COMPOSITION OF SHARK MEAL[1]

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INTRODUCTION

Shark meal, a livestock feedstuff high in crude protein content, has been produced in Florida and along the Pacific seaboard in increasing quantities during the past 7 years. This product has proved to be an excellent protein supplement in rations for growing dairy calves (*12*),[3] chicks (*13*), and growing-fattening swine (*14*). Analyses previously reported for shark meal (table 1) show it to be high in crude protein, calcium, and phosphorus. Assays for all of the constituents commonly determined in routine feedstuff analyses have not been reported for any single sample of shark meal.

French[4] stated that shark meal contains some urea nitrogen, which, when calculated as crude protein ($N \times 6.25$), gives a value for the nitrogenous constituents that is excessive. Rhian, Carver, Harrison, and Hamm (*16*) found from 0.09 to 4.37 percent of urea in eight samples of meal made from dogfish sharks. Analyses of these samples by a procedure for determing urea and ammoniacal nitrogen (*3, p. 79*), but omitting the urease, yielded what Rhian et al. termed "nitrogen fraction B" in amounts ranging from 0.35 to 3.55 percent.

Shipments of shark meal received in paraffined containers and paper parcels at the Florida Agricultural Experiment Station had a strong fishy odor in which it was thought that ammonia could be detected. Any loss of nitrogen as ammonia would indicate the presence of it or a precursor in the meal. To acquire more comprehensive information on the composition of shark meal, routine feedstuff analyses were made on 19 samples and spectrographic analyses for the presence of 33 elements were made on the ash of 12. A study was also made of the nature and amounts of nonprotein nitrogen present, and samples were assayed for urease activity.

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[3] Italic numbers in parentheses refer to Literature Cited, p. 218.

[4] French, R. M. Private communication to R. B. Becker, 1942.

TABLE 1.—*Composition of shark-meal samples as reported by different investigators*

Investigator	Processing method	Kind of shark	Analyses							
			Water	Crude protein	Ether extract	Crude fiber	Ash	Ca	P	Chlorine
			Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Rhian, Carver, Harrison, and Hamm (*16*).	Wet	Dogfish	5.0	67.3	20.8	------	------	3.14	2.01	------
	do	do	4.0	67.2	21.8	------	10.0	2.29	1.77	------
	Dry	do	5.0	77.3	13.3	------	13.3	2.33	1.87	------
	do	do	11.0	78.5	8.4	------	11.1	1.76	1.52	------
	do	do	10.5	77.2	7.1	------	11.4	1.94	1.75	------
Evans, Carver, and Hamm (*5*).	Wet	do	3.7	70.8	17.9	------	9.1	2.30	1.62	------
	do	do	4.5	73.2	17.4	------	9.9	2.52	1.73	------
	do	do	3.4	70.2	20.8	------	9.7	2.38	1.69	------
	Dry	do	7.5	82.1	10.5	------	11.0	2.15	1.74	------
French [1]	Wet	Unknown	10.6	82.4	6.3	1.2	10.1	------	1.50	0.46
	do	do	4.8	85.7	.9	.9	14.2	------	------	------
	do	do	8.4	85.6	1.0	1.0	13.3	------	------	.03
	do	do	5.1	87.0	1.2	1.8	10.1	------	------	------
	do	do	7.6	78.9	1.4	.9	11.0	------	------	------
	do	do	8.3	80.6	------	------	------	------	------	------
Almquist (*1*)	Unknown	do	------	74.0	------	------	------	------	------	------
	do	do	------	81.1	------	------	------	------	------	------
Grau and Almquist (*7*)	do	do	------	64.3	------	------	------	------	------	------

[1] French, R. M. Private communication to R. B. Becker, 1944.

MATERIAL AND METHODS

Nineteen samples of commercial shark meal manufactured by a wet-processing method (*14*) from sharks caught off the Florida coast during January, February, and March were available for analyses. Moisture, crude protein (N X 6.25), ether extract, crude fiber, ash, and calcium were determined according to the A. O. A. C. (*2*) methods for grain and stock-feed analyses. The phosphorus was determined by the method of Fiske and Subbarow (*6*). Magnesium was determined essentially by the method of Handy (*10*) except that HCl was used and bromcresol green replaced methyl red as the indicator. Nitrogen-free extract was calculated according to the method described by Morrison (*15*). Seventeen of these samples were analyzed for urea by Griem's modification (*8*) of the Griem and Walker method (*9*). Check determinations omitting the urease also were made simultaneously on these samples and the nitrogen values obtained are designated herein as nitrogen fraction A.

Twelve samples of shark meal were analyzed for the presence of 33 elements by the rough estimate method (*17*), using a Littrow type spectrograph. These samples were prepared for analysis by weighing 6 gm. of shark meal into a glazed silica evaporating dish and ashing at temperatures not exceeding 450° C. in a muffle furnace with concealed heating elements. The silica dishes had been leached previously for 24 hours in a mixture of 1 part of HCl, 1 part of HNO_3, and 4 parts of water which had been redistilled in a pyrex glass apparatus. The ash of each sample was placed in a glass bottle, which was sealed with a paper-lined screw top, and transferred to the spectrographic laboratory for analysis.

Tests were made for urease activity on five samples of shark meal. The apparatus used was essentially as described by Hawk and Bergeim (*11*).

Two grams of shark meal, 0.1 gm. of urea, 10 ml. of Clark's (4) phosphate buffer solution (pH 6.8), and 150 ml. of water that had been redistilled in a pyrex glass apparatus were placed in a large cylinder which then was stoppered tightly. These materials had been stored previously at a temperature of 40°±1° C. and, after mixing, were incubated at this temperature for 1 hour. Air then was aspirated through this material into 0.1 N HCl for 15 minutes and the excess acid titrated with 0.1 N NaOH. A blank determination with urea omitted was run simultaneously with the assay of each sample.

To study certain changes which might be associated with a loss of nitrogen by volatilization, nitrogen fraction A, urea, pH (using a glass electrode), and moisture were determined on five samples within a few days after processing and again after exposure to the atmosphere for 70 days of storage. The samples were prepared for storage by placing approximately 150 gm. of shark meal in a 400-ml. pyrex glass beaker which then was covered with eight thicknesses of cheesecloth, and set in a room where contamination would be avoided.

EXPERIMENTAL RESULTS

The averages of the analyses for 19 samples of shark meal were: Moisture 9.18 percent, crude protein 78.07, ether extract 2.80, crude fiber 0.32, ash 13.97, calcium 3.48, phosphorus 1.92, and magnesium 0.17 percent. Since the sum of the ingredients for which analyses were made exceeded 100 percent in most cases, calculation of the nitrogen-free extract by difference gave values for only 3 of the samples. Seventeen of these samples contained an average of 1.75 percent of urea and 0.49 percent of nitrogen fraction A. Analyses of each sample together with average and standard error (*18*) are presented in table 2.

TABLE 2.—*Composition of shark-meal samples with average and standard error*

Sample No.	Water	Crude protein	Ether extract	Crude fiber	Nitrogen-free extract	Ash	Ca	P	Mg	Urea	Nitrogen fraction A
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1	5.80	83.06	0.12	0.28	1.34	9.40	2.42	1.69	0.16	-------	-------
2	10.94	82.56	1.58	.37	0	11.66	2.90	1.52	.27	-------	-------
3	14.95	70.85	4.21	.32	0	13.24	3.19	1.76	.22	1.72	0.490
4	15.34	63.25	3.96	.20	0	19.03	5.24	2.92	.33	1.05	.765
5	14.53	66.04	4.02	.33	0	17.93	4.97	2.60	.25	1.32	.625
6	14.55	68.35	4.09	.19	0	16.46	4.39	2.48	.28	1.48	.680
7	13.83	80.90	4.70	.26	0	16.03	4.33	2.40	.28	1.44	.670
8	7.23	82.12	2.19	.43	0	15.75	3.19	1.72	.13	3.35	.325
9	9.91	87.48	2.78	.17	0	11.28	2.52	1.50	.15	1.25	.465
10	10.04	70.35	4.19	.22	3.49	11.71	2.84	1.60	.20	1.85	.405
11	3.14	79.94	6.44	.20	0	13.76	3.10	1.72	.19	2.51	.365
12	7.58	82.02	2.22	.30	0	12.80	2.57	1.52	.19	.94	.410
13	11.23	77.44	.98	.50	0	14.69	3.89	1.80	.07	2.06	.460
14	4.77	85.50	1.64	.26	0	13.86	3.09	1.76	.06	2.49	.445
15	7.66	82.50	1.39	.57	0	11.97	2.79	1.52	.04	3.16	.270
16	6.36	78.69	.94	.32	0	15.08	3.53	2.04	.06	1.27	.430
17	3.99	88.19	2.48	.45	0	10.85	3.06	1.76	.09	2.00	.495
18	6.49	73.13	2.42	.33	.79	16.84	4.14	2.36	.18	.40	.560
19	6.13	80.94	2.81	.33	0	13.06	3.95	1.76	.06	1.49	.415
Average	9.18	78.07	2.80	.32	-------	13.97	3.48	1.92	.17	1.75	.487
Standard error	±.91	±1.67	±.36	±.025	-------	±.59	±.19	±.10	±.02	±.19	±.102

The results of the spectrographic analyses on 12 samples of shark meal are presented in table 3. Calcium, phosphorus, sodium, magnesium, silicon, iron, strontium, manganese, zinc, lead, copper, boron, and barium were found in all of the samples. Tin was found in 8 samples, nickel in 3, and chromium in 2. Seventeen of the elements either were absent or present in quantities below the sensitivity range of the method.

TABLE 3.—*Elements detected in shark-meal samples by spectrographic analyses, using the rough estimate method* [1]

(Air-dry basis)

Element [2]	Sample No. 3	4	8	9	10	11	12	13	14	20	21	22	Average
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Ca	3.4000	4.9550	3.0240	3.0250	1.2830	1.3870	3.1520	3.7320	2.3040	5.3140	4.3850	2.4020	3.1970
P	1.7000	1.9800	3.0240	1.2100	1.2830	1.3870	1.5760	1.8660	1.1520	2.6570	1.7540	1.2010	1.7330
Na	.3400	.5946	.1814	.2420	.2566	.2774	.4728	.3732	.3456	.1594	.3508	.3603	.3303
Mg	.3400	.3964	.6048	.2420	.2566	.4161	.3152	.5598	.1152	.5314	.3508	.2402	.3640
Si	.1700	.1982	.0605	.1210	.0385	.0832	.1576	.1120	.1152	.0797	.1052	.0721	.1094
Fe	.0170	.0198	.0302	.0121	.0128	.0139	.0158	.0187	.0115	.0266	.0175	.0120	.0173
Sr	.0170	.0198	.0302	.0121	.0128	.0139	.0158	.0187	.0115	.0053	.0175	.0120	.0156
Mn	.0005	.0012	.0302	.0363	.0008	.0077	.0009	.0037	.0069	.0008	.0011	.0036	.0078
Zn	.0017	.0059	.0302	.0121	.0128	.0028	.0016	.0112	.0115	.0027	.0018	.0072	.0085
Pb	.0010	.0198	.0030	.0007	.0008	.0008	.0009	.0011	.0007	.0016	.0011	.0007	.0027
Cu	.0010	.0012	.0091	.0007	.0004	.0008	.0009	.0011	.0007	.0016	.0011	.0007	.0016
B	.0005	.0006	.0009	.0004	.0004	.0004	.0005	.0006	.0003	.0008	.0005	.0004	.0005
Ba	.0002	.0002	.0006	.0002	.0003	.0003	.0002	.0002	.0001	.0003	.0002	.0001	.0002
Sn	0	0	.0003	.0001	.0001	.0001	.0002	.0002	.0001	0	0	.0001	------
Ni	0	0	.0003	0	0	0	0	0	.0001	0	0	.0001	------
Cr	0	0	0	0	0	0	0	0	.0001	0	0	.0001	------

[1] The values given indicate that the quantity of a given element is estimated to lie within a range of from one-half to twice the figure given.

[2] Other elements not found in any sample by this method and their lower limits of detectability expressed as percent of the ash are: As, 0.1; Li, 0.03; W and Y, 0.02; Hg, 0.01; Cd, 0.003; and V, La, Co, Zr, Ti, Mo, Be, Bi, Sb, Ge, and Au, each 0.001.

No urease activity was observed in any of the five samples of shark meal tested for the presence of this enzyme.

Some of the nitrogen fraction A was lost during storage from each of the five samples tested. The average value for this fraction on freshly processed samples was 0.394 percent; after 70 days storage it was 0.309 percent when calculated on the basis of the original moisture content. There was no loss of urea during this study. The average

TABLE 4.—*Effect of exposing shark meal to the atmosphere during 70 days of storage on nitrogen fraction A, urea, and hydrogen-ion concentration*

Sample No.	Nitrogen fraction A			Urea			pH		
	Freshly processed	After exposure	Effect of exposure	Freshly processed	After exposure	Effect of exposure	Freshly processed	After exposure	Effect of exposure
	Percent	*Percent*		*Percent*	*Percent*		*Percent*	*Percent*	
8	0.325	0.251	−0.074	3.35	3.36	+0.01	6.05	5.95	−0.10
9	.465	.398	−.067	1.25	1.27	+.02	5.86	5.75	−.11
10	.405	.243	−.162	1.85	1.86	+.01	5.80	5.70	−.10
11	.365	.309	−.056	2.51	2.50	−.01	5.94	5.82	−.12
12	.410	.343	−.067	.94	.95	+.01	5.92	5.80	−.12
Average	.394	.309	−.085	1.98	1.99	+.01	5.91	5.80	−.11

pH of 5.91 for the freshly processed samples decreased to 5.80 during the exposure period. The effect of exposure of shark meal to the atmosphere for 70 days on nitrogen fraction A, urea, and pH is shown in table 4.

DISCUSSION

The total for the percentages of water, crude protein, crude fiber, ether extract, and ash exceeded 100 in many instances, probably because of the inclusion of nitrogen from nonprotein sources in the calculation of crude protein.

The proportion of skeletal material to flesh in the samples was responsible largely for the variation in mineral content and influenced inversely the percentage of crude protein. In the processing of shark meal (*14*) there was little mixing of the material to produce a uniform product. Shark meal is hygroscopic and its moisture content is increased by exposure to a humid atmosphere. Samples 3 through 7, inclusive, were received during very humid weather. The moistureproof bags in which they were shipped were damaged badly during transit and the material had absorbed considerable moisture, as indicated by the analyses (table 2).

The elements determined by the spectrographic method represent those present in the shark-meal samples after they were prepared for analysis. Contamination with some elements possibly could have resulted from contact with the equipment used in the commercial processing of shark meal and in preparation of the samples. The rough-estimate method of determination indicated a range within which the quantity of an element was estimated to lie. The range was from one-half to twice the figure given. This accounted for much of the variation reported in the composition of the samples.

Urease activity of shark-meal origin was not observed, nor was it expected since the product had been subjected to high temperatures during processing (*14*). However, if a large bacterial population were present and conditions were favorable for their growth, urease activity might occur since it has been found (*19*) that many species of bacteria produce this enzyme. Waksman and Davison (*20*) reported that some fungi also possess urease activity.

SUMMARY

The averages of the analyses of 19 samples of shark meal were: Water 9.18, crude protein 78.07, ether extract 2.80, crude fiber 0.32, ash 13.97, calcium 3.48, phosphorus 1.92, and magnesium 0.17 percent. Seventeen of the shark-meal samples averaged 1.75 percent urea and 0.49 percent nitrogen fraction A.

Spectrographic analyses for 33 elements on 12 shark-meal samples showed calcium, phosphorus, sodium, magnesium, silicon, iron, strontium, manganese, zinc, lead, copper, boron, and barium to be present in all samples. Tin was detected in 8 of the samples, nickel in 3, and chromium in 2.

In the 5 samples of shark meal tested for urease activity, none was observed.

The exposure of 5 samples of shark meal to the atmosphere for 70

days did not effect the urea content but resulted in a small loss of nitrogen fraction A and a slight increase in the hydrogen-ion concentration.

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