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THE EFFECT OF A SEAFOOD DIET ON THE RED CELL COUNT, HEMOGLOBIN VALUE, AND HEMATOCRIT OF HUMAN BLOOD[1/]

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Abstract: The effect of a seafood diet upon certain blood values was studied with six college women ranging in age from 19 to 24 years. Two of the subjects served as controls and consumed free-choice diets; four received the seafood diet. The experimental period was composed of a three-week preliminary period of a free-choice diet, a seven-week period of the seafood diet, and a final one-week period similar to the preliminary period. The first and third periods were used to obtain a comparison of the free-choice diet and the seafood diet for each of the four subjects. During the seven-week test period, seafoods furnished the protein of a daily main meal which was prepared and served during the noon lunch hour.

Each subject recorded the total daily food intake for the entire experimental period. From the dietary records, the consumption of protein, calcium, iron, vitamin A, thiamine, riboflavin, niacin, ascorbic acid, and the number of calories were calculated; those of the seafoods were reported separately.

A blood sample was taken by venipuncture once every week from each subject. The volume of packed cells (hematocrit reading), red blood cell count, and hemoglobin content were determined for these samples. The color, saturation, and volume indices were calculated, but these did not show significant results.

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The data indicated that a diet containing a daily portion of the seafood will maintain the red cell count, hematocrit, and hemoglobin values of the blood, as well as a free-choice diet containing an equivalent amount of meat. It is necessary for further study to be carried on before the exact hematopoietic value of seafood can be determined.

Introduction: Scarcities of food, whether due to war, depression or famine have always led to investigations and usually to the encouragement of more extensive uses of certain foods. Statistics show that at the present time, seafoods are becoming more popular; for example in 1920, the oyster consumption per person was 1.13 pounds, while in 1938 a little over double the amount was eaten (Newcombe, 1944). This increase in consumption may be explained by the convenient market forms (canned, frozen and package-to-pan) which have greatly reduced the difficulty involved in the preparation for cooking; or perhaps the increase may be due in part to the recent shortage of protein foods when more people have made use of the various seafoods without realizing their value in the diet.

Seafood products are of major importance for their nutritional value. It is reasonable to suppose that marine animals living in a medium containing all the mineral elements needed by the human body would be a highly nutritious class of food. Since the minerals may be supplied to us in a usable form, by marine animals, we can get iron and copper to prevent nutritional anemia, iodine to prevent goiter, as well as phosphorous, copper and magnesium which are needed to regulate other body functions.

Oysters, shrimp and crab meat in addition to being rich sources of iron, copper and iodine contain one-half as much calcium, three times as much magnesium, and much more phosphorus than an equal quantity of milk (Newcombe, 1944). The oyster is comparable to liver and to milk, in its rich sources of nutrients. Newcombe (1944) reports that one pound of oysters provides about 12 percent of the energy needed by a man for one day; also, 50 percent of the protein, 26 percent of the calcium, 40 percent of the phosphorus, over 184 percent of the iron, and about 110 percent of the iodine, as well as vitamin A, thiamine, riboflavin and ascorbic acid.

Fish, as well as shellfish, are good sources of protein, phosphorus, iron and iodine. The protein content of fish is comparable to beef and liver and is higher than that of milk.

Since the protein, iron and copper contents of seafood are so high, it seemed reasonable that the influence on the blood might be significant; therefore, this study was undertaken to investigate the effect of a seafood regimen on the blood of man, using three different blood tests in relation to a group of dietaries as an index.

Review of Literature: For many years, it has been known that certain types of seafood excel as sources of some of the dietary factors which are important in physiological functions. In spite of this fact, it appeared that compared to other foods--milk, meat, fruit, vegetables and other--little experimental work had been done to form a basis for this premise; therefore,

questions have arisen as to the more specific functions which seafood proteins perform in the body.

Early experiments studied the coefficient of digestibility and absorption of seafood proteins. Holmes (1918) showed that the proteins of fish were as easily digested as those of beef and other meats. Of the four fish tested, an average of about 92 percent of the protein was digested. He also found that the absorption of mineral salts was better from a diet of fresh or salt fish than from a diet where beef was used as the source of protein. In comparison to the experiment with humans of Holmes, we find that Drummond (1918) obtained similar results with rats since he stated that the coagulable proteins of cod, herring, and canned salmon possessed a nutritional value equal to that of beef muscle. Jones (1926) found that rats grew best when fed a diet containing clams; those with shrimp and oysters rating second and third, respectively. Kjeldahl's method for nitrogen determination and nitrogen balance experiments were used in these early protein studies.

Lanham and Lemon (1938) found, after testing the growth value of nine different fishery products, that the oyster protein had a higher nutritive value than the following seafoods: pilchard, shrimp, mackerel, haddock, shad, cod, salmon or croaker. The oyster protein also had a higher biological value than the beef protein which was used as the control.

About 1932 interest in the anemias began to develop. Coulson, et al (1932) found that oysters were excelled only by liver in the amount of iron and copper which they furnished to the diet in an average serving. It was found that the above minerals from oysters were readily available to the body for hemoglobin production. Experimental results showed that the feeding of oysters, oyster ash and a solution of iron, copper and manganese in the same quantities to anemic rats brought about hemoglobin regeneration at the same rate.

Experiments using fish in connection with hemoglobin regeneration date back to the early work of Robscheit-Robbins and Whipple (1926). These workers studied the effect of various protein foods on hemoglobin production. It was shown that canned salmon and dried codfish gave no increase in hemoglobin when included in the diet of dogs. They also stated that fish liver and fish muscle were inert in hemoglobin regeneration, but whole fish was a little more efficient. Cooked perch caused an increase in hemoglobin production of about 5 gm. to 20 gm. per weekly period. These same workers in a later study (1940) rechecked the hematopoietic power of certain foods and reported that salmon, supplemented with iron, was well utilized to produce hemoglobin, and that the output was equal to a comparative diet of liver and iron.

Saha and Guha (1941) stated that a more correct value of available iron in fish was obtained if a preliminary acid treatment were used before analysis by the di-pyridyl method. About 40 percent of the non-hemin iron was found in the form of iron-copper-nucleoprotein complex. Hemoglobin regeneration studies with rats showed that the complex possessed a remarkable hemoglobin regeneration capacity, but hematopoietic power was reduced by the elimination of copper. This fact was verified when copper and iron were administered in amounts equal to those in the complex; therefore, it

was thought that the protein of the complex had a positive role in hemoglobin production.

Appanna and Devadatta (1942) showed that fish and prawn muscle constituted cheap sources of animal proteins, phosphorus, calcium and iron. The protein of this source was found to possess high biological value.

A recent experiment by Deuel, et al (1946) involved studying the nutritive value of fish proteins by the rat growth method. Mackerel, sardines and tuna fish were used in this experiment, and fed in the diet as isolated fish protein. The acid hematin method was used to determine the hemoglobin production. The results of this work showed better growth and increase of hemoglobin values by the mackerel over the casein diet from 9.83 to 10.42 percent.

The effects of many variations on the handling, storing and preserving of fish have been quoted in the literature, but space does not allow the discussion of any variations except those directly associated with the products and conditions used in this study. Reay (1930) started a series of experiments to observe the effect of freezing on the protein of fish muscle. He concluded that the proteins were affected due to a change in the concentration of the salt solution of the cells. The most rapid change in the muscle was found in temperatures of -2° and -4° C.

Greene (1919) showed that a seasonal variation changed the fat and protein content of the King salmon. Peterson and Elvehjem (1928) in a similar study found that there were individual and seasonal variations in the mineral content of fish. Crooks and Ritchie (1939) made an extensive study on the seasonal variations of the haddock. The results in almost all cases showed the lowest percentage of copper, iron, and organic nitrogen during the months of March, April, and May. The highest percentage of these nutrients appeared during August.

Cooking losses were discussed by Baker (1943). Losses of total nitrogen, purine nitrogen, non-protein nitrogen and calcium were greatest in the boiling process with steaming and frying next. He stated that there was insufficient evidence as to the effect of normal cooking treatments on utilization of fish protein by the body and that much remained to be done on the study of the digestibility and biological value of fish proteins. Reay, et al (1943) agreed with Baker when he stated that less was known about proteins of fish than of warm-blooded animals. His work showed that the total non-protein nitrogen in fish and crustacean muscle was somewhat higher than in mammals. He believed that fish muscle might contain some unknown protein fractions.

Some workers have declared certain experiments as meaningless due to daily variations in the blood constituents. According to McCarthy and Van Slyke (1939) the greatest range of hemoglobin noted over a period of a day was 11 percent by the carbonmonoxide method. These results, however, were changeable and inconsistent. They believed the higher ranges in diurnal variation quoted in past literature might be attributed to methods of analysis which provided a significant part of the variations.

Another possible variation reported in the literature was the effect of the menstrual cycle upon the blood values. Leverton and Roberts (1933) found no consistent measurable effect of menstruation on daily values of hemoglobin or the red cells. They believed that daily variations occur irrespective of different phases of the menstrual cycle. Duckles and Elvehjem (1937) in a similar study showed that hourly variations were not consistently comparable at corresponding hours on different days. There was no difference between menstrual and intramenstrual days. Other workers, however, found that there was a downward trend in values during the time of menstrual flow and a gradual recovery after termination.

Sheets and Barrentine (1944) in tests on 604 healthy women showed that there was no positive relationship between underweight and level of hemoglobin.

The standards set for the various blood values, as quoted in periodicals and books, varied to a large extent. Osgood and Haskins (1927) stated that the "normal values" of 5 million and 4.5 million red cells per mm^3 for men and women respectively, were based on four blood examinations. These examinations were made in 1852 and 1854 by methods now obsolete, and these levels were then quoted from book to book without experimental confirmation. These workers gave normal levels as: 4.8 million red cells per mm^3, 41.02 percent as the volume of packed cells, and 13.64 gm. hemoglobin per 100 ml. blood. Myers and Eddy (1935) quoted 13.0 gm. hemoglobin and 45 mg. iron per 100 ml. of blood as normal for young women.

Ohlson, et al (1944) compiled data on an investigation of 4,550 women in colleges of the North Central states. The age range varied from 16 to 30 years with 90 percent of the subjects within a 17 to 24 year age group. The mean values quoted were: 13.4 gm. hemoglobin per 100 ml. blood, 4.56 million cells per $mm.^3$, and 40.0 percent packed cell volume.

Arens (1945) in a resume of the literature stated that the values for young women as found in textbooks were too high, she quoted: "Peters and Van Slyke-values for females 16 years to 25 years, a range of 14.9 gms. to 15.2 gms. per 100 mls. blood. Hawk and Bergeim gave 13.8 gms. and 15.6 gms. percent by the oxygen-combining capacity and 16.9 gms. percent by the spectrophotometric methods. Bodansky gave 14 gms. percent as normal for 16 year olds, while Todd and Sanford said that 15.0 to 15.5 gms. percent was normal for 16 to 25 year old women." Arens drew the conclusion, after a study of 200 young women subjects, that the mean value of hemoglobin was 13.1 gm. per 100 ml. blood which was from 7 to 27 percent lower than the quotations from these text books.

Experimental Procedure: The purpose of this experiment was to determine the effect of consumption of seafoods on certain blood constituents. It is well known that liver, kidney, and even beef muscle have hematopoietic value and interest has recently been aroused as to the value of seafoods in the same role.

Six healthy college women were chosen as subjects for this study. The ages of the six subjects ranged from 19 to 24 years. Four of these six girls served as the experimental subjects and received the seafood diet, the remaining two were the controls and continued to eat their regular diets. All of the girls were of medium build, that is, none was extremely under or over weight for her height, age and body build.

The total length of the experiment, eleven weeks, was divided into three periods. During the first and last periods the subjects ate self chosen diets; that is, regular everyday diets. The first three-week period established a basis of comparison for the test diet, while the last period of one week served as an index between the two diets after ingestion of seafood. The seven-week test diet consisted of a daily meal in which the seafood was the main source of protein, as well as an excellent source of minerals. Since the meals were only served five days a week, provisions were made for each of the four subjects to have enough fish to last over Saturday and Sunday. The meals, including a variety of seafoods, were served during the regular noon lunch hour; the seafood being prepared in various ways--broiling, baking, steaming and frying--to avoid monotony in the diet. Haddock, halibut, cod, mackerel, salmon and tuna were the fish used to the greatest extent in the experiment; however, a few of the less-common species were also used. A variety of shellfish as oysters, clams, crabs and shrimp were prepared as casserole dishes, salads, soups and appetizers. Two vegetables, a salad, dessert and a beverage were also included in the meal. The subjects given this diet ate the usual breakfast of fruit, cereal, egg, toast, and beverage, and, in most cases, a light supper. The consumption of meat was voluntarily restricted to a large extent. Subject IV consumed the seafood diet exclusive of meat protein.

Food records were kept by each subject of all food and drink taken during the entire experimental period. From these records, the amount of protein, calcium, iron, vitamin A, thiamine, riboflavin, niacin, ascorbic acid and the number of calories consumed were calculated per person per day by weekly periods. The dietary food values of the seafood were figured separately making it possible to determine exactly how much of the food value was due to this particular source.

A single sample of blood was taken weekly from the six subjects. The samples were collected in the forenoon of the same day each week by the venipuncture method. Blood samples were collected into small bottles which contained 0.05 ml. of 25 percent potassium oxalate and refrigerated for an hour or two before being used.

The packed cell volume was determined in Wintrobe hematocrit tubes. The tubes were filled with blood and centrifuged at 3,000 revolutions per minute for 30 minutes. The centrifuged blood was separated into layers of plasma, white cells, and red cells. The hematocrit tubes were graduated, making it possible to read the packed red cell volume in percent of whole blood. Duplicate determinations were made on each sample of blood; the duplicates were averaged and recorded. It was necessary to apply a correction factor of 1.04 (Stitt, et al, 1938) because of a slight shrinkage of the cells by potassium oxalate. Sodium citrate and a combination of ammonium and potassium oxalate were found to be unsatisfactory anticoagulants for use in this experiment. In discussing this determination, packed cell volume and hematocrit reading, will be used interchangeably.

Red cell counts were determined on each sample. The blood was diluted with Hayem's solution in Hellige blood pipettes. After a thorough shaking of the diluted blood to give a uniform suspension of cells, a drop was introduced into an improved Neubauer counting chamber. A count was made on the number of cells in 80 small squares and the result multiplied by 10,000. Three or four counts were made on each sample to eliminate errors in counting. The counts were averaged and the result was the number of red cells per mm^3 of blood.

The alkaline hematin procedure was chosen to determine the amount of hemoglobin in the blood. One-tenth ml. of each blood sample was diluted with 25 ml. of decinormal sodium hydroxide; the solutions were then immersed in rapidly boiling water for five minutes and immediately cooled. The hemoglobin concentration was determined by taking the readings of the transmitted light on a quartz prism photoelectric spectrometer by measuring the intensity of color. Horecker's (1946) method of preparing the hemin standard was used in this experiment. An accurately weighed sample of pure hemin was dissolved in a known amount of borate buffer and then aged overnight in the refrigerator. From this stock solution, dilutions were made to equal the different concentrations of hemoglobin. Fresh hemin dilutions were read in the photoelectric spectrophotometer each day with the alkaline hematin solutions, and the grams of hemoglobin were calculated per 100 ml. blood from the transmission values.

The amount of hemoglobin was measured on the basis that 29.6 mg. of hemin per liter were equal to 16.7 gm. hemoglobin per 100 ml. blood at a wave length of 570 Å units. The blood was converted to alkaline hematin in a dilution of 1 to 250 and the transmission readings recorded from the spectrophotometer. The standard hemin solutions read with each set of blood samples were plotted as the log of transmission readings against gm. of hemoglobin per 100 ml. of blood. From these standard curves, the hemoglobin content of the blood samples was determined.

The color, volume and saturation indices were calculated from the three blood values. The color index expressed the amount of hemoglobin in the red corpuscle as compared with the normal amount for female adults (1.00). This value was calculated by the formula:

$$C.I. = \frac{\text{Hb. in gm. per 100 ml. X 6.9}}{\text{RBC in millions per } mm^3 \text{ X 20}}$$

The volume index expressed the volume of the red cell as compared with normal volumes for female adults (0.85-1.00) and was calculated as:

$$V.I. = \frac{\text{Hematocrit X 2.3}}{\text{RBC in millions per } mm^3 \text{ X 20}}$$

The relative concentration of hemoglobin in the red cell as compared to normal values for female adults was known as the saturation index. It was determined by:

$$S.I. = \frac{\text{Hb. in gms. per 100 ml. X 6.9}}{\text{Hematocrit X 2.3}}$$

The factors 6.9, 20, and 2.3 were numbers which, when used to multiply normal blood levels, gave normal ranges for the indices.

Results: Six college women were included in a study of the effect of seafood on certain blood constituents. Four of the experimental subjects received a noon dinner including a serving of seafood; the two controls consumed their usual free-choice daily diet. The food values were calculated from the weekly consumption of individual food items and the total averaged to give the nutrient intake per day. The hemoglobin determinations, red cell counts and the hematocrit values, as well as certain calculated indices were determined from a single weekly sample of blood.

The recommended dietary allowances as quoted by the Food and Nutrition Board of the National Research Council, for the moderately active woman, were used as a standard for comparison throughout the study. These daily allowances are: 2500 calories, 60 gm. protein, 0.8 gm. calcium, 12 mg. iron, 5000 I.U. vitamin A, 1.2 mg. thiamine, 1.6 mg. riboflavin, 12 mg. niacin and 70 mg. ascorbic acid.

As may be noted in Table 1, Subject I met this standard except for calories, thiamine and niacin. The caloric value of the diet was low during every week but one and the thiamine content was slightly deficient during two weeks, while the niacin content was deficient during five weeks. The data in Table 1 also indicate that the level of blood constituents coincided with the level of food intake in that both showed a slight decrease after April 23. The food values were sufficiently large to permit uniform gain in weight, but were lower as compared to those of the earlier part of the experiment. The hemoglobin increased to a certain level and started a slow but constant decrease. There appeared to be fluctuations in the hematocrit and red cell counts which make it difficult to state positive results. The menstrual cycle showed a rather definite effect on the blood constituents. The hemoglobin level, the color index, and the saturation index showed a decrease just after menstruation while the packed cell volume and the cell count decreased just before menstruation. There was no effect on the volume index.

The three indices showed a general trend toward slightly increased levels until April 23, after which there was a gradual decrease.

The data in Table 2 showed that the caloric intake of Subject II was below the daily recommended allowance during the entire experiment. The calcium intake was below the allowance during two weeks, iron during two weeks, thiamine during four weeks, riboflavin during two weeks, and niacin during seven weeks. The majority of these values, however, was only slightly below the recommended allowances.

The menstrual period showed its effect by a decreased hemoglobin level both during and just after the period. After the decrease, due to menstruation, there was an increase in hemoglobin. It appeared that perhaps there might have been another increase at the end of the experiment, had the seafood diet been continued. The effect of menstruation was the same on the packed cell volume, the color index, and the saturation index. There was no effect shown on the red cell count and the volume index.

Table 1 - Mean Daily Food Intake of Subject I*

Date	Calories		Protein		Calcium		Iron		Vitamin A		Thiamine		Riboflavin		Niacin		Ascorbic Acid	
	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish
			gm.	gm.	gm.	gm.	mg.	mg.	I.U.	I.U.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
March 12-19	2,328	-	86.4	-	1.48	-	15.0	-	10,463	-	1.51	-	2.46	-	12.5	-	190	-
19-26	2,123	-	69.8	-	1.08	-	14.4	-	5,892	-	1.72	-	1.89	-	10.2	-	142	-
26-2	2,099	-	71.9	-	1.06	-	18.9	-	9,979	-	1.46	-	2.68	-	15.6	-	168	-
April 2-9	2,540	144	103.2	19.5	1.67	0.06	20.1	2.9	15,204	176	1.65	0.13	3.26	0.19	22.7	3.7	161	-
9-16	2,445	115	97.1	17.4	1.38	0.09	15.7	1.6	10,852	81	1.32	0.07	2.43	0.12	14.3	3.0	124	-
16-23	2,318	97	95.0	12.2	1.24	0.03	17.8	1.1	11,056	109	1.61	0.06	2.29	0.13	13.0	1.1	121	-
23-30	2,384	147	113.0	15.0	1.29	0.06	15.4	1.2	13,079	140	1.50	0.05	2.47	0.10	14.5	2.6	176	-
May 30-7	1,849	114	66.0	16.6	0.81	0.03	13.7	2.2	6,201	112	1.17	0.09	1.83	0.27	11.0	2.4	188	-
7-14	1,865	111	68.6	15.8	0.95	0.08	14.0	2.8	9,764	111	1.25	0.12	1.82	0.14	8.5	2.2	136	-
14-21	2,098	99	77.2	16.7	1.31	0.10	13.5	2.4	6,555	85	1.29	0.10	2.31	0.14	9.1	1.9	171	-
21-28	1,782	-	69.2	-	1.24	-	12.8	-	7,839	-	1.07	-	2.03	-	8.4	-	130	-

*The data on food intake in this and other similar tables were calculated from Bowes and Church (1944) and based on the food intake record of the various subjects in this experiment.

Table 1 (Cont.) - Hematological Data of Blood Samples Taken Each Week

Date	Hemoglobin	Color Index	Hematocrit	Saturation Index	Red Cell Count	Volume Index	Date of Menstruation
	gm./100 ml. blood				millions/cmm.		
March 13	13.0	1.10	42.4	0.92	4.09	1.19	3/10
19	12.9	0.94	40.1	0.97	4.72	0.98	
26	13.8	1.02	41.2	1.00	4.65	1.02	
April 2	14.6	1.03	43.6	1.00	4.89	1.03	
9	14.1	0.99	44.4	0.95	4.90	1.04	4/6
16	13.9	1.05	43.2	0.97	4.55	1.09	
23	15.3	1.08	40.0	1.15	4.90	0.94	
30	14.7	0.99	39.2	1.12	5.10	0.88	
May 7	13.5	0.97	39.6	1.02	4.80	0.95	
14	13.0	0.89	41.5	0.94	5.04	0.95	5/9
21	12.8	0.91	39.7	0.97	4.86	0.94	
28	12.7	0.95	40.7	0.94	4.63	1.01	

Table 2 - Mean Daily Food Intake of Subject II

Date	Calories		Protein		Calcium		Iron		Vitamin A		Thiamine		Riboflavin		Niacin		Ascorbic Acid	
	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish
			mg.	mg.	mg.	mg.	mg.	mg.	I.U.	I.U.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
March 12-19	2,385	-	90.4	-	1.54	-	16.2	-	10,882	-	1.63	-	3.06	-	15.3	-	166	-
19-26	1,904	-	75.4	-	0.97	-	14.1	-	11,609	-	1.65	-	2.38	-	15.1	-	135	-
26-2	2,023	-	77.9	-	1.37	-	15.6	-	13,438	-	1.45	-	2.39	-	12.4	-	182	-
April 2-9	1,962	125	85.2	18.9	1.14	0.09	13.6	2.9	12,828	185	1.42	0.15	2.64	0.19	13.3	3.1	184	-
9-16	1,876	189	75.8	21.9	0.94	0.08	13.4	3.1	6,498	158	1.16	0.16	1.90	0.21	10.9	2.7	128	-
16-23	1,572	126	73.9	17.5	0.68	0.04	12.6	1.7	9,660	117	1.42	0.10	1.54	0.16	11.1	2.6	136	-
23-30	1,672	143	67.4	15.0	0.82	0.08	11.3	1.1	7,942	148	1.21	0.04	1.55	0.11	11.3	3.2	143	-
May 30-7	1,574	146	78.6	23.6	0.69	0.07	13.3	1.3	4,647	305	0.99	0.08	3.19	0.15	10.8	3.0	141	-
7-14	1,852	116	74.8	18.8	0.92	0.09	12.5	3.3	6,327	93	1.25	0.14	1.75	0.16	9.3	1.8	153	-
14-21	1,656	175	71.6	19.5	1.06	0.13	13.4	3.3	10,759	231	1.16	0.15	2.13	0.21	10.6	1.8	146	-
21-28	1,088	-	56.7	-	0.89	-	9.0	-	7,538	-	1.11	-	1.67	-	9.2	-	118	-

Table 2 (Cont.) - Hematological Data of Blood Samples Taken Each Week

Date	Hemoglobin	Color Index	Hematocrit	Saturation Index	Red Cell Count	Volume Index	Date of Menstruation
	gm./100 ml. blood				millions/cmm.		
March 13	12.6	1.16	38.5	0.98	3.76	1.18	3/10
19	13.0	0.97	39.1	1.00	4.50	0.98	
26	13.1	1.01	38.8	1.01	4.49	0.99	
April 2	15.6	1.08	39.9	1.17	4.97	0.92	
9	13.0	0.99	41.7	0.94	4.51	1.06	4/9
16	12.4	0.90	39.9	0.93	4.76	0.96	
23	14.1	1.26	33.2	1.27	3.86	0.99	
30	14.1	1.10	37.7	1.12	4.44	0.98	
May 7	13.2	0.99	39.4	1.01	4.59	0.99	
14	12.5	0.94	38.4	0.98	4.57	0.97	5/11
21	12.2	0.88	37.8	0.97	4.81	0.90	
28	12.4	0.99	38.0	0.97	4.33	1.01	

Table 3 - Mean Daily Food Intake of Subject III

Date	Calories		Protein		Calcium		Iron		Vitamin A		Thiamine		Riboflavin		Niacin		Ascorbic Acid	
	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish
			gm.	gm.	gm.	gm.	mg.	mg.	I.U.	I.U.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
March 12-19	3,275	-	90.3	-	1.55	-	22.4	-	12,259	-	2.20	-	3.20	-	18.7	-	169	-
19-26	3,095	-	90.2	-	1.33	-	19.9	-	16,005	-	2.23	-	2.66	-	19.6	-	202	-
26-2	2,831	-	92.8	-	1.33	-	22.6	-	16,230	-	2.12	-	3.87	-	23.9	-	222	-
April 2-9	2,234	86	83.7	14.0	1.21	0.07	17.9	1.03	7,944	55	1.50	0.72	2.05	0.11	25.0	3.5	95	-
9-16	2,607	114	84.5	17.3	1.15	0.09	11.5	1.60	10,200	81	1.35	0.69	2.07	0.12	14.6	3.0	109	-
16-23	2,371	139	97.8	16.1	1.00	0.08	18.8	1.21	10,667	148	1.82	0.38	2.03	0.16	15.1	2.7	106	-
23-30	2,281	149	80.6	15.7	1.32	0.07	16.1	1.13	10,628	163	1.45	0.61	2.51	0.13	14.3	4.1	155	-
May 30-7	2,314	146	81.1	19.4	0.95	0.09	17.2	2.35	9,260	181	1.82	1.02	2.29	0.31	15.0	4.2	200	-
7-14	2,175	168	84.1	21.5	1.68	0.08	18.1	2.94	14,774	193	1.37	1.33	2.22	0.14	14.1	3.7	162	-
14-21	2,011	97	83.3	17.9	1.12	0.07	17.7	4.07	9,492	90	1.44	1.29	2.13	0.13	12.2	1.3	210	-
21-28	2,546	-	84.7	-	1.02	-	16.6	-	9,303	-	1.53	-	2.27	-	16.5	-	143	-

Table 3 (Cont.) - Hematological Data of Blood Samples Taken Each Week

Date	Hemoglobin	Color Index	Hematocrit	Saturation Index	Red Cell Count	Volume Index	Date of Menstruation
	gm./100 ml. blood				millions/cmm.		
March 13	13.0	0.96	38.7	1.01	4.66	0.96	
19	13.3	0.93	43.4	0.92	4.95	1.01	
26	13.4	0.95	41.0	0.98	4.86	0.97	
April 2	14.1	0.97	39.1	1.08	5.02	0.90	
9	14.4	1.00	43.8	0.99	4.97	1.01	4/6
16	14.0	1.05	42.9	0.98	4.62	1.07	
23	15.0	1.06	43.0	1.05	4.91	1.07	
30	15.0	0.99	38.7	1.16	5.22	0.85	
May 7	13.8	0.92	41.5	1.00	5.19	0.92	5/3
14	13.5	0.91	41.6	0.97	5.15	0.93	
21	13.1	0.84	40.1	0.98	5.36	0.86	
28	13.1	0.95	40.0	0.98	4.77	0.96	

The hematocrit and red cell counts seemed to fluctuate widely. It was interesting to note in Table 2 that after the first week of seafood diet, the blood values all showed a definite increase.

The daily diet of Subject III (Table 3) had a lower caloric value than the recommended allowance during six weeks. All of the other requirements, however, were adequate. There was a decrease in food values during the period of the seafood diet, but this level of intake was similar to that of the other girls, and allowed for maintenance of body weight.

Menstruation showed an effect by decreasing the hemoglobin level, the red cell count, and saturation index after the period. The hematocrit readings, color index and volume index,as shown in Table 3, were decreased before the menstrual period.

After the first week of the seafood diet, there was an increase in all the blood values except those that were decreased before menstruation. The blood values showed a continuous gradual rise until the fourth or fifth week of the seafood diet; but after this there was a gradual decrease to the end of the experiment.

The food records showed that Subject IV (Table 4) had a low intake of calories during the entire experimental period. The protein intake was only slightly low during three weeks, calcium during two weeks, iron during four weeks, thiamine during eight weeks, riboflavin during three weeks, and niacin during nine weeks. She was active physically, and lost about seven pounds during the experiment.

As with Subjects I, II, and III discussed before, the blood values increased until the fourth or fifth weeks of the seafood diet and then began a gradual decrease. The menstrual cycle did not affect the color index or the saturation index, but caused a decrease in the hemoglobin level, the red cell count, the packed cell volume, and the volume index.

This subject did not eat meat, but did consume dairy products. These data show that, even so, the blood values were maintained equally as well as for the other experimental subjects, and the gain in hemoglobin was next to the greatest of the subjects consuming the seafood diet. There was also a gain in red cells, but the hematocrit was not affected.

With the exception of one week, Subject V (Table 5) had a caloric intake below that of the recommended allowances. The diet appeared to meet all of the other recommended allowances with the exception of niacin which was below the standard during four weeks. There seemed to be some significance to the fact that during the week of the highest intake of protein, iron, thiamine, riboflavin, and niacin there was the greatest increase in hemoglobin and red cell count. The blood values showed a steady increase until April 23 and then decreased.

The menstrual cycle exerted its greatest influence during the period, though some decrease was also noted before the period in the case of the packed cell volume, the color index, and the volume index. The red cell count and saturation index showed a decrease after menstruation.

Between May 4 and 8, this subject suffered an infection of the jaw which possibly may have explained the increased blood values during that time. The number of red blood cells in particular may have increased during this time of infection.

The caloric intake of Subject VI (Table 6) during the entire period was lower than the recommended allowances of 2500 calories. The calcium intake was low during two weeks, iron during four weeks, vitamin A during three weeks, thiamine during five weeks, riboflavin during two weeks, and niacin during eight weeks.

The hemoglobin level remained fairly constant with this control subject except immediately after a trip to Chicago. Arens (1945) found that geographical location may exert an influence in hemoglobin levels.

The hemoglobin was not affected to a great extent by menstruation, perhaps because of the closer periods. Only slight decrease was noted (see Table 6) before menstruation in the hematocrit readings and in the red cell counts. The indices showed a slight decrease after the menstrual period.

Table 4 - Mean Daily Food Intake of Subject IV

Date	Calories		Protein		Calcium		Iron		Vitamin A		Thiamine		Riboflavin		Niacin		Ascorbic Acid	
	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish	Total	Fish
			gm.	gm.	gm.	gm.	mg.	mg.	I.U.	I.U.	mg.	mg.	mg.	mg.	mg.	mg.	mg.	mg.
March 12-19	2,098	-	60.2	-	0.72	-	11.5	-	7,266	-	1.24	-	1.47	-	12.7	-	102	-
19-26	2,233	-	71.3	-	0.97	-	13.4	-	9,150	-	1.64	-	1.84	-	11.8	-	132	-
26-2	2,366	-	72.5	-	0.92	-	15.4	-	8,702	-	1.61	-	1.93	-	10.8	-	190	-
April 2-9	1,957	97	69.3	13.2	1.03	0.05	13.8	1.0	9,883	100	1.19	0.08	1.50	0.10	11.2	1.8	146	-
9-16	1,977	112	56.4	15.3	0.94	0.07	10.6	1.3	7,033	111	0.99	0.05	1.60	0.14	8.5	2.5	109	-
16-23	2,128	105	61.9	12.7	1.01	0.04	13.5	1.0	10,985	96	1.14	0.07	1.76	0.11	9.7	1.4	151	-
23-30	1,851	260	59.1	21.3	0.88	0.07	11.6	2.4	6,510	271	0.97	0.18	1.75	0.18	8.4	5.1	128	-
May 30-7	2,147	176	70.4	23.5	0.85	0.05	12.8	2.6	7,038	187	0.18	0.12	2.10	0.42	13.1	4.8	127	-
7-14	2,065	135	67.4	20.0	0.91	0.08	15.1	4.2	11,084	164	1.08	0.18	1.84	0.24	9.0	3.2	121	-
14-21	1,867	123	56.3	15.2	0.90	0.10	12.4	2.4	5,056	358	1.08	0.11	1.56	0.13	6.9	1.6	124	-
21-28	1,950	-	68.0	-	0.71	-	11.7	-	5,144	-	1.18	-	1.60	-	11.3	-	77	-

Table 4 (Cont.) - Hematological Data of Blood Samples Taken Each Week

Date	Hemoglobin	Color Index	Hematocrit	Saturation Index	Red Cell Count	Volume Index	Date of Menstruation
	gm./100 ml. blood				millions/cmm.		
March 13	13.2	0.98	44.4	0.89	4.63	1.10	
19	13.5	1.02	43.4	0.93	4.58	1.09	
26	13.2	1.07	43.9	0.90	4.25	1.19	3/22
April 2	14.3	1.04	43.0	1.00	4.77	1.04	
9	14.0	0.99	46.3	0.91	4.90	1.09	
16	13.8	1.05	41.1	1.01	4.55	1.04	
23	14.8	1.25	40.5	1.10	4.09	1.14	
30	15.3	1.09	41.1	1.12	4.84	0.98	
May 7	14.4	0.99	43.4	1.00	5.04	0.99	
14	13.0	0.90	41.2	0.95	4.96	0.96	
21	12.9	0.93	39.7	0.98	4.81	0.95	5/15
28	12.7	0.90	41.6	0.92	4.88	0.98	

Table 5 - Mean Daily Food Intake of Control Subject V

Date	Calories	Protein	Calcium	Iron	Vitamin A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
	Total	Total	Total	Total	Total	Total	Total	Total	Total
		gm.	gm.	mgs.	I.U.	mgs.	mgs.	mgs.	mgs.
March 12-19	1,869	77.7	1.20	18.1	16,409	1.57	3.23	16.3	149
19-26	1,970	89.2	1.36	23.0	15,159	1.61	3.75	19.1	228
26-2	2,885	103.1	1.76	17.0	7,692	1.70	3.08	13.7	133
April 2-9	1,988	85.9	1.52	14.5	10,382	1.38	2.96	10.9	115
9-16	1,908	81.8	1.29	15.1	14,276	1.40	2.69	13.6	208
16-23	2,354	110.3	1.56	18.0	8,945	1.69	3.45	15.2	232
23-30	2,061	79.0	1.09	12.6	13,082	1.29	2.39	10.4	89
May 30-7	1,962	80.9	1.18	13.9	8,628	1.34	2.24	11.6	142
7-14	2,030	69.5	1.32	13.6	7,944	1.25	2.58	9.2	125
14-21	2,169	76.6	1.13	15.7	10,817	1.41	2.49	12.3	135
21-28	2,455	89.3	1.16	16.2	12,508	1.39	2.59	14.8	169

Table 5 (Cont.) - Hematological Data of Blood Samples Taken Each Week

Date	Hemoglobin	Color Index	Hematocrit	Saturation Index	Red Cell Count	Volume Index	Date of Menstruation
	gm./100 ml. blood				millions/cmm.		
March 13	10.3	0.80	38.0	0.81	4.46	0.98	
19	12.7	0.99	41.0	0.93	4.42	1.07	
26	13.3	1.06	39.5	1.01	4.35	1.04	
April 2	11.9	0.98	31.6	1.13	4.20	0.87	4/2
9	13.6	1.13	44.1	0.93	4.15	1.22	
16	13.7	1.03	44.6	0.92	4.57	1.12	
23	14.8	1.02	37.8	1.16	4.99	0.87	
30	14.5	1.03	38.6	1.13	4.36	0.91	4/29
May 7	14.1	1.03	41.2	1.03	4.73	1.00	
14	13.0	0.95	41.2	0.95	4.71	1.00	
21	12.9	1.02	38.7	1.00	4.38	1.02	
28	12.8	0.88	39.5	0.96	5.01	0.97	

Table 6 - Mean Daily Food Intake of Control Subject VI

Date	Calories Total	Protein Total	Calcium Total	Iron Total	Vitamin A Total	Thiamine Total	Riboflavin Total	Niacin Total	Ascorbic Acid Total
		gm.	gm.	mg.	I. U.	mg.	mg.	mg.	mg.
March 12-19	2,160	85.8	0.93	14.1	7,388	1.56	2.34	12.9	118
19-26	2,143	78.3	1.10	14.5	7,940	1.42	2.36	13.8	107
26-2	1,942	66.4	0.89	12.8	11,677	1.64	1.86	11.8	144
April 2-9	1,745	64.4	0.88	11.9	8,687	1.06	2.10	11.6	108
9-16	2,047	78.3	1.13	14.5	10,834	1.61	1.73	11.2	151
16-23	1,693	65.0	0.74	10.7	4,779	1.15	1.54	11.2	89
23-30	1,814	72.5	0.63	12.1	3,300	1.37	1.60	11.9	177
May 30-7	2,039	63.2	1.21	12.7	4,751	1.34	2.30	11.3	92
7-14	1,679	63.6	0.89	11.3	4,248	1.03	1.66	9.8	93
14-21	1,901	77.8	0.98	12.8	6,708	1.14	2.32	14.9	127
21-28	1,772	67.2	0.77	11.2	6,927	1.10	1.79	11.5	85

Table 6 (Cont.) - Hematological Data of Blood Samples Taken Each Week

Date	Hemoglobin	Color Index	Hematocrit	Saturation Index	Red Cell Count	Volume Index	Date of Menstruation
	gm./100 ml.blood				millions/cmm.		
March 13	12.1	0.90	39.0	0.93	4.65	1.04	3/14
19	12.2	0.85	37.8	1.02	4.92	0.96	
26	12.2	0.95	38.4	0.95	4.44	1.01	
April 2	12.3	0.95	36.5	1.02	4.49	1.01	
9	12.5	0.99	39.4	0.95	4.37	0.97	4/8
16	13.1	0.95	42.4	0.93	4.78	0.98	
23							
30	14.4	1.05	40.1	1.08	4.74	1.03	
May 7	13.8	0.99	40.5	1.02	4.86	1.04	5/4
14	13.0	1.01	39.5	1.05	4.43	0.98	
21	11.8	0.90	35.8	0.99	4.51	1.10	
28	12.3	0.82	38.6	0.96	5.15	1.11	

Discussion: The red cell is a container for the hemoglobin and round trips are made constantly from the lungs to the tissues by the cells in the act of conveying oxygen. The span of life of a red cell averages 30 days and a trillion are formed and destroyed each day. Approximately 25 gm. of hemoglobin are formed daily (Haden, 1937). The exact procedure for the manufacture of hemoglobin is not definitely known. Whipple, et al (1945) believe that the globin of hemoglobin is manufactured from amino acids in the red bone marrow and then the hemoglobin accumulates in the maturing cell. Orten and Orten (1945) stated that no single amino acid can be regarded as a "key" amino acid in hemoglobin snythesis in the organism but rather a combination of amino acids are needed in, as yet, undetermined proportions.

Stare (1945) after an analysis of fish stated that the amino acid content is usually high and a large percentage are the indispensable acids. Block, et al (1944) found no difference between meat and fish muscle proteins in their amino acid content except for a greater lysine content in meat. It has been stated that the biologic value of proteins depends on the content of amino acids, particularly the indispensable ones. Naturally, many variations influence the nutritive value of seafoods such as the effect of season, locality, storage, cooking, and even differences in chemical composition such as have been found in the flesh in various sections of the same fish. Several investigations have postulated that these variations may also influence the hematopoietic value.

A balanced diet is important in the formation of normal blood, but the addition of any food that possesses the hematopoietic property further encourages this physiological function.

McCarthy and Van Slyke (1939) stated that many variations are observed in the measurement of certain blood values and that these variations may be due to the method of analysis. The methods for the determination of the hemoglobin content of blood are not precise according to the literature. Certain methods are stated to be unsuitable for sensitive measurements of hemoglobin. The Alkaline Hematin method has been discussed by many workers. Rimington (1942) simply stated that this method is "less erratic" than some other methods. Clegg and King (1942) found that after the five-minute heating period the color reaction was invariably completed. Turbidity, however, developed later. The change in color involved is that of the red oxyhemoglobin to the brown alkaline hematin. They believed this method to be one of the more precise. Ponder (1942) stated that the alkaline hematin and Wong's iron method did not agree at all, the discrepancy averaging 2.4 gm. percent. Rimington (1943) stated that blood and hemoglobin gave 30 percent more color than an equivalent amount of hemin. He believed it was due to the formation of compounds with denatured globin which might be expected to have spectra absorption quantitatively different from that of pure hemin in alkali. Collier (1944) stated that Clegg and King's method for the standardization of alkaline hematin against pure hemin (crystalline hemin in N/10 NaOH), was unreliable; that the absorption spectra of the alkaline hematin from hemoglobin and hemin diverge. Horecker (1946) stated that more stable standard solutions resulted by using N/10 borate buffer (pH 9.4) in place of N/10 NaOH for dissolving the crystalline hemin. These standards had absorption spectra more closely resembling the spectrum of alkaline hematin prepared for whole blood.

It has been noted that the determination of hemoglobin remains one of the most unsatisfactory of all analytical procedures. This fact is surprising, in that this determination is one of the most widely used of the blood tests.

The above discussion may help to explain some of the results found in the hemoglobin determinations in this study. Diurnal variations of about 11 percent were reported by McCarthy and Van Slyke (1939); however, since the subjects gave the samples of blood at approximately the same time each day, these variations do not enter into this study. Since the effect of menstruation on the blood values was not definitely known, no definite average rate of increase or decrease can be ascribed to this physiological function. Peters and Van Slyke (1931) stated that vigorous exercise may cause an increase in hemoglobin concentration which may exceed 20 percent. This is partially due to a decrease in plasma volume, and hence, a greater percentage of hemoglobin. Long continued exercise in untrained subjects may lead to destruction of some of the red cells, which may be followed by a stimulation of bone marrow and production of a large number of red cells to replace those destroyed. The red cells may swell and thus diminish the cell: volume ratio, known as the volume index, and the hemoglobin becomes diluted. The two control subjects in this experiment spent part of the experimental period in the Home Management House of the University, which means that household chores had to be carried on in addition to classwork and studies. Just how much effect this additional exercise had on the hemoglobin value and the cell count is difficult to state, but it may be a factor sufficiently important to consider. The variations just discussed should be considered in evaluating the results of this experiment. Some workers believe that many of these variations were due to the uncertain methods of analysis, while still others think that numerous variations do exist.

Disregarding temporarily any possible variations which might have occurred, it was interesting to note that after the first week of consuming the seafood diet, the four experimental subjects showed an increase in hemoglobin and red cell count, while those for the controls remained fairly constant in both respects.

In general, the data for the entire experiment showed a surprisingly close correlation of the food intake and the blood levels between the controls and the subjects on the test diet. The trend shown was that the blood values increased until April 23 to 30 and then made a gradual, but consistent decrease until the values were approximately near the starting level. Subjects I, II, and III consumed an average of 21.7 percent, while Subject IV consumed 27.5 percent of the protein as seafood.

Table 7 shows the average weekly consumption of the food nutrients consumed by the six subjects. The trend shown for each of these nutrients coincided very well with the data for blood constituents; that is, the consumption remained on a comparatively higher level until April 23 to 30, after which there was a lower level of food intake. The higher consumption during the first weeks of the experiment might have been due to the fact the subjects were more conscious and careful of their diets. One explanation of the decreased food intake at the end might be that the adequacy of the diet became more lax as the novelty of the experiment decreased. Contrary to some experiments, the subjects seemed to enjoy the test diet during the entire period but complained of gaining in weight.

Although the normal blood levels for young women are not agreed upon, the more recent observations (Osgood and Haskins, 1927; Myers and Eddy, 1935; Ohlson, et al, 1944 and Arens, 1945) show that the normal range for hemoglobin is 13.0 to 13.6 gm. per 100 ml. blood. The packed cell volume was found to be 40.0 to 41.8 percent by Ohlson, et al (1944), while reported normal red cell counts ranged from 4.56 to 4.80 million cells per cubic millimeter (Osgood and Haskins, 1927, and Ohlson, et al, 1944). Several of these recent studies were made with a larger number of subjects and therefore were more likely to be of average value than some of the earlier observations. The data obtained show that the blood levels in this experiment came within these ranges.

Summary and Conclusions: The effect of seafood upon certain blood values was studied in six college women ranging in age from 19 to 24 years. Two of the subjects served as controls, and consumed a free-choice diet; the remaining four were the experimental subjects and received the seafood regimen, which consisted of a daily noon meal including some type of seafood. The experiment was divided into three periods; an initial period of three weeks, the test period of seven weeks, and a final period of one week. A free-choice diet was consumed by all during the first and third periods. During the second period the two subjects who acted as controls continued with the free-choice diet, while the other four subjects consumed a free-choice diet except for one meal daily which included some type of seafood. Subjects I, II, and III decreased, but did not exclude meat protein, while Subject IV consumed only the seafood diet during the test period. All consumed some dairy products.

Dietary records were kept by the six subjects of all food and drink taken during the entire experiment and from these records, the consumption of protein, calcium, iron, vitamin A, thiamine, riboflavin, niacin, ascorbic acid, and the number of calories were calculated. The nutrients supplied by the seafood were calculated separately.

A sample of blood was taken by venipuncture from six subjects once each week during the experiment. Hemoglobin and hematocrit determinations, as well as red cell counts were made on each sample. The alkaline hematin method was used to measure the hemoglobin, while the standard methods for red cell counts and hematocrit determinations were used. Color, saturation, and volume indices were calculated from the blood values but these indices did not show significant results.

There was an increase in the cell count and hemoglobin level of the four subjects who consumed the seafood after the first week on the experimental diet, while no significant change was noted for the controls. In the case of Subject IV the seafood protein maintained the blood levels equally as well as for the other subjects who consumed at least some meat protein. The seafood supplied from 20 percent to 27 percent of the protein during the test period.

The dietary intake of the different nutrients by the six subjects was compared with the blood values and there appeared to be a rather close over-all correlation. This was true for the control subjects as well as for those on the test diet. The general trend seemed to be for an increase in the blood values until April 23 to 30, after which there was a gradual, but consistent decrease. The average intake of nutrients increased and decreased approximately the same as the blood values.

Table 7 - The Mean Food Intake of the Six Subjects

Date	Calories	Protein	Calcium	Iron	Vitamin A	Thiamine	Riboflavin	Niacin	Ascorbic Acid
	Total	Total	Total	Total	Total	Total	Total	Total	Total
		gm.	gm.	mg.	I. U.	mg.	mg.	mg.	mg.
March 12-19	2,353	81.8	1.24	16.2	10,777	1.62	2.63	14.7	149
19-26	2,245	79.0	1.14	16.6	10,959	1.71	2.48	14.9	158
26-2	2,358	80.7	1.22	17.1	12,155	1.67	2.64	14.7	173
April 2-9	2,071	82.0	1.24	15.3	10,804	1.37	2.42	15.8	135
9-16	2,143	79.0	1.14	13.5	11,754	1.31	2.07	12.2	138
16-23	2,073	84.0	1.04	15.2	9,348	1.47	2.10	12.6	139
23-30	2,011	78.6	1.01	13.2	9,091	1.30	2.05	11.8	145
May 30-7	1,981	73.4	0.95	13.9	6,512	1.31	2.33	12.1	148
7-14	1,944	71.3	1.11	14.1	9,024	1.21	1.98	10.0	132
14-21	1,950	73.8	1.08	14.3	8,231	1.26	2.16	11.0	152
21-28	1,932	72.5	0.97	12.9	8,209	1.23	1.99	11.9	120

The data indicatedthat a diet containing a daily portion of seafood could maintain the red blood count, cell volume and hemoglobin values of the blood, as well as a free-choice diet containing an equivalent amount of meat. This study indicated that the intake of seafood assisted in regulating the formation of several blood constituents. The effect of such physiological variables as exercise and menstruation, as well as specific difference in the nutritive value of the seafood itself cannot be determined except through further experimental work.

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