Studies on the Biochemical Composition of some Freshwater Fishes

I — MUSCLE

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[Twenty five different species belonging to 16 genera of freshwater fishes were analysed for protein, fat, moisture, ash, carbohydrate, phosphorus, calcium and total iron content in their muscle. Calorific value for protein, fat, and carbohydrate fractions and total calories for each species were also calculated.]

Introduction

Fish is known to be the best and cheapest source of animal protein of very high digestibility and nutritive value. A large volume of work on the chemical composition of fish has appeared from many countries of the world. Notable references are those of Atwater, 1888 ; Clark and Almy, 1918 ; Dill, 1921 ; Jowett and Davies, 1938 ; Sulit *et al.*, 1954 ; Idler and Bitners, 1958 ; Love *et al.*, 1959 ; Mannan *et al.*, 1961 ; and Borgstrom, 1961. In India also some interesting information on the chenical composition and nutritive value of important freshwater fishes is available from Bengal, Bihar, South India, Maharashtra and Gujarat (Basu and De, 1938 ; Saha and Guha, 1939 & 1940 ; Mitra and Mittra, 1941 ; Airan, 1950 ; Natarajan and Sreenivasan, 1961 ; and Bhatt *et al.*, 1962). Investigations on similar lines have also been carried out on marine fishes from the coastal waters off Bombay and Madras (Niyogi *et al.*, 1941; Setna *et al.*, 1944; and Chari, 1948). However, no systematic investigations have so far been made on the nutritive value and chemical composition of the freshwater fishes from the northern part of the country. The present communication which deals with the chemical composition and nutritive value of the flesh of the common freshwater fishes of Uttar Pradesh brought to light many new facts and it was found that the earlier information available was far too meagre and in some cases rather unsatisfactory.

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Experimental Procedure

Fishes were obtained from the Aligarh fish market. Care was taken to ensure that all fishes used for various analyses were in fresh condition. In each species, individuals of a definite size range were selected and their length and weight noted. For obtaining a sample of flesh, five or more specimens of large-sized fishes were taken and in small fishes even a larger number was essential. Muscle from the rear portion of the trunk region of each fish was carefully removed so as to eliminate all bony elements. It was then macerated and processed for various estimations. For each estimation, duplicate samples of muscle were taken which each gave two or more readings. All investigations were carried out in the months of November and December, '63 so as to avoid seasonal differences in the chemical composition and thus making a comparison in between various species as fair as possible.

Protein content was estimated by slightly modifying Wong's (1923) micro-kjeldahl method. The sample was digested in 1 : 1 sulphuric acid and then nesslerized. The colour was compared in a Klett-summerson photoelectric colorimeter. The amount of nitrogen obtained was then multiplied by the protein factor (6.25) to get the value of protein (Alexander, 1956).

Total fat was estimated by extracting a known amount of sample in a soxhlet for about 10 - 12 hours using petroleum ether (B.P. 40 - 60°C) as a solvent.

Moisture percentage was determined by taking a weighed sample of muscle in a silica crucible and then drying it to a constant weight in an electrical oven running at 100°C. This usually took 14 - 16 hours.

For the estimation of ash, another weighed sample was ignited in a silica crucible and then reweighed. Calcium and phosphorus were estimated according to the techniques given by Clark and Collip (1925) and Fiske and SubbaRow (1925) respectively. Estimation of total iron (ferric) was done by the method of Kennedy (1927).

Results

Protein : Protein content of all the species under investigation varied from 20.625 to 12.340% (Table 1). Among the various species analysed, the murrels had the highest protein value, the average being 18.851%. The values of *Ophicephalus punctatus* and *Ophicephalus striatus* obtained in the present investigation was higher than those reported from Bengal (Saha and Guha, 1939).

Carps came next in their protein content after murrels. They had, on an average, a value of about 16%. Among the carps, the mahseer, *Barbus* (*Tor*) *putitora* had the highest protein percentage (19.370%). *Cirrhina mrigala*, *Labeo rohita* and *Labeo gonius* with 18.745, 17.185 and 17.810 percentages respectively were the other carps rich in protein. The values obtained for *L. rohita* was higher than that reported by Saha and Guha (1939 & 1940) from Bengal and was more or less similar to the value given by Mitra (as referred by Kuppuswamy et al., 1958) for the same species from Bihar. The value of *C. mrigala* was also more or less similar to those reported from the other parts of

India (Saha and Guha, 1939 and Natarajan and Sreenivasan, 1961). The poorest protein content among the carps was found in *Labeo bata* (Table 1).

The cat-fishes were generally poor in protein content except for a few species like *Clarias magur* and *Rita rita* where the values were high (18.750 & 18.595% respectively). Others were relatively poor and the lowest values were recorded in *Callichrous pabda* and *Callichrous bimaculatus*.

The feather-back, *Notopterus notopterus* had 18.280% protein. This was significantly higher than the protein value of the other closely related species, *Notopterus chitala*. The mullet, *Mugil corsula* was found to have a fairly high protein value (17.687%) and the spiny-eel, *Mastacembelus armatus* showed a value of 17.340%.

Fat : The fat content showed an inverse relationship with that of protein i. e. fishes with a minimum protein percentage had the maximum percentage of fat. Thus the murrels whose protein percentage was found to be the highest had the lowest fat percentage, the average being 0.373% only (Table 1).

In general, the carps were found to have relatively low fat content. The maximum fat percentages, however, among the carps, were recorded in *Barbus stigma*, *B. sarana* *B.* (*Tor*) *putitora*. In *L. rohita*, *C. mrigala* and *Catla catla* the values were more or less similar and the lowest was obtained in *L. gonius* (Table 1).

The cat-fishes which were poorest in protein content were found to be the richest in fat. Fishes like *Mystus seenghala*, *Mystus aor*, *Bagarius bagarius* and *Rita rita* which, among the cat-fishes, were relatively rich in protein had low fat percentages. The highest fat content was found in *Pseudeutropius garua* and the lowest in *M. seenghala*.

The mullet, *M. corsula* and the feather-backs, *N. notopterus* and *N. chitala* were found to be fairly rich in fat and in the spiny-eel, *M. armatus* the fat content was very high (Table 1).

It is interesting to note that the amount of fat present in fishes is more or less group specific. Species which are closely related systematically have similar fat values. A comparison of the figures obtained in the present investigation with those of earlier authors on the same species showed marked differences. Fat in fishes is known to be one of the most variable constituents of the body (Venkataraman and Chari, 1951). As will be shown later, in the same species, the fat varies greatly from one season to the other and according to the size of the fish. It is, therefore, likely that the differences in figures reported by the earlier authors might have been because of the size of the fish or the season in which the analysis was made.

Moisture : The moisture percentage of different fishes varied from 73.215 to 81.170 (Table 1). In several earlier investigations it has been pointed out that moisture has an inverse relationship with the fat content (Brandes, 1954 and Brandes and Dietrich, 1958). However, in the present investigation no such relationship could be established in general (Table 1).

Ash : The values obtained for the ash content in the muscle varied within a very narrow range of 0.946 — 1.673% and fell in accordance with the values reported earlier (Saha and Guha, 1939 & 1940 ; Alexander, 1955 and Natarajan and Sreenivasan, 1961).

Carbohydrate: An approximate estimate of carbohydrate percentage in the muscle was made by subtracting the added values of fat, protein, moisture and ash from 100. The average carbohydrate percentage in the muscle of all the species examined came to about 3%. There was no general pattern in the carbohydrate distribution in various species (Table 1).

Phosphorus : Phosphorus content of the muscle varied from 0.300 to 0.975% on fresh weight basis and in most fishes it fell within the range of 0.300 to 0.390% (see Table 1). In general a higher percentage of phosphorus was accompanied with a higher percentage of fat. Thus the maximum (0.975%) was obtained in the spiny-eel, *M. armatus* which had a high fat content (3.400%). The cat-fishes with a rich fat content were also rich in phosphorus (average 0.408%). This probably indicates that the presence of phosphorus in the muscle is associated with lipids, presumably in the form of phospholipids.

Calcium : The percentage of calcium in the muscle of all the fishes examined varied from 0.012 to 0.075 on fresh weight basis (Table 1). On an average, the feather-backs were found to contain the maximum calcium (0.047%). The next fishes were the carps. Among the carps the highest percentage of calcium (0.075%) was noted in the common barbel, *B. stigma*. The mahseer, *B.* (*Tor*) *putitora* had the lowest calcium percentage (0.012%). The spiny-eel with a calcium percentage of 0.022 came next to carps. The mullet had 0.018% calcium. The cat-fishes on an average were rather poor in the calcium content. Among the cat-fishes the highest value (0.043%) was noted in *C. magur*. Murrels with an average value of (0.015%) were the poorest in calcium.

Iron : Values obtained for the total iron (ferric) content varied over wide limits. They ranged from 13.000 to 51.250 mg. per 100 gm. of fresh tissue (Table 1). The highest value was found in the spiny-eel, *M. armatus*. Murrels on an average had a higher iron content than the carps. The mullet, feather-backs and cat-fishes had relatively low values. Natarajan and Sreenivasan (1961) while giving the iron contents of various species from Bhavanisagar quote surprisingly high values. In our opinion the data given by them have either been misprinted or the authors in expressing the values have overlooked the units.

Calorific value : Rubner's table as given by Durve and Bal (1961) was used for calculating the total calorific values of different fractions in various species. The energy factors used were 9.3 for fat and 4.1 for protein and carbohydrate. The calorific value of all the fishes analysed ranged from 77.663 to 145.975 calories per 100 gm. of fresh tissues (Table 2). On an average the highest values were found in cat-fishes. These were because of the high fat content present in them. The mullet, murrels and feather-backs had relatively low values and the lowest values were found in carps.

Energy values for protein fraction were highest in murrels (average 77.291 calories). Values for mullet, feather-backs and spiny-eel were more or less similar. Carps and cat-fishes had comparatively low values.

TABLE I — The relative values of biochemical

	SPECIES	Local Name	No. of fishes analysed	Average length (cm)	Average weight (gm)	Protein %
	CARPS					
1.	Cirrhina mrigala (*Ham.*) ...	Mrigal	10	43.8	858.0	18.745
2.	Catla catla (*Ham.*) ...	Catla	5	49.9	2221.8	14.060
3.	Labeo rohita (*Ham.*) ...	Rohu	8	52.0	1336.4	17.185
4.	Labeo calbasu (*Ham.*) ...	Kalmonch	9	34.1	512.3	14.995
5.	Labeo bata (*Ham.*) ...	Bata	5	35.2	474.8	14.060
6.	Labeo gonius (*Ham.*) ...	Keli	6	34.6	448.3	17.810
7.	Barbus sarana (*Ham.*) ...	Puthi	13	27.2	291.8	14.370
8.	Barbus stigma (*Cuv. & Val.*)	Bhoor	30	7.4	6.5	14.215
9.	Barbus (Tor.) putitora (*Ham.*) ...	Mahseer	5	53.5	1813.3	19.370
	CAT - FISHES					
10.	Mystus seenghala (*Skyes*) ...	Seenghara	10	62.4	1281.6	15.935
11.	Mystus aor (*Ham.*) ...	Jhabaria	8	67.2	1143.7	15.780
12.	Bagarius bagarius (*Ham.*) ...	Gonch	5	71.3	2260.8	15.465
13.	Rita rita (*Ham.*) ...	Gomna	5	43.2	986.1	18.595
14.	Pseudeutropius garua (*Ham.*)	Bichua	5	36.5	411.3	14.680
15.	Wallagonia attu (*Bloch*) ...	Lanchi	9	67.2	1717.4	15.625
16.	Callichrous pabda (*Ham.*) ...	Pabda	40	12.4	15.4	12.340
17.	Callichrous bimaculatus (*Bloch*) ...	Pabda	60	19.0	44.4	14.370
18.	Clarias magur (*L.*) ...	Magur	45	19.4	68.7	18.750
	MURRELS					
19.	Ophicephalus punctatus *Bloch* ...	Soli	65	18.1	78.2	20.625
20.	Ophicephalus striatus *Bloch* ...	Sol-dharidar	5	50.2	1260.5	18.435
21.	Ophicephalus marulius *Ham.* ...	Sol-guldar	5	53.6	1278.0	17.495
	FEATHER - BACKS					
22.	Notopterus notopterus (*Pallas*) ...	Chital	6	34.3	366.2	18.280
23.	Notopterus chitala (*Ham.*) ..	Chital	6	45.7	618.6	16.720
	MULLET					
24.	Mugil corsula (*Ham.*) ...	Andwari	5	37.3	481.4	17.687
	SPINY - EEL					
25.	Mastacembelus armatus (*Lacep.*) ...	Bam	7	57.9	410.6	17.340

constituents in the muscle of freshwater fishes

Fat %	Moisture %	Dry matter %	Ash %	Carbohy-drate %	Phos-phorus %	Calcium %	Total Iron (ic)
0.518	77.042	22.958	1.268	2.427	0.326	0.022	27.500
0.753	78.476	21.524	1.268	5.443	0.331	0.020	20.000
0.401	78.375	21.625	1.021	3.018	0.341	0.023	28.750
0.228	78.608	21.392	1.363	4.806	0.375	0.022	20.620
0.231	78.558	21.442	1.600	5.551	0.360	0.032	20.000
0.125	79.543	20.457	1.673	0.849	0.332	0.030	13 000
1.194	77.433	22.567	1.403	5.600	0.390	0.029	45.000
1.300	79.194	20.806	1.098	4.193	0.307	0.075	21.250
1.146	77.984	22.016	1.320	0.180	0.390	0.012	22.500
0.220	75.526	24.474	1.220	7.099	0.315	0.012	25.000
0.489	78.941	21.059	1.165	3.625	0.300	0.013	22.500
0.254	78.678	21.322	1.332	4.271	0.322	0.015	27.500
0.388	78.756	21.244	1.186	1.075	0.355	0.015	25.000
7.995	73.215	26.785	1.321	2.789	0.410	0.016	23.750
2.979	77.718	22.282	1.188	2.490	0.900	0.015	20.000
1.466	81.170	18.830	0.946	4.078	0.322	0.030	20.250
2.585	77.178	22.822	1.194	4.673	0.375	0.031	25.000
0.443	77.806	22.196	1.369	1.632	0.375	0.043	25.000
0.370	76.431	23.569	1.431	1.143	0.300	0.015	30.000
0.388	76.403	23.597	1.284	3.490	0.315	0.015	35.000
0.362	77.484	22.516	1.287	3.372	0.311	0.015	26.250
1.318	77.151	22.849	1.266	1.985	0.330	0.054	22.500
1.471	79.241	20.759	1.097	1.471	0.375	0.040	21.500
0.706	77.210	22.790	1.090	3.307	0.360	0.018	25.000
3.400	75.118	24.882	1.460	2.682	0.975	0.022	51.250

TABLE II — Calorific values of different fracti ons of the muscle of freshwater fishes

	SPECIES		PROTEIN Calories per 100 gm. of fresh muscle	FAT Calories per 100 gm. of fresh muscle	CARBOHYDRATE Calories per 100 gm. of fresh muscle	TOTAL CALORIES per 100 gm. of fresh muscle	CALORIE RANGE
	CARPS						
1.	Cirrhina mrigala	...	76.854	4.817	9.950	91.621	
2.	Catla catla	...	57.646	7.002	22.316	86.964	
3.	Labeo rohita	...	70.458	3.729	12.373	86.560	
4.	Labeo calbasu	...	61.479	2.120	19.704	83.303	
5.	Labeo bata	...	57.646	2.148	22.759	82.553	78–97
6.	Labeo gonius	...	73.021	1.162	3.480	77.663	
7.	Barbus sarana	...	58.917	11.104	22.960	92.981	
8.	Barbus stigma	...	58.281	12.090	17.191	87.562	
9.	Barbus (Tor) putitora	...	79.417	10.657	7.380	97.454	
	CAT-FISHES						
10.	Mystus seenghala	...	65.333	2.046	9.105	96.484	
11.	Mystus aor	...	64.698	4.547	14.862	84.107	
12.	Bagarius bagarius	...	63.406	2.362	17.511	83.279	
13.	Rita rita	...	76.239	3.608	4.407	84 254	
14.	Pseudeutropius garua	...	60.188	74.353	11.434	145 975	81–146
15.	Wallagonia attu	...	64.062	27.704	10.209	101.975	
16.	Callichrous pabda	...	50.594	13 633	16.719	80.946	
17.	Callichrous bimaculatus	...	58.917	24.040	19.159	102.116	
18.	Clarias magur	...	76.875	4.119	6.691	87.685	
	MURRELS						
19.	Ophicephalus punctatus	...	84.562	3.441	4.686	92.689	
20.	Ophicephalus striatus	...	75.583	3.608	14 309	93.500	89–94
21.	Ophicephalus marulius	...	71.729	3.366	13.825	88.920	
	FEATHER-BACKS						
22.	Notopterus notopterus	...	74.948	12.257	8.138	95.343	
23.	Notopterus chitala	...	68.552	13.680	6.031	88.263	88–95
	MULLET						
24.	Mugil corsula	...	72.516	6.565	13.558	92.639	
	SPINY-EEL						
25.	Mastacembelus armatus	...	71.094	31.620	10.996	113.710	

For fat fraction the highest value was noted in the cat-fish, *P. garua* (74.353 calories). The spiny-eel, *M. armatus* with a value of 31.620 calories recorded the next highest. The average values for carps, mullet and feather-backs were 6.092, 6.565 and 12.968 calories respectively. The lowest value (3.471 calories) was recorded in murrels.

The average energy value for the carbohydrate fraction in the muscle was highest in carps and cat-fishes (15.345 and 14.455 calories respectively). *M. corsula* was next with a value of 13.558 calories. Murrels and spiny-eel only had average values and the lowest values were obtained in the feather-backs.

Discussion

It is well known that the biochemical composition of fish varies considerably from species to species. Variations have also been noted among the individuals of the same species. Many workers have attributed these variations to some such factors as sexual development, time of spawning, age, season and feeding conditions (Bruce, 1924 ; Lovern and Wood, 1937 ; Wilson, 1939 ; Hart et al., 1940 ; Arevalo, 1949 ; Venkataraman and Chari, 1951). In many species the data obtained in the present investigation did not agree with those of the earlier workers on the same forms. In most of the earlier accounts nothing has been said about the size of the fish or the season during which the estimations were made. However, observations of Saha and Guha (1939 & 1940) and Natarajan and Sreenivasan (1961) indicate that the variations in various constituents of fish might well be attributed to the change in season during which the investigations were made. In the absence of suitable information it is difficult to ascertain whether variations obtained in fishes of Uttar Pradesh from those of the other parts of the country are because of seasonal or environmental differences. To arrive at a fair comparison of the chemical composition of any fish, detailed work on a seasonal basis from different parts of the country is required.

Summary

From twenty five different species belonging to 16 genera of freshwater fishes analysed for protein, fat, moisture, ash, carbohydrate, phosphorus, calcium and total iron content of their muscle and calorific value for protein, fat and carbohydrate fractions and total calories for each species, the murrels were found to have the highest protein value and the cat-fishes the poorest. In carps the protein value was next to murrels. The total fat content in practically all the species showed an inverse relationship with protein. On this basis the cat-fishes with low protein had the highest fat content and conversely, murrels with a high protein content had the lowest values of fat.

The moisture and ash contents in various species did not differ markedly. Carbohydrate content was generally high in carps and cat-fishes and low in murrels.

A high phosphorus content was found to be associated with a high fat content and for this reason the cat-fishes tended to show relatively high phosphorus values. Calcium content was found to be the highest in feather-backs and the total iron content was

highest in the spiny-eel. In terms of total calorific value, from among the popular food fishes, the cat-fishes because of being rich in fat content gave the highest values. The murrels were the next and the carps only gave average values.

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