Munida	Euphausia
Ash	1.75	1.30
Protein (total N × 6.25)[a]	(14.12)	(63.80)
Protein (amino N × 6.25)	13.19	37.75
Fat	38.08	1.77
Fiber	2.00	1.26
Carbohydrate, chitin, etc.	44.98	57.92
Caloric value[b]	575	399

[a] Values in parentheses are based upon the untenable common assumption that Kjeldahl N × 6.25 = protein.
[b] Based on caloric equivalents per gram of 9, 4, and 4 for fat, carbohydrate, and protein, respectively.

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are high in fat (38.08%), while euphausids are high in estimated protein (63.80%) and low in fat (1.77%). The protein and fat content of the euphausid appears to be about like that of the edible small shrimp *Artemisia longinaris* Bate (Burkholder *et al.*, 1966). However, the analyses for nitrogen probably included appreciable amounts of nonprotein matter, such as chitin, nucleic acids, etc. For this reason, the authors decided to make separate determinations of the amino acid nitrogen by the method stated above. The results were as follows: galatheids 2.11% and euphausids 6.14% of the dry weight occurring as amino acid nitrogen, which corresponds, respectively, to about 93 and 60% of the total nitrogen in the dried samples.

These numbers compare well with the sums of the amino acids for the two samples, which are 91.6 and 67.3%, expressed on the basis of N = 16, which assumes that the nitrogen is in the form of protein. In order to place the amino acid data on a comparable basis, the individual *Munida* results were divided by 0.93 and the *Euphausia* results by 0.60. This procedure more nearly expresses the quantitative composition of amino acids in the proteins of the species based upon the determinations of amino acid nitrogen.

The amino acid composition of the samples is shown in Table II, as per cent of dry matter and as per cent of the estimated protein content, based upon the total amino nitrogen. All of the essential amino acids are present in the proteins of both species. Compared with the analysis of the South Atlantic shrimp *Artemisia longinaris* (Burkholder *et al.*, 1966), the following amino acids appear relatively lower in *Euphausia:* aspartic acid, cystine, glutamic acid, and histidine. Published results on the amino acid composition of edible shrimp meat (Orr and Watt, 1957), compared with these data on *Euphausia*, suggest a close similarity in the composition of the proteins in the shrimp of commerce and the euphausid food of whales. The proteins of euphausids seem to be somewhat richer in phenylalanine, tryptophan, and tyrosine.

The distribution of fatty acids in the galatheids was investigated because of the relatively high fat content observed in the proximate analysis. The quantitative occurrence of fatty acid constituents, varying in carbon elements from 12 upward, is presented in Table III. The principal components appear to be two major compounds each with 16 carbon atoms, another with 18 atoms, and an unknown with possibly 23 carbons. All together, 23 peaks were observed under the conditions of vapor phase chromatography used in the analysis, which was 1 hour at 200° C., and a 2-meter diethylene glycol succinate column. The list of fatty acids given in the table accounts for 99.97% of the total lipid extracted into the ethanol-ether solvent.

General observations on *Munida* indicate that these decapods are abundant in the waters around Tierra del Fuego and can be collected in large amounts with suitable nets. The high oil content of these animals may provide a source for oils containing carbon atoms chiefly with numbers of 16, 18, and higher. The *Munida* oils give off the characteristic odor of fish. Following extraction of the oil, the residue contains proteins with amino acid composition not unlike euphausids or shrimp. The euphausids, of which *E. superba* is just one of a half dozen species, occur plentifully in some areas of the Antarctic. They can be

Table II. Amino Acid Composition of *Munida gregaria* and *Euphausia superba*[a]

	Results			
	Munida, %		Euphausia, %	
Determination	Dry wt.	Amino nitrogen	Dry wt.	Amino nitrogen
Nitrogen in dried samples	2.26 (Total)	2.11 (Amino)	10.2 (Total)	6.14 (Amino)
Alanine	1.13	8.73	2.57	6.92
Arginine	0.91	7.02	2.80	7.52
Aspartic acid	1.24	9.61	3.86	10.37
Cysteic acid	0.39	2.97	6.70	1.83
Cystine	0.12	0.91	0.59	1.59
Glutamic acid	1.56	12.08	5.85	15.70
Glycine	0.92	7.08	3.22	8.62
Histidine	0.31	2.43	0.90	2.43
Isoleucine	0.46	3.63	1.70	4.51
Leucine	0.87	6.71	3.25	8.72
Lysine	0.79	6.15	3.44	9.22
Methionine	0.28	2.21	1.30	3.50
Phenylalanine	0.56	4.35	2.25	6.05
Proline	0.56	4.28	2.08	5.59
Serine	0.56	4.27	1.71	4.57
Threonine	0.61	4.79	1.84	4.94
Tryptophan	0.32	2.50	0.70	1.88
Tyrosine	0.54	4.18	1.94	5.21
Valine	0.52	5.70	2.26	6.07

[a] Calculated on a dry weight basis and as per cent of the amino acid nitrogen assayed in the dried samples.

Table III. Fatty Acid Distribution of *Munida gregaria*[a]

Fatty Acid Carbon No.	Retention Time, Min.	Fatty Acid Levels, % of Total
C-12 (0)	3.2	0.11
C-14 (0)	5.3	3.89
C-14 (1)	6.1	0.22
C-15 (0)	7.0	0.11
C-16 (0)	9.2	22.91
C-16 (1)	10.6	17.80
C-17 (0)	11.9	3.00
C-17 (1)	13.5	1.22
C-18 (0)	15.8	1.33
C-18 (1)	18.2	30.48
Unknown 1	19.6	3.00
Unknown 2	32.4	5.67
Unknown 3	60.8	10.23

[a] Lipids were extracted with ethanol-ether, methylated, and examined on a Perkin-Elmer Model 154 vapor fractometer equipped with a 2-meter diethylene glycol succinate column and operated at 200° C.

caught in trawls with relatively fine mesh, such as might be used to catch small shrimp. Dehydrated euphausids retain a characteristic odor and flavor of shrimp. The shells of these crustaceans are thin and dried material can be easily ground into a fine powder containing the attractive organoleptic properties and nutritive valuse of "shrimp." If the need arises for more food from the sea, perhaps plankton will help to satisfy this need. Obviously the "most important zooplankton organism in Antarctica" should be seriously considered in the exploitation of unconventional sources of food from the sea.

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