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From the viewpoint of human and animal nutrition the fishes are an important and abundant animal protein food. Since ages man has relished and adored fish meat. Paintings of fish and frequent references made to them in the records of the ancient human civilisation are met with. Since the dawn of civilisation a section of human population, specially the dwellers of coastal areas have caught and traded fish for a living. Many a times in human history various nations have taken to fishing as a profession.

Research on the biochemistry of fishes is almost a century old. An impetus to research of the biochemistry of fishes occurred during World War I. Most studies were conducted on vitamin A and D content of the fish muscle. The ravages of World War II destroyed the vast resources of protein food in many countries making the prices of the food beyond the buying capacity of an average family. Because of this condition dietitians and nutritionists started searching for a substitute food rich in food value and yet cheap in prices. Ultimately fish was discovered as a good source of food having rich food value yet inexpensive. This stimulated the early systematic investigations on the fish biochemistry.

Fishes are utilised chiefly as a food, primarily for human consumption, but to a lesser extent in the nutrition of animals as well. A knowledge of chemical composition with
respect to nutritive value is important in order that the fish can compete with other sources of animal protein foods such as meat and poultry products. Such information is important to the fishing industry in advertising its products. Chemical composition is also a subject of importance to the housewives since different fish cookery methods are applicable to species of widely different composition in processing for human consumption. Similarly, in the storage of frozen fish a great deal of difficulty that may be encountered will depend upon the nature and extent of the oils present in the flesh especially with respect to their susceptibility to oxidation. In canning and drying of the fish, the knowledge of carbohydrate is essential for its presence even in minute amount may result in browning (Maillard reaction between sugars and proteins). When fish waste is processed into meal and oil, the selection of the most suitable processing technique will depend to a large extent upon the oil content of the raw material. Need for special precautions in the processing will depend upon the content of the various unstable constituents such as certain of the vitamins, and unless some knowledge of chemical composition is available an incomplete recovery of such substances may be obtained. The nitrogenous extractives of fish muscle which consist of ammonia and trimethylammonium bases, guanidine and imidazol derivatives, and miscellaneous substances such as urea, amino acids, purines and pyrimidines are of significance from the point of preservation and processing of fish. These substances probably influence the potential keeping quality
and appear to contribute to the flavour of the fish. The nature and concentration of their decomposition products are of primary importance in deciding the edibility of the fish.

Fish contains many important substances quite aside from the main components such as protein, fat, phosphorus, moisture and ash. Some of these, to mention just a few, have been utilised in the past include vitamins, free amino acids, cholesterol, lecithin, insulin etc. Undoubtedly, a better knowledge of the composition of fish might reveal a large number of important constituents that could be recovered from fish waste which are not now utilised, and whose presence may not even be suspected. Changes in the concentration of some of the chemical constituents reflect the early changes occurring in the muscle prior to the onset of organoleptically detectable spoilage and hence are of value as tests for the quality of fish.

A great mass of data on chemical composition of fish has accumulated over a number of years. Undoubtedly the most comprehensive analyses of the chemical composition of fish ever carried out are those of Atwater (1892) who along with his students at Wesleyan University in Connecticut carried out thousands of analyses from 1880 to 1890 and reported the gross chemical composition of 53 species of American food fishes and shellfishes. He has given complete details of all the samples he had analysed, so that one can imbibe the practical significance of the results reported. In most of
his studies the numbers of fish comprising a sample was very small (sometimes only a single fish) that makes the results almost meaningless. Unfortunately, however, subsequent compilers of the data on nutritive value of food fishes have indiscriminately quoted the data of Atwater (1892) as typical for various species and many erroneous values have crept into the literature.

Clark and Almy (1918) investigated the seasonal variations in chemical composition of a large number of fishes of Atlantic coast. Another notable contribution came from Dill (1921a and 1921b) who studied the seasonal variations in biochemical composition and nutritive value of a number of fishes from California. Other noteworthy contributions regarding the chemical composition of the fishes of United States came from Stensby (1947), Kerrick et al. (1966), Teeri et al. (1967), Thurston et al. (1969), Sohn et al. (1961) and Thurston (1961 and 1962).

Biochemical studies of Canadian fishes were thoroughly made by Bailey (1942), Bailey et al. (1952), Idler and Bitners (1958, 1959 and 1960), Fraser et al. (1961), and Munnan et al. (1961a and 1961b).

Fishes of Peru were studied for their biochemical composition by Arevalo Pedilla (1962) and Castillo la Rosa Sanchez (1952).

Studies on the chemical composition of African fishes were conducted by Busson et al. (1963) and of South African cane fishes by van Wyk (1944). Similarly Egyptian food
fishes were analysed by Elsaby (1934).

Goncalves-Ferreiro (1961) analysed the chemical composition of Portuguese fish species, Carteni and Alo (1934) and Costabello (1936) of Italian food fishes and Arevelo (1948) of Spanish fishes.

Johnstone (1915, 1918a, 1918b and 1918c and 1920) made a detailed study of chemical composition of herring and other clupeoides of U.K. Lovern and Wood (1947) and Reay et al. (1943) studied the variations in chemical composition of the British marine and freshwater fishes.

Marinkovic and Zei (1959) studied the nutritive value of Yugoslavian fish flesh in relation to their ecology.

Chemical composition of USSR fishes were made by Levanidov (1950) and mineral composition by Vinogradov and Odum (1963). Vasilieva et al. (1961) studied the mineral composition in certain fish of Soviet Union and made verification of correlation between the mineral elements and protein level therein.

Japanese workers such as Kondo et al. (1941) and Kochi and Era (1959) investigated the chemical composition of Japanese fishes.

Valenzuela (1923) and Balagtas (1923) analysed a large number of Philippine fish species. Sulit et al. (1953) reported the chemical composition of 63 species of Philippine
food fishes with reference to size and different parts of the body.

Jowett and Davies (1933) studied the chemical composition of Australian fishes with respect to their nutritional and commercial importance. Their study also included seasonal variation in the chemical composition of Australian salmon and sea mullet.

In addition to those McCance and Widdowson (1946), Tylor and MacLeod (1949), Watt and Merrill (1960), Chatfield (1964) and Love et al. (1959) have compiled the analytical results of the fish chemical composition in the form of nutritive tables. Recently van der Rijst (1960) has compiled a bibliography of 436 references on the chemical composition of fishes. Other bibliographic work containing 361 references came from Congres International d'Etude Sur le Role Du Poisson Dans L'Alimentation (Anonymous 1960).

A number of official documents of fish biochemistry have also been published (FAO, 1949 and 1954; other organisation, Nilson, 1943 and United States, Stronsby, 1963 and 1964). The biochemistry of fishes was recently reviewed by Williams (1961) and Tarr (1968).

Research on the biochemistry of Indian fishes is a young science and its development is one of the country's recent scientific activities. On experimental basis research work on fisheries and on the biochemical aspects of fishes
started in Kerala and Bengal during the early part of this century. Very soon its potentialities were recognised by other states and an impetus to the biochemical research was given during the World War II when the country suffered an acute food shortage.

The earliest record on the chemical composition of Indian fishes is that of Basu and De (1938 I, II and III). Saha and Guha (1939 and 1940) investigated the chemical composition of 37 species of Bengal freshwaters. Miyogi et al. (1941) studied the chemical composition of about 18 varieties of marine fishes from Bombay coasts. Appana and Devadatta (1942) investigated the nutritive value of 4 species of Bombay and Konkan coast. Setna et al. (1944) studied the chemical composition of representative fishes from the commercial catches of the Bombay coast. Patakoot et al. (1960) also analysed about 32 species of common marine fishes from Bombay coast. Airan (1950) studied the protein and mineral composition of 7 species of Kolhapur freshwater.

Studies on similar lines have been made by Chari (1948) on the marine fishes of 'Andras coast. Natarajan and Sreenivasan (1961) studied the mineral composition of as many as 36 species of Bhavanisagar and 'ettur reservoirs of 'Andras. Sreenivasan and Natarajan (1961) reported the seasonal variations in chemical constituents of three species of Bhavanisagar reservoir.
Bhatt et al. (1962 and 1963) have reported the mineral contents of some important freshwater fishes of Gujrat and Maharashtr. Sekharan (1949 and 1956), Chidambaram et al. (1951), Venkataraman and Chari (1961 and 1963) and Vasavan et al. (1960) have investigated the seasonal variations in the chemical composition of some freshwater fishes. Giri et al. (1943) investigated the food value of fish and other marine products. Alexander (1966) studied the protein content of five species of marine and one species of freshwater fish.

Knowledge of protein fractions is as essential in nutritional studies as that of the total protein. Fractionation method of protein study is a recent one and was confined to the muscle of mammals until Reay and Kuchel (1937) applied the method of Bate-Smith (1934) to haddock muscle. On such studies important communications are those of Reay (1933), Reay and Kuchel (1937), Subba Rao (1943), Dyer et al. (1950) and Hannir (1961 and 1966 a and 1966 b). In India only Basu and De (1938 I, II and III) studied protein fractions.

Non-protein nitrogen and amino nitrogen are also useful in assessing the nutritive value of fish meat. The papers dealing with non-protein and amino nitrogen are those of Shewan and Jones (1957), Ranke et al. (1957), Fraser et al. (1961) and Mannan et al. (1961 a and 1961 b). From India notable contributions are those of Airan (1960), Velankar and Govindan (1957 and 1958), Anonymous (1962) and Siddiqui and
and Siddiqui (1968 a).

The nutritive value of fish meat and that of other meats not only depends upon the protein and its fractions or other constituents but to a greater extent to the amino acid composition of proteins. Amino acids are not only found to constitute the proteins but are found in the free state and bound to peptides. In order to evaluate fully the nutritive value of fish protein, it is desirable to establish its amino acid composition. The earliest data relating to the amino acid composition of fish muscle are furnished by the hydrolysis of the muscles of halibut by Osborne and Hoyl (1908) and Okuda and Oyama (1916). Another earlier work on the amino acids of fish flesh is that of Agren (1944). But the results of their analyses markedly deviate from recent figures and this may be due to the advent of more advanced techniques employed nowadays. Innumerable analyses of the amino acid composition of fish protein have been published since Geiger (1948), Jaquot and Creac'h (1950) and Block and Bolling (1961) presented their reviews. Available listings of Orr and Watt (1957), Harvey (1968), and Love et al. (1959) are far from complete. Notable contributions are those of Neilands et al. (1949), Connell and Howgate (1959) and Boge (1960).

Fragmentary analyses have also been made on the amino acid composition of cod (Abderhalden et al., 1936, Beach et al., 1943 and Neilands et al., 1949), haddock (Edwards et al., 1946 and Lahiry and Proctor, 1956) and Atlantic herring (Konosu et al.,
1956). The study of Pottinger and Baldwin (1946) is restricted mostly to one or several of the nutritionally important amino acids. Other such analyses came from Sekine (1921), Sekine and Akiyama (1926), Valanju and Sohonie (1967 a and 1967 b) and Venkataraman and Chari (1967).

Various types of fish proteins have been analysed for essential amino acid contents. Notable researches on such lines are those of Beach et al., (1943), Edwards et al., (1946), Pottinger and Baldwin (1940), Deas and Tarr (1949), Neilands et al. (1949), Block and Bolling (1961) and Goncalves-Ferreiro (1961).


Very little is known about the peptide bound amino acids in fish muscle and only few references (Ranke et al., 1955; Ranke, 1959 and Bramstedt and Vorzbacher, 1960) are available.

Most of the earlier studies referred to total phosphorus (Atwater, 1392 and Williams, 1897 and 1911) but the study of the phosphorus fractions in fish muscle was initiated by Tarr (1960). Distribution of phosphorus compounds in fish muscle
has been studied by Chang et al. (1960), Nakano (1960) and
Nakano and Tsuchiya (1960).

From India Bhushane Rao (1966) and Siddiqui and Siddiqui
(1966) studied the phosphorus fractions of the flesh and blood
of fish respectively.

The changes in fat and water contents in relation to
feeding and spawning have been worked out quite early by
Atwater (1892), Milroy (1903) and later by Johnstone (1915),
Clark and Almy (1918), Wimpenny (1929), Channon and Elsaby
(1932), Wilson (1939), van Wyke (1944), Lovern and Wood (1947),
Del Riego (1948), Sekharan (1949), Levanidov (1960), Chidambaram
et al. (1951), Venkataraman and Chari (1953), Kerrick
et al. (1956), McBride et al. (1959), MacLeod et al. (1960),
Dambergs (1964) and Parker and Venstone (1966).

Bruce (1924) and Tiwari and Srivastava (1962 b) have
observed the changes of fat in relation to age and growth of
the fishes.

Besides fat, crude extract and water solubles have
also been determined and the only literature on these
fractions are those of Dambergs (1959, 1963 and 1964).

Reciprocal relationship of fat and water in the muscle
was pointed out by Brandes (1954), Mikicinska (1964) and
Brandes and Dietrich (1953) and in the eggs of fishes by
Hasan and Jafri (1964).
Although literature on fish biochemistry is enormous yet in India systematic work of this nature is relatively scarce. Particularly the biochemistry of north Indian fishes has not been properly worked out. Keeping in view this fact an attempt has been made to determine the chemical composition of some common food fishes of north India.

*Ophicephalus punctatus* (Bloch), the common pond murrel, has been subjected to detailed chemical investigation. Age group studies and seasonal variation in the chemical composition of the common pond murrel has been done.

The present study is expected to make considerable addition to the existing knowledge on the chemical composition and nutritive value of some freshwater food fishes. A correlation of the chemical composition with known facts of the biomics of the fish will undoubtedly bring to light the building up and utilisation of reserves from month to month and season to season. It will also reveal the chemical changes which the muscle of the fish undergoes during its growth. Apart from the physiological and biochemical considerations an understanding of the chemical composition of fishes is also important for nutritional studies.

The present investigation covers a period of three years and the investigations carried out are presented here in the form of this thesis. The form of the presentation of the thesis is as follows:
Chapter I deals with the experimental procedures employed to determine various chemical constituents in the fish flesh.

Chapter II gives an account of the total nitrogen and protein nitrogen. Nitrogen fractions as well as protein fractions have also been studied. An attempt has also been made to confirm the already established protein nitrogen and total nitrogen (PN/TN) ratio and albumin and muscle globulin (A/G) ratio.

Chapter III reveals the study of the amino acid composition of the fish muscle. Not only the amino acids which are building blocks of proteins but also those which are found in the exogenous system of the muscle and in the peptide linkages have been studied.

Chapter IV is confined to the study of different fractions of phosphorus.

Chapter V is devoted to the study of some miscellaneous constituents such as crude extract, water solubles, crude fat and moisture contents. The relationship between crude fat and moisture content has also been established. Regression coefficients for such correlation in the muscle of different age groups and in different seasons of the fish species, O. punctatus, and also for some freshwater fishes have been worked out.