VITAMIN CONTENT OF FISHERY BYPRODUCTS

Part 3 - Riboflavin, Nicotinic Acid, Vitamin B_{12}, Moisture, Oil, Ash, and Protein Content of Commercial Fish Meals

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ABSTRACT

Samples of commercial fish meals prepared from herring, mackerel, menhaden, sardine, and tuna were assayed for their content of riboflavin, nicotinic acid, vitamin B_{12}, protein, moisture, ash, and oil. The results of these assays are reported in six tables.

INTRODUCTION

In recent years the nutritive factors present in fish meal have received increased attention from both producers and consumers. Actually, the true value of the product is based upon these ingredients--both known and unknown--even though the price of the meal is based upon the crude protein content. One example of this interest occurs among those feed manufacturers who utilize the vitamin content of fish meal as one of the vitamin sources in their feed mixes. They are at a disadvantage, however, because little information has been published on the vitamin content of fish meals.

Fig. 1 - The weighing of samples before the vitamins are extracted for their quantitative determination by microbiological assays.

To increase the existing knowledge of the nutritive ingredients in fish meal, the Service's Seattle Technological Laboratory therefore undertook to survey fishery byproducts for some of their nutritional factors, including proximate composition and content of three members of the vitamin B complex.

Information needed by the users of fish meal includes (1) an indication of the variability of the vitamin content of fish meals; (2) the range of values for the different kinds of meal; (3) whether a range can be established for a particular kind of meal and, if so, what percentage of the meals will fall outside the range; (4) whether a knowledge of the history of the meals will help to determine if the meals will come within the range; (5) whether having high values for one vitamin indicates high values for all of the vitamins; and (6) the variation in the content of protein, moisture, oil, and ash in the meals.

An extended survey of products on the commercial market has been necessary to answer these questions. Thus, this project has been carried out over a period of several years, and the results are being published in a series of papers. The first paper reported the effect of processing methods on the content of riboflavin, nicotinic acid, and vitamin B12 in solubles and meal (Karrick and Stansby 1954). The second paper reported the content of these vitamins in visceral organs of albacore

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tuna (Germo alalunga) and of sardine (Sardinops caerulea) (Karrick 1955). This paper reports the results of vitamin and proximate analyses on the principal kinds of fish meals produced commercially in the United States. Fish meal samples whose history, method of production, and sampling procedure usually were known were analyzed for their content of riboflavin, nicotinic acid, and vitamin B_{12} as well as for their content of moisture, oil, protein, and ash. The vitamins are among those that are important in animal nutrition. Analyses for nicotinic acid were specifically requested by the American Feed Manufacturers' Association. The vitamin B_{12} results were also of major interest to both producers and users of fish meal.

To encourage the production of a more uniform product, the California Hay, Grain and Feed Dealers Association has suggested a code for fish meal (Anonymous 1951) that includes recommendations on the protein, fat, and moisture content. They recommend (1) that the protein content of individual bags of meal within a lot should not vary over a range greater than 5 pounds per 100 pounds of meal; (2) that the moisture content should be from 6 to 10 percent; and (3) that the fat content should be between 5 and 10 percent, and preferably not more than 8 percent. Producers of fish meals are interested in the comparison of the analyses of their meals with these recommendations as well as how much variation occurs both within a lot and among different lots. The proximate compositions of the samples of fish meal were determined in order to check both whether they fall within the recommended ranges and what variation occurred in them.

SAMPLES

The samples analyzed for this project were commercially-prepared meals and were obtained from two sources: testing laboratories and the plants where the meals were processed. Most of the samples obtained from the testing laboratories were representative of carload lots, although the tuna and the mackerel samples represented from 500 to 1,000 100-pound bags. The remaining samples varied in the amounts of meal represented. The majority of these remaining samples were representative of 100-pound bags of meal, but a few were random samples that cannot be considered representative of any amount of meal other than the size of the sample, which was usually 2 to 3 pounds. There were a few samples that represented large batches of unknown size. When the results of the analyses were being evaluated, a sample representing a large batch of meal was given more weight than was a sample representing only itself or a 100-pound bag. This method of evaluation is not meant to imply that samples of a 100-pound bag were analyzed as a substitute for samples from larger batches of meal; rather, the samples from the small amounts of meal were analyzed to determine the variability of fish meal from bag to bag and within lots.

As complete a history as possible was obtained for each sample to help to evaluate the results of the analyses. This history, whenever possible, included the following:

1. Species of fish.
2. Location of the catch.
3. Storage history of the raw material.
4. Condition of the raw material when processed.
5. Portion of the fish processed.
6. Methods used for cooking, pressing, and drying the raw material.
7. Storage history of the meal.

After samples of the meals were obtained, they were stored in glass jars at 0° F. until analyzed. Before the assays were started, the meals were ground as fine as possible in an attrition-type laboratory mill.

ASSAY METHODS

The meal samples were assayed microbiologically for their content of riboflavin, nicotinic acid, and vitamin B_{12}. Riboflavin and nicotinic acid were determined by a modification of the method of Roberts and Snell (1946). Vitamin B_{12} was determined by a modification of the method of Hoffman, Stokstad, Hutchings, Dornbush, and Jukes (1949).

Riboflavin and nicotinic acid were extracted from the meals by incubating 1-gram samples with papain and takadiastase in a pH 4.6 buffer at 37° C. for 16 hours. The samples then were neutralized, filtered, diluted, and assayed. Vitamin B_{12} was extracted by autoclaving 1-gram samples for 5 minutes at 15 pounds pressure with about 25 milliliters of water and 0.025 grams of sodium bisulfite. The samples then were filtered, diluted, and assayed.

In all of the assays, the samples were run in duplicate at four different concentrations, and the growth of the organism produced by the sample was measured by titration of the acid formed. The amount of vitamin present was determined by comparison with the growth produced by known amounts of the vitamin.

The content of protein, moisture, oil, and ash in the products was determined using standard techniques of the Association of Official Agricultural Chemists (1950).

HERRING MEALS

The results of the analyses of 29 herring meals for their proximate composition and content of riboflavin, nicotinic acid, and vitamin B_{12} are reported in table 1.

Table 1 - Analyses of Herring-Meal Samples Representing Large Batches 1/ of Meal

Type of Drier	Date Processed 2/	Proximate Composition 3/				Vitamin Content (Moisture- and Oil-Free Basis)		
		Protein	Moisture	Oil	Ash	Riboflavin	Nicotinic Acid	Vitamin B12
		(Percent)				(Micrograms Per Gram)		
Direct-heat	1/5/53	68.1	7.8	11.6	11.1	6.4	71	0.40
	1/5/53	68.2	8.3	11.9	11.1	7.6	70	0.39
	1/27/53	69.9	7.8	11.3	10.9	8.2	57	0.34
	1/27/53	69.1	8.6	11.5	11.2	8.9	61	0.33
	2/24/53	60.9	7.1	20.2	10.7	4.3	57	0.26
		67.9	7.5	11.8	10.8	7.3	47	0.37
	2/26/53	71.4	8.0	11.5	11.5	7.8	81	0.36
		71.1	6.7	11.5	11.6	8.7	75	0.37
	7/21/53	69.2	8.0	14.3	10.1	8.9	99	0.52
		74.2	7.9	13.6	10.0	8.1	98	0.52
		68.9	8.3	13.7	9.6	8.5	102	0.48
		69.0	7.7	14.5	9.2	8.9	103	0.50
	8/12/53	70.5	7.2	11.4	10.0	7.8	100	0.47
		70.7	6.8	11.6	9.8	7.4	101	0.44
	8/31/53	68.3	8.3	12.9	9.7	7.5	103	0.40
		70.2	8.0	13.6	9.5	7.7	104	0.45
		70.3	7.9	12.2	10.0	7.7	99	0.43
		69.9	7.7	11.8	-	7.5	105	0.43
		69.6	7.9	12.3	-	7.9	108	0.44

1/ The amount of meal represented by the samples was carload lots.
2/ Meals processed by the same company are grouped together.
3. Protein and ash determinations reported in this table were made by the feed control laboratory of the Bureau of Field Crops of the State of California Department of Agriculture.

The 29 meals were processed during 1953 in Alaska or British Columbia from whole fish. Meals processed by the same company are grouped together in the table. Information concerning the details of methods used to dry these meals was not avail-

able; however, all of the processing plants used direct-heat driers. The exact amounts represented by each sample were not known, but the samples were all from large composite batches of herring meal representing thousands of pounds of product.

The range covered by the values for proximate composition was less than a first glance at table 1 would indicate. One of the samples was unusually high in oil and low in protein. If this sample were not included, the range in proximate composition would be as follows: protein, from 67.9 to 74.2 percent; moisture, from 6.7 to 8.6 percent; oil, from 9.6 to 14.5 percent. The amount of oil is the only one of these results that is not within the recommendations in the suggested code for fish meal (Anonymous 1951).

The same sample that had the unusual proximate composition had a lower vitamin content than did the other samples. It contained the least riboflavin and vitamin B_{12} and the next to least nicotinic acid. The range in vitamin content of the meals would be changed very little, however, if this meal were not included. The vitamin content of the samples of herring meals was determined as micrograms of vitamin per gram of meal on a moisture- and oil-free basis. The values ranged from 4.3 to 8.9 for riboflavin, from 47 to 108 for nicotinic acid, and from 0.26 to 0.52 for vitamin B_{12}. For all three vitamins, the maximum value was at least twice the minimum value.

MACKEREL MEAL

The results of the analyses for proximate composition and vitamin content of 12 samples of mackerel meal manufactured in California are reported in table 2. Four

Table 2 - Analyses of Mackerel-Meal Samples

Type of Drier	Amount of Meal Repr. by Sample	Date Processed 1/	Proximate Composition				Vitamin Content (Moisture- and Oil-Free Basis)		
			Protein	Moisture	Oil	Ash	Riboflavin	Nicotinic Acid	Vitamin B_{12}
	Bags		(Percent)				(Micrograms Per Gram)		
Steam-tube	1	11/10/50	62.8	9.7	7.3	18.6	5.5	62	0.40
			66.3	9.0	6.7	19.1	5.6	62	0.41
			63.6	10.4	6.9	16.8	6.8	71	0.49
Direct-heat	1	1/29/51	60.2	9.7	10.9	-	5.3	70	0.32
	624	7/14/53	59.8	5.6	12.4	21.0	5.4	70	0.24
	500	8/13/53	61.4	6.5	12.4	18.9	6.1	75	0.30
Modified direct-heat	600	6/29/53	57.1	7.8	9.3	22.1	4.9	120	0.23
		7/13/53	55.6	7.4	10.2	23.7	4.2	112	0.24
		7/23/53	54.1	6.7	11.3	23.2	3.8	93	0.20
		7/20/53	59.7	7.6	11.2	19.4	7.0	142	0.23
		7/24/53	60.6	7.7	9.8	19.6	6.5	137	0.23
		8/7/53	60.6	6.8	8.7	20.3	6.6	139	0.24
Minimum 2/			54.1	5.6	8.7	18.9	3.8	70	0.20
Average 2/			58.6	7.0	10.7	21.0	5.6	111	0.24
Maximum 2/			61.4	7.8	12.4	23.7	7.0	142	0.30
Standard deviation			2.65	0.76	1.38	1.78	1.18	28.8	0.028

1/Meals processed by the same company are grouped together.
2/Only the analyses of samples representing large batches of meal were included in these calculations.

of these samples were each representative of one 100-pound bag. The other eight samples were representative of 500 to 624 100-pound bags. In the computation of averages and of standard deviation, the samples representing one bag could not be considered equal to those samples representing 600 bags. Thus the four samples of individual bags were not included in these calculations. It is interesting to note that, for most of the analyses, the samples of individual bags fall outside of the range

found for the samples of large lots. The four individual bags of meal were processed in a different year. Three of these meals were dried in a steam-tube drier, but since none of the other 12 samples were dried in this way, no comparisons can be made. The fourth meal was prepared in a direct-heat drier by a company that had processed two of the large batches of meal. The composition of these three meals that were dried by direct heat was quite similar.

For none of the samples could any correlation be established between the composition of the meal and the type of drier used for processing the meal. The oil content of 5 out of the 8 samples representing large batches of meal were higher than that recommended in the suggested code for fish meal.

MENHADEN MEAL

Analyses for 23 samples of menhaden meals are reported in table 3. These were random samples not representative of any particular amount of meal. The meals were processed by 16 different companies and those processed by the same company are grouped together. Since only 2 samples were not dried in a direct-heat drier, no conclusions can be made about the effect of other types of driers.

Table 3 - Analyses of Menhaden-Meal Samples [1/]

Type of Drier	Date Processed [2/]	Proximate Composition				Vitamin Content (Moisture- and Oil-Free Basis)		
		Protein	Moisture	Oil	Ash	Riboflavin	Nicotinic Acid	Vitamin B_{12}
		(Percent)				(Micrograms Per Gram)		
Direct-heat	6/12/51	60.3	9.2	7.8	20.6	4.0	59	0.19
	8/14/51	59.3	9.2	8.5	-	4.0	64	0.17
	No Date	57.4	9.8	10.4	21.8	4.4	65	0.20
	6/12/51	59.1	9.4	9.0	18.9	4.4	61	0.23
	8/27/51	54.9	7.2	13.2	23.0	4.0	42	0.25
	No Date	50.1	9.1	10.7	25.6	3.7	50	0.21
	6/12/51	59.2	10.2	7.8	20.1	4.2	52	0.23
	8/27/51	59.7	8.4	9.7	19.7	3.6	57	0.18
	10/17/51	57.7	8.6	9.8	22.4	4.4	62	0.19
	6/13/51	59.9	8.1	7.5	22.9	3.0	55	0.08
	8/14/51	60.9	9.5	6.8	19.5	4.1	56	0.19
	8/27/51	57.5	8.1	12.5	20.6	4.7	72	0.21
	8/15/51	60.3	8.4	8.5	20.8	4.0	54	0.19
	9/7/51	58.1	9.4	9.8	19.8	4.2	67	0.32
	9/16/51	62.4	9.9	12.5	15.9	3.7	91	0.23
	9/18/51	61.9	8.6	11.4	18.8	3.0	80	0.18
	9/17/51	62.3	10.8	8.1	19.4	3.0	91	0.15
	9/20/51	58.9	8.9	10.1	21.4	3.0	79	0.15
		53.4	8.9	13.5	24.4	2.6	71	0.12
	11/16/51	57.6	10.4	8.6	20.0	4.8	62	0.17
	8/52	60.6	9.2	8.3	21.5	4.1	64	0.20
Hot Air	8/14/51	60.1	8.7	9.3	21.0	3.9	81	0.09
Steam	11/16/51	59.0	10.4	7.5	21.5	4.4	68	0.19
Minimum		50.1	7.2	6.8	15.9	2.6	42	0.08
Average		58.7	9.2	9.6	20.9	3.9	65	0.19
Maximum		62.4	10.8	13.5	25.6	4.8	91	0.32
Std. deviation		2.78	0.86	1.91	2.05	0.60	12.6	0.046

1/ These samples were taken at random and are not representative of any given amount of meal.
2/ The samples obtained from the same company are grouped together.

Standard deviations and ranges calculated for the different ingredients indicated that there was not an unusual number of extreme values. This observation is of interest because greater individual variation might be expected from random samples of meals. The moisture contents were in general, within the recommendations suggested in the code for fish meal (Anonymous 1951). The oil contents, however, tended to be high and the protein contents varied more than the recommended 5 percent.

SARDINE MEALS

The results of the analyses of sardine meals are reported in table 4. All of the samples were representative of large batches. The meals which were produced in

Table 4 - Analyses of Sardine-Meal Samples Representing Large Batches of Meal

Type of Drier	Amount of Meal Repr. by Sample	Date Processed[1]	Proximate Composition				Vitamin Content (Moisture- and Oil-Free Basis)		
			Protein	Moisture	Oil	Ash	Riboflavin	Nicotinic Acid	Vitamin B_{12}
			(Percent)				(Micrograms Per Gram)		
Air-lift	Carload	10/13/50	59.4	9.9	7.4	20.8	4.2	73	0.23
		11/3/50	60.0	10.6	7.6	21.0	5.0	75	0.23
	1 day's production	11/14/50	53.6	13.3	7.0	-	2.6	42	0.22
Direct-heat	Carload	10/4/50	57.7	7.5	7.0	22.7	4.3	73	0.24
		10/14/50	59.0	7.7	7.3	21.8	5.0	82	0.29
			59.3	7.9	8.0	20.9	5.8	96	0.37
		10/4/50	59.8	7.0	8.5	21.0	5.4	85	0.23
		11/3/50	58.1	6.4	9.7	22.4	5.4	87	0.25
		10/6/50	59.6	7.7	9.3	17.0	5.8	89	0.26
		10/14/50	62.2	8.2	7.5	17.8	5.7	98	0.29
		10/6/50	57.4	8.7	7.5	22.9	5.0	66	0.22
		10/21/50	57.4	10.6	8.2	22.9	5.9	81	0.26
		11/1/50	56.6	10.6	7.7	23.8	5.3	69	0.23
		10/12/50	58.1	6.1	7.0	23.3	4.2	61	0.20
		11/4/50	58.6	8.3	7.3	22.7	4.7	69	0.26
		11/8/50	55.6	8.9	10.8	21.5	6.2	87	0.29
		10/13/50	65.2	3.9	7.4	18.8	5.0	93	0.29
		10/13/50	62.1	7.4	7.2	19.5	5.2	94	0.27
		10/20/50	66.9	7.8	7.1	14.8	7.2	115	0.33
		10/31/50	64.8	7.1	8.5	18.5	6.0	107	0.27
Modified direct-heat	1 day's production	11/14/50	57.2	7.5	7.9	-	3.8	80	0.24
Steam-tube	Carload	11/3/50	69.4	10.2	7.1	12.8	6.6	125	0.38
Unknown	Carload	10/13/50	60.2	8.8	8.0	18.7	5.4	89	0.31
		10/20/50	59.3	8.4	7.2	21.6	5.6	84	0.32
		11/3/50	63.2	4.8	8.8	-	4.7	74	0.24
Minimum			53.6	3.9	7.0	12.8	2.6	42	0.20
Average			60.0	8.2	7.9	20.3	5.2	84	0.27
Maximum			69.4	13.3	10.8	23.8	7.2	125	0.38
Standard deviation			3.66	1.98	0.95	2.85	1.0	17.4	0.046

1/Meals processed by the same company are grouped together.

1950 are classified according to the type of drier in which they were dried: airlift, steam-tube, modified direct-heat, or direct-heat drier.

The protein contents of the samples had a range of 16 percent. The moisture contents of five of the samples were above the recommended upper limit of 10 percent (10.6, 13.3, 10.6, and 10.2 percent), and those of two samples were below the recommended lower limit of 6 percent (3.9 and 4.8 percent). Except for one value of 10.8 percent, the oil contents of the samples were within the recommended limits.

The contents of all three of the vitamins covered a wide range, with values from 2.6 to 7.2 micrograms per gram of moisture- and oil-free material for riboflavin, 42 to 125 for nicotinic acid, and 0.22 to 0.38 for vitamin B_{12}. Despite this wide variation in actual values, however, only a comparatively few samples had extreme values. It might be noted that in two samples the analyses of the vitamin content showed high results for all three vitamins. One of the batches of meal represented by the samples had been dried by a steam-tube drier and the other by a direct-heat drier. With the knowledge available, however, there is no way to ascertain why the vitamin content of these meals was higher than that of the other meals.

TUNA MEALS

Table 5 reports results on 14 samples of tuna meals, all of which were representative of large lots of meal. The kind of tuna used in the preparation of these

Table 5 - Analyses of Tuna-Meal Samples Representing Large Batches of Meal

Type of Drier	Amount of Meal Repr. by Sample	Date Processed 1/	Proximate Composition				Vitamin Content (Moisture- and Oil-Free Basis)		
			Protein	Moisture	Oil	Ash	Riboflavin	Nicotinic Acid	Vitamin B_{12}
	Bags		(Percent)				(Micrograms Per Gram)		
Direct-heat	360	7/8/53	60.3	5.2	11.4	18.6	4.8	117	0.23
	870	7/20/53	56.7	5.0	12.5	22.2	4.9	107	0.22
	600	7/30/53	60.3	4.6	14.2	17.4	5.4	136	0.24
	1065	8/13/53	57.0	5.7	14.3	19.6	6.0	121	0.27
Modified direct-heat	600	6/30/53	60.5	5.0	11.8	19.7	6.6	93	0.25
		7/13/53	60.9	5.2	12.4	20.3	7.2	97	0.30
		8/8/53	58.1	6.3	13.7	20.0	7.3	145	0.33
		7/14/53	59.6	6.6	10.6	-	6.6	178	0.30
		7/27/53	58.3	9.3	9.8	19.1	5.6	120	0.26
		8/3/53	55.4	8.8	13.3	-	6.6	150	0.27
		8/7/53	55.3	8.8	12.1	20.6	5.5	126	0.27
		8/10/53	55.1	7.8	11.4	21.8	5.5	127	0.22
		8/12/53	59.3	7.8	10.4	19.8	6.3	136	0.28
Steam-tube	Carload	11/3/50	61.7	5.9	11.4	18.0	7.3	174	0.26
Minimum			55.1	4.6	9.8	17.4	4.8	93	0.22
Average			58.5	6.6	12.1	19.8	6.1	131	0.27
Maximum			61.7	9.3	14.3	22.2	7.3	178	0.33
Standard deviation			2.24	1.62	1.4	1.40	0.96	25.2	0.32

1/Meals processed by the same company are grouped together.

meals is unknown. With one exception, the meals were processed during the summer of 1953. One meal was dried by steam-tube drier, nine were dried by a modified direct-heat drier, and four by a direct-heat drier. The samples processed by the same company are grouped together.

Probably the most significant observations can be made by comparing the range covered by the samples reported in table 5 with that covered by those reported in table 6. The samples in table 6 are representative of individual 100-pound bags and, as such, would be expected to cover a wider range than would the samples representative of larger amounts. The amount of material represented by the samples reported in table 6 is 22 100-pound bags of meal as compared with more than 8,000 100-pound bags represented by the samples in table 5. This means that the results reported in table 6 are applicable only to the bags reported there. The fact that the results in table 6 cover a wider range than do those in table 5, however, indicates that there are wide differences among individual bags.

The individual differences in table 6 are of particular interest because all but two of the samples were dried by the same type of drier--a steam-tube drier. In the case of these samples, the kind of tuna scrap that was used to prepare the meals is also known, and 16 of the 22 samples were from the same kind of tuna and were processed on the same day. It is interesting to note that, of the three groups of samples prepared by the same type of drier, the analyses within a group are essentially the same, although the results of the groups do differ. The exception to this is

the moisture content of the 12 meals produced from 50-percent skipjack and 50-percent yellowfin scrap.

Table 6 - Analyses of Tuna-Meal Samples Representing Single 100-Pound Bags of Meal

Type of Drier	Raw Material	Date Processed 1/	Proximate Composition			Vitamin Content (Moisture - and Oil-Free Basis)		
			Protein	Moisture	Oil	Riboflavin	Nicotinic Acid	Vitamin B_{12}
			(Percent)			(Micrograms Per Gram)		
Steam-tube	50 percent skipjack 2/	11/7/50	62.9	8.1	8.9	6.7	120	0.26
			63.8	8.6	8.4	6.8	123	0.26
	50 percent yellowfin 3/ scrap		64.7	9.3	7.1	6.6	126	0.28
			64.1	9.6	7.4	6.3	135	0.29
		11/15/50	66.6	3.6	9.8	8.3	157	0.35
			66.0	5.4	9.5	7.9	159	0.39
			65.4	6.2	10.2	8.0	165	0.41
			66.3	3.2	9.7	8.1	157	0.37
			66.5	4.4	9.8	7.6	150	0.40
			66.3	4.2	9.7	7.6	156	0.39
			65.4	5.3	9.4	7.8	155	0.36
			65.6	6.5	9.1	7.6	162	0.37
			65.4	6.3	9.0	7.8	164	0.37
			65.3	5.4	9.2	7.9	153	0.37
			65.3	5.5	9.1	8.1	162	0.39
			65.6	4.8	9.3	8.2	158	0.35
	Albacore 4/ scrap	9/15/50	52.9	6.3	13.3	6.8	166	0.29
			54.6	6.0	13.8	7.2	171	0.29
			54.0	8.8	11.7	6.6	169	0.30
	Mixed tuna scrap	11/14/50	67.2	8.3	8.7	6.4	201	0.27
Direct-heat	Skipjack 2/ scrap	12/28/50	52.5	9.3	11.0	6.4	142	0.34
	Yellowfin 3/ scrap	11/31/51	-	14.4	8.0	4.2	67	0.22
Minimum			52.2	3.2	7.1	4.2	67	0.22
Average			63.2	6.8	9.6	7.2	151	0.33
Maximum			67.2	14.4	13.8	8.3	201	0.41
Standard deviation			4.91	2.57	1.64	0.95	25.9	0.055

1/Meals processed by the same company are grouped together.
2/Katsuwonus pelamis.
3/Neothunnus macropterus.
4/Germo alalunga.

DISCUSSION

The data collected on a large number of fish meals gave no indication that any correlation existed between the results of proximate analyses and of vitamin analyses and the methods used to process the meals. This lack of correlation would indicate that any differences in analytical results that may occur due to processing methods are either concealed or compensated for by other factors. An important point to be made, however, is that no biological tests were made on these meals. Thus, from the data reported here, it is not possible to say how important processing methods may be in determining the biological value of the meals. It also is not possible to determine whether any correlation exists between the analytical results and the over-all nutritive value of the meals.

When an attempt was made to correlate analytical results of fish meals from different species, only meals representing large quantities of meal were included

because the use of large batches of meals would tend to give average results, or at least to avoid extreme values. Consequently, this discussion will include only the data in tables 1, 2, 4, and 5. These data are on samples representative of large amounts of meal.

The data on the proximate analyses can be compared with the recommendations for fish meal suggested by the California Hay, Grain, and Feed Dealers Association (Anonymous 1951). The code recommends that moisture be between 6 and 10 percent and oil between 5 and 10 percent.

In moisture content, all of the herring meals were within the recommended range. One of the mackerel meals was low (5.6 percent); one of the sardine meals was low (3.9 percent); and seven of the tuna meals were low (5.2, 5.0, 4.6, 5.7, 5.0, 5.2, and 5.9). Five of the sardine meals were high (10.6, 13.3, 10.6, 10.6, and 10.2), and none of the others were high.

In oil content, none of the meals were below the recommended range. Most of the herring meals were high, the average being 12.0 percent. Five out of eight mackerel meals were high. The average, however, was only 10.7 percent. One of the sardine meals was above the recommended range, and it was only 10.8 percent. Most of the tuna meals were high, with the average being 12.1 percent.

The recommendation on protein was concerned with variability among the bags in a batch of meal and did not recommend a definite amount. Among the meals analyzed the mackerel, sardine, and tuna meals averaged close to 60 percent. The herring meal averaged nearly 70 percent.

If the data on the amount of each of the vitamins in the large batches of meal are combined, the variation in the moisture- and oil-free meals was as follows: riboflavin ranged from 2.6 to 8.9 micrograms per gram, nicotinic acid ranged from 42 to 178 micrograms per gram, and vitamin B_{12} ranged from 0.20 to 0.52 micrograms per gram. Thus the maxima ranged from about 2.5 to 4 times that of the minima.

The herring meals, in general, had higher contents of both riboflavin and vitamin B_{12}. The tuna meals generally ranged higher in nicotinic acid. These results again indicate that fish meals are variable in their contents of nutritive factors and suggest that much work remains to be done before a standard product can be obtained. In the meantime, much of the information needed by the users of fish meal must be determined on the individual batches of meal. The large variations obtained in the vitamin analyses indicate that the variations are due to complex factors and that no one phase in the production of fish meal will yield the complete solution to the manufacture of a standard product.

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LITERATURE CITED

Anonymous
1951. Suggested Code for Fish Meal. Commercial Fisheries Review, vol. 13, no. 11a (November Supplement), pp. 34-35.

Association of Official Agricultural Chemists
1950. Official Methods of Analysis. Seventh edition, Association of Official Agricultural Chemists, P. O. Box 540, Benjamin Franklin Station, Washington 4, D. C., pp. 296-297, 346.

Hoffmann, C. E.; Stokstad, E. L. R.; Hutchings, B. L.; Dornbush, A. C.; and Jukes, T. H.
1949. The Microbiological Assay of Vitamin B_{12} with Lactobacillus leichmannii. Journal of Biological Chemistry, vol. 181, no. 2 (December), pp. 635-644.

Karrick, N. L.
1955. Vitamin Content of Fishery Byproducts. Part 2 - Vitamin B_{12} in Pacific Sardine (Sardinops caerulea) Organs and Riboflavin, Nicotinic Acid, and Vitamin B_{12} in Albacore Tuna (Germo alalunga) Organs. Commercial Fisheries Review, vol. 17, no. 2 (February), pp. 8-11.

Karrick, N. L., and Stansby, M. E.
1955. Vitamin Content of Fishery Byproducts. Part 1 - Effect of Processing Methods on Riboflavin, Nicotinic Acid, and Vitamin B_{12} Content of Solubles and Meal. Commercial Fisheries Review, vol. 16, no. 2 (February), pp.7-10.

Roberts, E. C., and Snell, E. E.
1946. An Improved Medium for Microbiological Assays with Lactobacillus casei. Journal of Biological Chemistry, vol. 163, no. 2 (May), pp. 499-509.

PARTIAL LIST OF REFERENCES ON THE UNIDENTIFIED GROWTH FACTORS IN FISHERY PRODUCTS

The purpose of this list is to aid in the search for unidentified factors in fishery products.

To limit the list strictly to the subject indicated in the title, however, would largely defeat its purpose, for the elucidation of the growth factors in these fishery products has involved much work with the so-called animal protein factor, vitamin B_{12}, and antibiotics. Furthermore, the rate of progress has been determined in no small part by the adequacy of the available assay methods. It was therefore felt that these other subjects should be included.

The list was prepared almost exclusively from articles appearing in the journal called Commercial Fisheries Abstracts. Inasmuch as this journal covers only 73 periodicals largely published in the United States, undoubtedly many important references, especially those in the foreign literature, have been omitted. It is for this reason that the word "partial" appears in the title.

Progress in the field of unknown growth factors has been so rapid that the significance of many of the articles is lost unless consideration is given to the time at which the work was done. Therefore, in order that the historical perspective be maintained, the references are listed chronologically. The list is divided in five sections as follows: (1) Animal Protein Factors. (2) Vitamin B_{12}, (3) Antibiotics, (4) Methods of Assay, and (5) Unidentified Growth Factors. A limited supply of the list is available for research workers and students in the field of fishery technology and may be obtained by writing to the author (F. Bruce Sanford) at the Fishery Technological Laboratory, Branch of Commercial Fisheries, U. S. Fish and Wildlife Service, 2725 Montlake Blvd., Seattle 2, Wash.