THE CONTENT OF CERTAIN AMINO ACIDS IN SEAFOODS 1/

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For proper growth and maintenance of the body, certain food components such as proteins, carbohydrates, fats, vitamins, and minerals must be supplied by the diet. Each of these has its specific function in maintaining health. Although fish, shellfish, and crustacea are usually included in the diet as a source of protein, they also furnish other food essentials, particularly fats, vitamins, and minerals in varying quantities. Proteins are found in all plant and animal matter in different quantities; flesh contains a high percentage in the water-free material, while cereal grains contain only a relatively small amount.

The food value of the different proteins varies greatly, however, and may be either of excellent or inferior quality. This quality factor depends largely upon the differential amino acid content of the protein. Some 22 different amino acids have been isolated chemically from the proteins of animal and vegetable origin, but only 10 have been determined by experimental feeding tests to be essential for growth and maintenance. The proteins or amino acids function in a number of ways, such as supplying material for structural units of the cells, for maintenance of fluid balance within the body tissues, and for producing cellular enzymes and hormones.

During digestion the protein is broken down or hydrolized into its constituent amino acids. They are then absorbed into the blood stream and carried to the various tissues of the body for resynthesis of proteins. Therefore, the main function of the proteins in the diet is to supply amino acids, which furnish the "building stones" used to repair tissues destroyed during metabolism or to build new body tissues. Excess amino acids, either essential or nonessential, are utilized by the body to yield energy or, in other words, to supply calories.

Information regarding the amino acid requirements of the body has been obtained by feeding experiments with purified proteins deficient in certain of the amino acids or by feeding amino acid mixtures. An excellent quality protein is one which contains all of the so-called essential amino acids in sufficient amounts to promote optimum metabolism. Proteins from animal sources are recognized as excellent sources of the amino acids needed.

The essential amino acids must not only be present in a protein, but they must be present in such a way as to be available for absorption and assimilation. Some proteins are almost wholly indigestible, in which case the amino acids are not available. Other proteins that are, for the most part, digestible may be poor sources of certain of the essential amino acids.

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According to Rose (1937), the following amino acids were considered to be indispensable for growth or maintenance:

arginine	histidine	lysine	tryptophane	methionine
phenylalanine	threonine	leucine	isoleucine	valine

At the time the studies reported herein were started (1935), cystine was thought to be essential and, therefore, was included in the determinations. It is now believed that cystine is not essential when methionine is present, although there is still some question about its status.

There is some question also regarding the indispensability of arginine and histidine, although arginine appears to be necessary for the normal production of sperm cells. The actual process of the metabolism of some of the amino acids is uncertain, while still others are definitely known to be synthesized by the body. From a physiological standpoint, all of the nonessential amino acids may be considered indispensable (Patton, 1946). Some of these amino acids may be very important for functions other than growth; in any event, they are desirable in the diet since they spare the essential amino acids, according to this investigation.

A review of the literature and data from studies made by the Fish and Wildlife Service on the nutritive value of some proteins from fishery products (Lanham and Lemon, 1938), indicate that fish proteins, as a class, have been found to be of high nutritive value, which in turn infers that they contain the essential amino acids and are also very digestible. Feeding experiments, in general, have shown fish to be a most valuable food.

So far as chemical composition is concerned, however, very little information is available in the literature relative to the amino acid content of fish proteins. Most of the work reported was done a number of years ago, using methods not generally recommended today. Of the more recent work found in the literature, that of Beach, et al. (1943), might be mentioned. The content of 10 amino acids in six soft organs of beef and in the muscle tissues of several cold and warm blooded animals, including turtle, frog, salmon, codfish, and shrimp, is reported by these workers. It was found, in general, that muscle tissues of the different classes of animals studied do not differ widely in their amino acid structure. Although the organs show some similarity to the muscle tissue in composition, larger differences in amino acid content were found.

Because of a desire by investigators in the field of nutrition for information of this type, the former Bureau of Fisheries (now the Fish and Wildlife Service) undertook the quantitative estimation of arginine, histidine, lysine, tryptophane, and cystine in a large number of the more important species of fish, shellfish, and crustacea.

PREPARATION OF SAMPLES: Because of the perishable nature of fish and the rapid decomposition of the proteins, it was impractical to use raw samples for the analyses. Furthermore, certain difficulties in procedure might have been encountered because of the high moisture content and, in some instances, the high oil content of the product.

Removal of most of the water from protein material reduces decomposition to a minimum. Heating, in order to drive off the water, is impractical where large samples are desired; also, the composition of the protein will most likely be altered by the effect of the heat unless very careful control is possible. Accordingly, a solvent method was used for preparing the samples, dehydration being

affected by extraction of the raw flesh with anhydrous acetone. This solvent also removes most of the fat which is present in the body tissues of the fish, producing a final product having a low water content and containing practically no fat.

Table 1 - Percentage of Arginine, Histidine, Lysine, Tryptophane, and Cystine in the Proteins from the Edible Portions of Fish, Shellfish, and Crustacea

Species	Scientific name	Date sample was prepared	Arginine	Histidine	Lysine	Trypto-phane	Cystine1/
F I S H							
Catfish	Ameiurus catus	Aug. 1937	-	-	-	0.97	-
Cod	Gadus callarias	June 1936	5.58	1.72	6.83	1.06	1.41
Croaker	Micropogon undulatus	May 1936	5.81	1.37	6.10	1.24	1.15
Haddock	Melanogrammus aeglefinus	Sept. 1935	5.70	1.17	6.41	0.85	1.16
Halibut	Hippoglossus hippoglossus	Dec. 1936	6.00	1.66	6.16	1.64	1.45
Herring:							
Lake	Leucichthys artedi	Nov. 1937	-	-	-	1.25	-
Sea	Clupea harengus	March 1937	5.09	1.56	7.03	1.23	-
Lake trout	Cristivomer namaycush	June 1937	5.73	1.40	7.15	1.17	-
Mackerel:							
Boston	Scomber scombrus	Aug. 1936	5.78	1.93	7.13	1.36	1.18
Spanish	Scomberomorus maculatus	Jan. 1936	5.27	1.48	6.53	1.37	1.25
Mullet	Mugil species	Feb. 1937	5.78	1.61	6.74	1.36	1.29
Pilchard	Sardina caerulea	March 1937	5.60	1.23	6.78	1.30	-
Red snapper	Lutianus blackfordii	Nov. 1936	6.18	1.57	6.72	1.22	1.29
Salmon:							
Chum	Oncorhynchus keta	May 1938	5.55	1.30	5.69	1.33	-
King	" tschawytscha	April 1937	5.02	1.41	6.27	1.20	1.27
Pink	" gorbuscha	April 1937	-	-	-	1.09	1.15
Silver	" kisutch	Jan. 1937	5.68	1.87	6.57	1.44	1.39
Sockeye	" nerka	Sept. 1937	-	-	-	1.25	-
Shad	Alosa sapidissima	May 1936	4.54	1.09	6.45	1.22	1.17
Squeteague or "sea trout"	Cynoscion regalis	June 1937	5.90	1.42	6.78	1.01	-
Tuna:							
Albacore	Germo alalunga	Nov. 1937	-	-	-	1.18	-
Bluefin	Thunnus saliens	Oct. 1937	-	-	-	1.25	-
Bonito	Sarda chiliensis	Sept. 1937	-	-	-	1.19	-
Skipjack	Euthynnus pelayms	Dec. 1937	-	-	-	1.16	-
SHELLFISH & CRUSTACEA							
Clam, hard	Venus mercenaria	Sept. 1936	5.27	1.45	5.40	1.19	-
Crab, blue	Callinectes sapidus	Nov. 1936	7.61	1.51	6.38	1.11	-
Oyster	Ostrea virginica	Oct. 1936	5.71	1.79	5.24	1.67	-
Shrimp	Peneus brasiliensis	June 1936	7.50	1.61	7.35	0.96	1.25

1/Cystine determinations were conducted by H. C. Harris, Graduate Student Assistant, at the Fishery Technological Laboratory, College Park, Maryland.

The samples of fish proteins were prepared from skinned and boned fillets. the samples of shellfish and crustacea proteins were prepared from the edible portion. Representative samples were assured by using 100 pounds of fish or shellfish for the preparation of each lot of dried material. After extraction of the ground product, the dry, fat-free tissue was again ground in a laboratory mill and stored in evacuated glass jars until ready for analysis. The final product was a white, very light-weight, coarse powder.

ANALYTICAL PROCEDURE: Although several methods are recognized for the quantitative estimation of the various amino acids in proteins, the methods are not strictly comparable. Some methods for the quantitative estimation of amino acids are based on the calculation of the quantity of an amino acid from the nitrogen content of certain fractions of the hydrolyzed protein. These methods tend to overestimate the quantity of some of the amino acids, because the calculations are based on the total amount of nitrogen found; whereas, some part of this nitrogen may be from a source other than that which is desired. The method (Block, 1934) selected in this investigation for the estimation of arginine, histidine, and lysine depends on the quantitative isolation of the specific amino acid salts. The values obtained are more likely minimal, however, as inevitable losses occur in the separation and purification.

The colorimetric procedure of Folin and Ciocalteu (1927) was used for the estimation of tryptophane. From the standpoints of rapidity and duplicability of results, it appeared to be best fitted to the needs of this problem.

Cystine was determined by the colorimetric method of Sullivan and Hess (1930). The hydrolysate was usually highly colored, which made the color comparison difficult.

DISCUSSION OF DATA: The data in Table 1 (shown on p. 7) show the proteins of fish, shellfish, and crustacea, as a group, to be good sources of the amino acids arginine, histidine, lysine, tryptophane, and cystine. With the exception of the values for the arginine content of shellfish and crustacea, the percentages of the five amino acids determined are comparatively uniform for the different species.

In Table 2 are shown the arginine, histidine, lysine, tryptophane, and cystine content of casein, beef round, and egg albumin. The protein of milk, which is largely casein, is considered to be of satisfactory nutritional quality. Other animal proteins, such as those of meat and eggs, are also considered as being of good quality.

Table 2 - Percentage of Arginine, Histidine, Lysine, Tryptophane, and Cystine in the Proteins of Casein, Beef Round, and Egg Albumin--From Various Sources

Protein	Arginine	Histidine	Lysine	Tryptophane	Cystine
Casein	5.2	2.6	7.6	2.2	0.3
Beef round	7.5	1.8	7.6	0.9	1.3
Egg Albumin	6.0	2.3	3.8	1.3	0.9

Comparing the analytical results reported in Table 2 with those in Table 1, the proteins of fish, shellfish, and crustacea will be seen to compare very favorably with casein, beef, and egg albumin in the content of the five amino acids studied.

Fishery products may be used freely as a main source of protein, or as a supplementary protein to balance the deficiencies of less nutritive proteins included in the average diet.

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IRISH MOSS has been used as a food and in medicinal products for centuries. The early settlers imported small quantities for these purposes up to the year 1835, at which time extensive growths were discovered along the New England coast. This gave rise to a new industry for the population of that section, and, while its growth has not been large, it gives seasonal employment to several hundred people. Irish moss had been used chiefly as a component of puddings and as a demulcent in cough remedies; also, to some extent, in the manufacture of stabilizers for ice cream, chocolate milk, cheese, bakery products, confections, and dental impression compounds. The production of Irish moss in 1940 amounted to approximately 600,000 pounds, valued at $59,000.

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