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NUTRITIONAL SIGNIFICANCE OF SMALL INDIGENOUS FISHES IN HUMAN HEALTH

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Nutrient Profiling and Evaluation of Fish as a Dietary Component

Outreach Activity Consortium # 3

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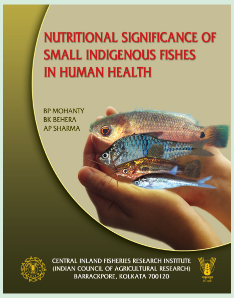

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Foreword

Fish is a health-food for many reasons and has been an important part of the human diet in almost all countries in the world. Fish is one of the cheapest sources of animal proteins and is playing an important role in preventing protein-calorie malnutrition. Small indigenous fishes (SIFs), a subset of the total fish and shellfish, contribute greatly to human nutrition. Besides being an important source of proteins, these small indigenous fishes are the rich source of micronutrients, i.e. minerals and vitamins. The majority of fish eaten by the rural poor is the small indigenous fishes and these small fishes are typically eaten whole, with organs and bones. Therefore, the majority of micronutrients required by the human body are fulfilled by consuming these fishes. Small indigenous fishes provide proteins, fatty acids and especially high amount of vitamins and minerals. They are rich source of calcium, iron, zinc, iodine, phosphorous, selenium and fluorine and these minerals are highly bioavailable. They are rich source of vitamins, particularly, vitamins A, D and E as well as thiamin, riboflavin and niacin (vitamins B1, B2 and B3). Vitamin A is required for normal vision and for bone growth. The small indigenous fish mola, *Amblypharyngodon mola* is a very rich source of vitamin A as compared to many other species. India, like many other countries has not yet eliminated problems of under nutrition, especially among children of its poor communities. Studies carried out in India have shown that the incidence of 'low birth weight' is a major child health issue and maternal health needs to be taken care of to combat this problem. In this context, the small indigenous fishes are important for tackling such problems.

I am sure the document, "**Nutritional Significance of Small Indigenous Fishes in Human Health**" will provide very useful information on the nutrient profile of small indigenous fishes and their significance in human health. I would be happy to see that the information being generated in the on-going ICAR Outreach Activity Consortium on 'Nutrient Profiling and Evaluation of Fish as a Dietary Component', especially on small indigenous fishes, is incorporated and this document is revised to serve as a 'Handbook' on Small Indigenous Fishes. The efforts of the authors deserve appreciation.

(S. Ayyappan)
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and
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Dated the 2nd March, 2010
New Delhi

Foreword

Value of fish as health food is well known, but poorly documented. Fish is the cheapest animal protein that is accessible to the poor and it is aptly called the 'rich food of the poor'. Apart from essential fatty acids and protein, fish is rich in vitamins and minerals. By virtue of the presence of PUFA, consumption of fish can prevent and fight cardiovascular ailments. Fish as a protective food assumes greater significance in India due to the rich fish and fisheries resources of the country, which can play a pivotal role in mitigating the protein deficiency. Except a few, most of the 1300 marine and 720 inland fish species present in Indian waters are edible but they vary widely in their proximate, fatty acid and mineral composition. For instance, marine fish species like tuna, sardines and mackerels are known to have high PUFA content compared to their inland counterparts. Similarly, some inland fish species like singhi (*Heteropneustes fossilis*), murrels (*Channa* spp.) and magur (*Clarias batrachus*) are known to have therapeutic properties. Fish also comes in a wide range of prices making it affordable to the poor. But, in spite of all these advantages of consuming fish, its nutritive value is not well-documented. Considering that the nutrient profile of fish varies depending on species, size, geographical locations and production systems, available knowledge is not sufficient to enable the physicians and dieticians to prescribe fish as health food. Recognizing this gap in knowledge, the Indian Council of Agricultural Research has launched an inter-institutional outreach research programme during the XI Plan to investigate all possible fish species, covering different production system across the country to document their nutritional status.

The project participants have done a commendable job in gathering a wealth of background material on the subject, which form the basis of this publication. I am sure, this document will put the technical programme of the outreach programme in the right perspective and I earnestly hope that the project, when completed, will result in full documentation of the nutrient profile in respect of all major fish species and thereby updating our understanding of fish as a health food.

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Preface to Revised Edition

The first revised edition of the Bulletin No. 162 that was published a year back is being brought out. The document has been well appreciated by the scientists, faculty members of the agricultural universities and other universities, and students. There has been a demand for bringing out the 'Hindi version' of the document also.

The revised edition has updated the information; besides taking care of the shortcomings of the earlier edition. The authors are thankful to the readers and scientists colleagues whose feedback have been instrumental in bringing out this revised edition. Dr. Soma Das, MFSc, Ph.D., Scientist, FREM Division deserves a special mention for the help in meticulously editing the document, especially the list of small indigenous fishes and figures, to make it error free.

Authors

Contents

Health Benefits of Eating Fish

Fish as a food is consumed by many animal species, including humans. It has been an important part of the diet of humans in almost all countries in the world. Animal proteins are generally superior to plant proteins and fish is one of the cheapest sources of animal proteins and availability and affordability is better for fish in comparison to other animal protein sources. Fish serves as a health-food for the affluent world owing to the fish oils which are rich in polyunsaturated fatty acids (PUFAs), at the same time, it is a health-food for the people in the other extreme of the nutrition scale owing to its proteins, oils, vitamins and minerals and the benefits associated with the consumption of small indigenous fishes. Under nutrition, malnutrition and starvation and resultant mortality are major problems in developing and underdeveloped countries. Two forms of child under nutrition, 'Marasmus' (chronic deficiency of calories) and 'Kwashiorkar' (chronic protein deficiency), often occurring together, are world health problems. In this context, fish, being one of the cheapest sources of animal proteins, is playing a big role and can still play a bigger role in preventing the protein-calorie malnutrition.

Nutrient profiling of fishes show that fishes are superior nutrients and umpteen number of health benefits are believed to be associated with regular fish consumption. Fish, especially saltwater fish, is high in Omega-3 fatty acids, which are heart-friendly, and a regular diet of fish is highly recommended by nutritionists. This is conjectured to be one of the major causes of reduced risk for cardiovascular diseases in Eskimos. It has been suggested that the longer lifespan of Japanese and Nordic populations may be partially due to their higher consumption of fish and seafood. Fish are also great for the skin. Nutritionists recommend that fish be eaten at least 2-3 times a week. Oily fish is claimed to help prevent a range of other health problems from mental illness to blindness. The health benefits of eating fish are being increasingly understood now.

Massive studies to evaluate the health benefits of eating fish are being taken up globally. Recently, a $20-million US Government sponsored probe has been launched to examine whether fish oil and Vitamin D can help prevent heart disease, cancer and a range of other illnesses. Oily fish is claimed to help prevent a range of other health problems from mental illness to blindness. Similarly, there are Govt of India (ICAR)-sponsored projects running which aim at nutrient profiling of important food-fishes from the Indian waters and also to study the health benefits of eating fish.

Nutrient Profile of Fish

Fish is an important component of human diet. More than 50% of Indian population is fish eating and in some states more than 90% of the population consume fish. Fish contains proteins and other nitrogenous compounds, lipids, minerals and vitamins and very low level of carbohydrates. Biochemical composition of fish has been described in the Table 1 & 2. The superior nutritional quality of fish lipids (oils) is well known. Fish lipids differ greatly from mammalian lipids in that they include up to 40% of long-chain fatty acids (C14 - C22) that are highly unsaturated and contain 5 or 6

double bonds; on the other hand mammalian fats generally contain not more than 2 double bonds per fatty acid molecule. Fish is generally a good source of vitamin B complex and the species with good amount of liver oils are good source of fat soluble vitamins A and D. Fish is particularly a good source of minerals like calcium, phosphorus, iron, copper and trace elements like selenium and zinc. Besides, saltwater fish contains high levels of iodine also. In fact, fish is a good source of all nutrients except carbohydrates and vitamin C. Some inland fish species like singhi (*Heteropneustes fossilis*), magur (*Clarias batrachus*), murrels (*Channa* sp.), and koi (*Anabas testudineus*) are known to be of therapeutic importance.

Fish and Macronutrients

Proteins

Protein content of fish varies from 15 to 20% of the live body weight. Fish proteins contain the essential amino acids in the required proportion and thus, improve the overall protein quality of a mixed diet.The importance of fish in providing easily digested protein

of high biological value is well documented. In comparison to the other sources of dietary proteins of animal origin the unit cost of production of fish is much cheaper. Fish also come in a wide range of prices making it affordable to the poor. A common man can afford to meet the family's dietary requirement of animal proteins because he has the option to choose from a fairly large number of fish species available. A portion of fish provides with one third to one half of one's daily protein requirement. This explains how fish plays an important role in meeting the nutritional food security, especially in preventing the protein-calorie malnutrition. In the past this has served as a justification for promoting fisheries and aquaculture activities in several countries. On a fresh-weight basis, fish contains a good quantity of protein, about 18-20%, and contains all the eight essential amino acids (Table 3) including the sulphur-containing lysine, methionine, and cysteine.

Fatty acids/ Fish Oils

There are mainly three types of fatty acids: saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs) and poly-unsaturated fatty acids (PUFAs). The first two are synthesized endogenously, but the third one cannot be synthesized by the humans and therefore must be obtained from the diet.

The human body cannot synthesize n-3 fatty acids de novo, but it can form 20-carbon unsaturated n-3 fatty acids (like EPA) and 22-carbon unsaturated n-3 fatty acids (like DHA) from the eighteen-carbon n-3 fatty acid á-linolenic acid. These conversions occur competitively with n-6 fatty acids, which are essential closely related chemical analogues that are derived from linoleic acid (LA). Both the n-3 á-linolenic acid and n-6 linoleic acid are essential nutrients which must be obtained from food. Synthesis of the longer n-3 fatty acids from linolenic acid within the body is competitively slowed by the n-6 analogues. Thus accumulation of long-chain n-3 fatty acids in tissues is more effective when they are obtained directly from food or when competing amounts of n-6 analogs do not greatly exceed the amounts of *n*-3.

Importance of omega-3 fatty acids in diet

The long chain PUFA (LC-PUFA) (i.e. C20 and C22) that belong to the omega (ω)-3 family, have a number of neutraceutical and pharmaceutical applications. Eicosapentaenoic acid (EPA, 20:5 ω–3) and docosahexaenoic acid (DHA, 22:6 ω–3) are the important ω–3 PUFA (Table 4, 5 and 6). EPA and DHA are important in treatment of arthrosclerosis, cancer, rheumatoid arthritis, psoriasis and diseases of old age such as Alzheimer's and age-related macular degeneration (AMD). Fish oils are the major source of PUFA, and considerable evidence has indicated that ω–3 PUFA in fish oil are actually derived via the marine food chain zooplankton consuming ω-3 PUFA-synthesizing micro algae. The most widely available source of EPA and DHA is cold water oily fish such as salmon, herring, mackerel, anchovies and sardines. Oils from these fish have a profile of around seven times as much n-3 as n-6. Other oily fish such as tuna also contain n-3 in somewhat lesser amounts.

Like n-3 fatty acids, n-6 fatty acids (such as α-linolenic acid and arachidonic acid) play a similar role in normal growth. n-6 is "better" at supporting dermal integrity, renal function, and parturition. These preliminary findings led researchers to concentrate their studies on n-6, and it was only in recent decades that n-3 has become of interest.

Nutritional Significance of Fish Oils and PUFAs for Human Health- Some Clinical Correlations:

Coronary Heart Disease (CHD) and ω (omega) -3 fatty acids

ω-3 fatty acids have been shown in epidemiological and clinical trials to reduce the incidence of Coronary Heart Disease (CHD). Studies have indicated decreases in total mortality and cardiovascular incidents (i.e. myocardial infarctions) associated with the regular consumption of fish and fish oil supplements. Recommendations made by American Heart Association (AHA) Dietary Guidelines include at least two servings of fish per week (particularly fatty fish).

Lack of Essential fatty acids and Attention-Deficit Hyperactivity Disorder (ADHD)

Lack of Essential fatty acids causes behavioural problem in the pediatric population which is known as Attention-Deficit Hyperactivity Disorder (ADHD). Children suffering from ADHD are inattentive, impulsive and hyperactive. Studies have reported that children with ADHD had significantly lower levels of arachidonic acid (AA), eicosapentaenoic acid (EPA) and decosahexaenoic acids (DHA) in their blood and these hyperactive children suffered more from symptoms associated with essential fatty acid deficiency (thirst, frequent urination, and dry hair and skin) and were more likely to have asthma.

Fish Oils and Childhood Asthma

Children who consume fresh, oily fish have significantly lower risk of developing asthma (airway hyper responsiveness). Omega-3 fatty acids, EPA and DHA, especially EPA is reported to prevent development of asthma or reduce its severity. Studies have suggested long-term fish oil supplementation may reduce asthma severity. Major dietary sources of DHA are fish and fish oils.

Dementia and AMD (Age-related Macular Degeneration) associated with low plasma concentration of n-3 fatty acids

Low dietary intakes and plasma concentration of n-3 fatty acids are associated with dementia (memory loss), cognitive decline and age-related macular degeneration (AMD) risk. AMD is a disease associated with aging that gradually destroys sharp, central vision. Central vision is needed for seeing objects clearly and for common daily tasks such as reading and driving. AMD affects the macula (located in the center of the retina, the light-sensitive tissue at the back of the eye), the part of the eye enables to see fine detail. AMD is a leading cause of vision loss in people over 60 years of age. It has been reported that n-3 Fatty acids, particularly DHA delay the progression of dementia and AMD. Major dietary sources of DHA are fish and fish oils.

Higher fish consumption associated with low risk of Low Birth Weight (LBW)

In a study of nearly 9,000 pregnant women, researchers found women who ate fish once a week during their first trimester had 3.6 times less risk of low birth weight (LBW) and premature birth than those who ate no fish. Low consumption of fish was a strong risk factor for pre-term delivery and low birth weight (LBW).

Utero environment controls prenatal development and also set off structural and functional mechanisms that will have a prolonged effect in entire life span. New facts in humans describing the importance of the womb environment for the long-term health of offspring showed for the first time (27). Study shows that diet taken by a mother in late pregnancy can alter the stress response in future progeny and eventually will throw to cardiovascular and other stress-related disease in adulthood. Higher level of meat and fish intake of pregnant mother resulted into prominent concentration of fasting plasma cortisol in offspring (28). Unbalanced high protein diet and low-carbohydrate diet in late pregnancy will boost up adult blood pressure in the children. Chronic elevation of cortisol levels in children and young adults can increase the threat of hypertension, diabetes, and heart disease in later stages.

Scientists from the University of Cambridge have sited an increased risk of type 2 diabetes in old age which also leads to heart disease and cancer in children born to mother with unhealthy maternal diet during pregnancy. The gene Hnf4a, which has been linked to type II diabetes, is controlled by maternal diet through epigenetic modifications to DNA. It also plays an important role in pancreatic development and insulin secretion (29). Epigenetic changes decrease the expression of the Hnf4a gene in the offspring prone to type II diebatics.

Exposure of high saturated fat diet to maternal womb generally leads to onset of chronic disease in mice in old age. Thus, birth weight, length, body proportion and placental weight are strongly related to coronary heart diseases, non-insulin dependent diabetes etc which are after result s of the high fat diets (30, 31, 32). Chronic maternal consumption of a HFD with fetal hepatic apoptosis and suggests that a potentially pathological maternal fatty acid milieu is replicated in the developing fetal circulation in the nonhuman primate (33). Maternal diet-induced obesity in mice led to an increase in mitochondrial potential, mitochondrial DNA content and biogenesis (34).

Health experts in a maternity hospital in Motherwell, Scotland have recommended eating one pound of red meat daily during pregnancy (35). Research have shown that Compared with offspring of mothers who had reported eating not more than 13 meat/fish portions per week, the average cortisol concentrations were raised by 22% and 46% in offspring of those reporting 14-16% and at least 17 portions per week respectively. Diets with low-carbohydrate or high protein have been associated with an increased risk of kidney problems and metabolic ketoacidosis which is a potential prenatal stressor. The onset of ketoacidosis starts when carbohydrate intake is restricted and simultaneously body turns to alternative energy sources like fat; acids known as ketones formed in the blood. When the level of beta-hydroxybutyrate (by-products of ketoacidosis) rises during gestation period, it can inhibit psychological behavioral and scholarly development in offspring.

Seafood consumption, ω-3 fatty acid and supplementation and 'Mood disorders'

n-3 fatty acids are known to have membrane-enhancing capabilities in brain cells. One medical explanation is that n-3 fatty acids play a role in the fortification of the myelin sheaths. A benefit of n-3 fatty acids is helping the brain to repair damage by promoting neuronal growth. Several epidemiological studies suggest covariation between seafood consumption and rates of '*mood disorders*'. Long term disturbances of mood are considered mood disorders. Biological marker studies indicate deficits in omega-3 fatty acids in people with depressive disorders, while several treatment studies indicate therapeutic benefits from omega-3 supplementation.

Obesity

Obesity defines as the consequence of the excessive accumulation of fat in adipose tissue. This caused several health problems including cardiovascular disorders such as hypertension, stroke and CHD, conditions associated with insulin resistance such as type 2 diabetes, and certain types of cancers (36, 37) resulting in significant morbidity and mortality. Studies of cumulative degree of weight loss on health benefits by (38, 39) showed a weight loss of 5-10% can reduce these risks of obesity. Recent studies of effect of n-3 PUFA to improve adherence to weight loss and weight maintenance have been conducted successfully on abdominal adipose tissues. Lower plasma concentrations of total n-3 PUFA has been observed in obese individual in comparison with healthy weight individuals (40). Higher plasma levels of total n-3 PUFA were associated with healthier BMI, waist and hip circumference. Although it is difficult to maintain weight loss in the long term (41), effective measures need to be taken for conducting more intervention trials with dietary supplementation with n-3 PUFA-rich fats/oils in adults examining in assisting weight loss and weight maintenance. Maternal diet-induced obesity in mice led to an increase in mitochondrial potential, mitochondrial DNA content and biogenesis. Maternal obesity prior to conception alters mitochondria in mouse oocytes and zygotes (34).

Fish and Micronutrients

Vitamins

Fish is a rich source of vitamins, particularly vitamins A, D and E from fatty species, as well as thiamin, riboflavin and niacin (vitamins B1, B2 and B3). Vitamin A from fish is

more readily available to the body than from plant foods. Among all the fish species, fatty fish contains more vitamin A than lean species. Studies have shown that mortality is reduced for children under five with a good vitamin A status. Vitamin A is also required for normal vision and for bone growth. The small indigenous fish Amblypharyngodon mola is a very rich source of vitamin A as compared to many other species (Table 7).

Vitamin D present in fish liver and oils is crucial for bone growth since it is essential for the absorption and metabolism of calcium. It also plays a role in immune function and may offer protection against cancer. Oily fish is the best food source of unfortified vitamin D. Vitamin D is not found in many foods and tends to be a vitamin that many vulnerable groups go short of, such as teenage girls and the elderly. Fish is also a good source of the B vitamins and can provide a useful contribution to the diet for this group of vitamins, as does red meat. The B group of vitamins is responsible for converting food to energy in the cells of the body and they help with the function of nerve tissue. If eaten fresh, fish also contains a little vitamin C which is important for proper healing of wounds, normal health of body tissues and aids in the absorption of iron in the human body.

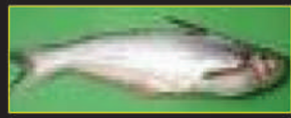
Minerals

The minerals present in fish include iron, calcium, zinc, iodine (from marine fish), phosphorus, selenium and fluorine. These minerals are highly 'bioavailable' meaning that they are easily absorbed by the body. Mineral content of small indigenous fishes has been depicted in the Table 8.

India, like many other developing countries has not yet eliminated problems of under nutrition, especially among children of its poor communities. 'Low birth weight (LBW)' is indicative of intra-uterine growth retardation and studies carried out in India and abroad suggest that children who suffer from such problems show substandard growth and development and are susceptible to obesity in adulthood. Studies carried out in India have shown that the incidence of low birth weight (<2500 gms) deliveries among the poor is around 25-30% and nearly 50% of children less than three year of age are stunted (height less than WHO norms). Combating low birth weight would be a valuable contribution towards reducing incidence of obesity and type II Diabetes mellitus. Studies have shown that apart from correction of anemia, supplementation with foods rich in n-3 fatty acids could significantly reduce the low birth weight incidence. It is evident that fish contribute more to people's diets than just the high quality protein they are so well known for. Fish should therefore be an integral component of the diet, preventing malnutrition by making these macro- and micro-nutrients readily available to the body.

Table 1 : Biochemical Composition of Fish

Moisture	65-80%
Protein	15-20%
Fat	5-20%
Ash	0.5-2%



Nutritional Significance of Small Indigenous Fishes in Human Health

Small Indigenous Fishes

India, one of the 17 global mega biodiversity hotspots, is native to many freshwater fish species. About 450 species, out of the 765 freshwater species reported, are categorized as small indigenous fishes (SIF). Although there is no clear definition for small indigenous fishes, the freshwater species which grow to a size of about 25-30 cm in matured or adult stage are categorized as small indigenous fishes. From a functional point of view, the SIFs in the rural households include the minnow Amblypharyngodon mola, Puntius sophore and other Puntius species, Esomus danricus (darkina), Esomus longimanus which may weigh from 5-15 gm to Anabas testudineus, Mastocembelus armatus, Hetetropneustes fossilis weighing from 200-250 gm. The small indigenous fishes are prolific breeders that need little or no management and grow in the backyard ponds, derelict water bodies, beels, wetlands and in all such places and therefore, they are commonly available in the rural areas where such aquatic habitats are common. People in the villages usually consume small indigenous fishes not because they are micronutrient rich, rather as these are commonly available and do not have good market demand as compared to large-sized fishes. Many times as affordability for pulses and vegetables is difficult, rural people live on the small indigenous fishes which they get as a by-catch. Thus, whether by choice or by default, they consume more small indigenous fishes and get the associated health benefits. In fact, fish and rice has been the staple food for majority of rural households. In the urban areas, people are more health conscious and therefore, there is more demand for the small indigenous fishes and SIFs have got a fair share in the regular fish consumption schedule of the urban communities.

Significance of Small Indigenous Fishes in Human Health

Like the Indian major carps (IMCs), large catfishes and other food fishes, the small indigenous fishes contribute high quality animal protein for human nutrition, proportional to their muscle biomass. Besides, the small indigenous fishes are a rich source of micronutrients. Micronutrients are the essential dietary elements that are needed only in very small quantities. They include the vitamins and trace minerals which the body must obtain from outside sources. Micronutreints are essential to the body in small amounts as they are either components of enzymes (the cofactors) or act as coenzymes in many biochemical reactions and metabolic processes vital for survival, growth and reproduction (Table 10, 11, 12). The vitamins include different fat-soluble vitamins like Vitamin A, D, E and K and the water-soluble vitamins B-complex and C. The trace elements include copper, zinc,

selenium, iodine, magnesium, iron, cobalt, and chromium. Other than the trace elements (micronutrients), small indigenous fishes are also rich in macro minerals like calcium and phosphorous. These fishes are also rich in vitamin A. It has been documented that vitamin A is present as dehydroretinol and retinol and are found mainly in the eyes and viscera, although the proportions of these preformed vitamin A forms vary with species. The culinary practices in those countries of the world, where micronutrient deficiency, protein-calorie malnutrition etc are always a challenge, are such that many small indigenous fishes are eaten whole, with head, organs and bones.

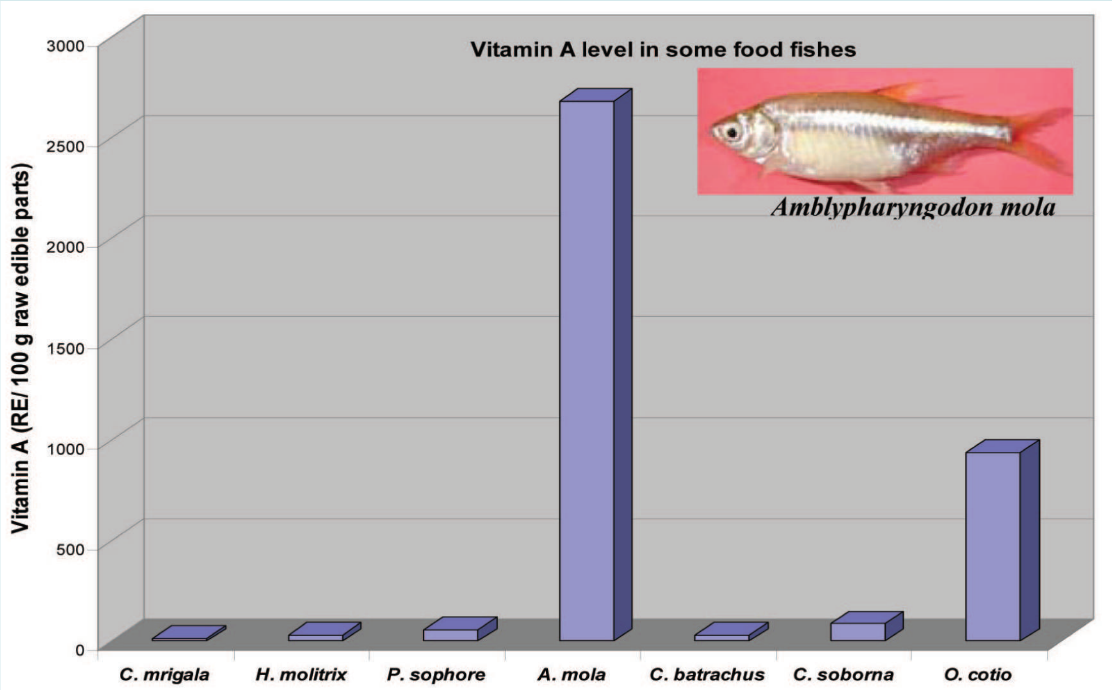


Figure 1 : *Vitamin A content in some food fishes.*
Mola (*Amblypharyngodon mola*, Cyprinidae) is a very rich source of vitamin A
(Data source : ref. 25)

The small indigenous fishes contribute to food and nutritional security akin to the large fishes and thus, serve as a health-food; however, the large fishes contribute more towards the proteit and fish oil, especially PUFAs, requirement where as the small indigenous fishes are important for their richness in micronutrients. In this chapter, the major focus of discussion is on the different macro- and trace-elements and vitamins.

Small Indigenous Fishes and Micronutrients

Vitamins

Fish is a rich source of vitamins, particularly vitamins A, D and E from fatty species, as well as thiamin, riboflavin and niacin (vitamins B_1, B_2 and B_3). Vitamin A

from fish is more readily available to the body than from plant foods. Among all the fish species, fatty fish contains more vitamin A than lean species. Studies have shown that mortality is reduced for children under five with a good vitamin A status. Vitamin A is also required for normal vision and for bone growth. As sun drying destroys most of the available vitamin A better processing methods are required to preserve this vitamin. The small indigenous fish *Amblypharyngodon mola* is a very rich source of vitamin A as compared to many other species (Figure1). The amino acid and fatty acid profile of Mola fish has been depicted by chromatogram (Figure 2 and 3).

Vitamin D present in fish liver and oils is crucial for bone growth since it is essential for the absorption and metabolism of calcium. It also plays a role in immune function and may offer protection against cancer. Oily fish is the best food source of unfortified vitamin D. Vitamin D is not found in many foods and tends to be a vitamin that many vulnerable groups go short of, such as teenage girls and the elderly. Fish is also a good source of the B vitamins and can provide an useful contribution to the diet for this group of vitamins, as does red meat. The B group of vitamins is responsible for converting food to energy in the cells of the body and they help with the function of nerve tissue. If eaten fresh, fish also contains a little vitamin C which is important for proper healing of wounds, normal health of body tissues and aids in the absorption of iron in the human body.

Presence of vitamin D receptors (VDR) and hydroxylases in brain tissue facilitated developmental movements of brains. Calcitriol or 1, 25 dihydroxy cholecalciferol, the bioactive form of vitamin D is the key component to augment the mechanism (42, 43). Vitamin D posses curative properties for chronic diseases like osteoporosis, cancer, cardiovascular diseases, mood disorders and diabetes (44, 45). Recent studies also shows as ailment role for vitamin D in cognitive function and mental health (46, 47, 48, 49). Studies on depression diagnosis in the US population showed the likelihood of having depression in vitamin D deficient persons which is significantly higher compared to those with adequate vitamin D status (50). Future studies need to carried out in interpreting the productive role of vitamin D in psychosomatic disorders.

Minerals

The minerals present in fish include iron, calcium, zinc, iodine (from marine fish), phosphorus, selenium and fluorine. These minerals are highly 'bioavailable' meaning that they are easily absorbed by the body.

Iron

It is important in the synthesis of hemoglobin in red blood cells which is important for transporting oxygen to all parts of the body. Iron deficiency is

associated with anemia, impaired brain function and in infants is associated with poor learning ability and poor behavior. Due to its role in the immune system, its deficiency may also be associated with increased risk of infection. Compared to other animal sources, although fish contain less iron than the amount found in red meat, iron in white fish is well absorbed and so is a useful source of iron. However, on a weight for weight basis, shellfish contais as much iron as lean meat.

Calcium

It is required for strong bones (formation and mineralization) and for the normal functioning of muscles and the nervous system. It is also important in the blood clotting process. The intake of calcium, phosphorus and fluorine is higher when small fish are eaten with their bones rather than when the fish bones are discarded. Deficiency of calcium may be associated with rickets in young children and osteomalacia (softening of bones) in adults and older people. Fluorine is also important for strong bones and teeth.

Zinc

It is required for most body processes as it occurs together with proteins in essential enzymes required for metabolism. Zinc plays an important role in growth and development as well in the proper functioning of the immune system and for a healthy skin. It also has a role in cell division, cell growth, wound healing and the break down of carbohydrates and is needed for the senses of smell and taste. Zinc deficiency is associated with poor growth, skin problems and loss of hair among other problems. High-protein foods like meat and fish contain the highest amount of zinc, and it is easily absorbed from these sources. Oysters provide more zinc than any other food. Other types of oily fish and seafood such as skate, anchovies, herring, sardines, crab, prawns, shrimps, mussels, and winkles also provide a significant amount of zinc.

Iodine

It present in seafood, is important for hormones that regulate body metabolism and in children it is required for growth and normal mental development. A deficiency of iodine may lead to goitre (enlarged thyroid gland) and mental retardation in children (cretinism). Fish is one of the few reliable sources of iodine. The UK recommended intake of iodine for adults is 140 mcg a day and a 100g portion of some fish can provide all the requirement of iodine for the day.

Selenium

Fish is a particularly good source of selenium. In UK, the recommended intake for selenium is 75 mcg a day for men and 60 mcg a day for women and a 100g portion of baked cod could provide 34 mcg of selenium, which is roughly half the daily recommended intake. Selenium is a component of some of the enzymes which protect the body against damage due to oxidation (free radical damage). It is also necessary for the use of iodine in thyroid hormone production and for immune system function. Low levels of selenium intake may be associated with the increased risk of some cancers.

It is evident that fish contribute more to people's diets than just the high quality protein they are so well known for. Fish should therefore be an integral component of the diet for preventing malnutrition by making these macro- and micro-nutrients readily available to the body.

List of Small Indigenous Fishes

Table 1 : List of Small Indigenous Fishes

Sl. No.	Scientific Name	Commom name / Local Name
1	*Ailia coila*	Kojoli, Kajri, Banspata
2	*Amblypharyngodon mola*	Mola, Mouralla
3	*Anabas testudineus*	Climbing perch, Koi
4	*Anodontostoma chacunda*	Chacunda gizzard shad
5	*Aplocheilus panchax*	Techokha
6	*Aspidoparia morar*	Olahalale
7	*Badis badis*	Badis, Chameleon fish
8	*Barilius barila*	Chalake
9	*Barilius barna*	Barna baril
10	*Barilius bendelisis*	Zhorya
11	*Barilius bola*	Bhol, Indian Trout
12	*Barilius vagra*	-
13	*Botia dayi*	Rani, Loach
14	*Botia lohachata*	Reticulate loach
15	*Brachydanio rerio*	Zebra fish
16	*Chanda nama*	Chanda, Glass fish
17	*Chanda ranga*	Chanda, Glass fish
18	*Channa gachua*	Chang
19	*Channa orientalis*	Walking/Brown snake head, Cheng
20	*Channa punctatus*	Lata/ spotted snake head
21	*Channa stewartii*	Assamese snake head
22	*Channa striatus*	Striped Snake head
23	*Chela bacaila*	Chela
24	*Chela laubuca*	Indian hatchet fish, Chep chela
25	*Clarias batrachus*	Magur, Walking catfish
26	*Clupisoma garua*	Garua Bachcha, Ghaura
27	*Colisa fasciata*	Kholse, Cheli

Sl. No.	Scientific Name	Commom name / Local Name
28	*Colisa lalia*	Kholshe, Ranga Kholsey, Dwarf gourami
29	*Corica soborna*	Kanchki,Sona Khorke
30	*Cynoglossus lingua*	Long tongue sole
31	*Danio aequipinnatus*	Giant danio
32	*Danio devario*	Sind danio
33	*Eleotris fusca*	Dusky sleeper
34	*Esomus danricus*	Flying barb, Danrika
35	*Euryglossa orientalis*	Oriental sole
36	*Eutropiichthys vacha*	Bacha, Kangon
37	*Gagata cenia*	Jungla
38	*Glossogobius giuris*	Beli
39	*Gonialosa manmina*	Ganges gizzard shad
40	*Gudusia chapra*	Khoira, Chapra
41	*Heteropneustes fossilis*	Stinging catfish, Singhi
42	*Laubuca laubuca*	Blue laubuca, Indian glass barb
43	*Lepidocephalus caudofurcatus*	-
44	*Lepidocephalus guntea*	Gute, Poe
45	*Mastacembelus armatus*	Ban/ Zig-zag eel
46	*Mystus cavasius*	Gangetic mystus
47	*Mystus gulio*	Nona tangra, Gule tangra
48	*Mystus tengara*	Stripped Dwarf Catfish, Bajari-Tengra
49	*Mystus vittatus*	Tangra
50	*Nandus nandus*	Gangetic leaffish
51	*Nemacheilus zonatus*	Victory Loach
52	*Oreichthys cosuatis*	Highfin barb, Purjebarbi
53	*Oreochromis niloticus*	Tilapia
54	*Osteobrama belangeri*	Pengba
55	*Osteobrama cotio*	Cunma osteobrama
56	*Osteobrama neilli*	Nilgiri osteobrama
57	*Pama pama*	Bhola

Sl. No.	Scientific Name	Commom name / Local Name
58	*Pellona sp.*	-
59	*Polynemus paradiseus*	Paradise threadfin
60	*Pseudambassis/ Parambassis lala*	Highfin glassy perchlet
61	*Pseudapocryptes lanceolatus*	-
62	*Neutropius atherinoides*	Indian Potasi
63	*Pseudosciaena coitor*	
64	*Puntius arulius*	Arulius barb
65	*Puntius binotatus*	Spotted Barb
66	*Puntius chagunio*	Chaguni
67	*Puntius chola*	Swamp barb
68	*Puntius conchonius*	Puti, Kankan puti, Rosy barb
69	*Puntius cumingi*	Cuming's Barb
70	*Puntius denisonii*	Redline Torpedo Barb
71	*Puntius dunckeri*	Bigspot Barb
72	*Puntius everetti*	Clown Barb
73	*Puntius fasciatus*	Melon Barb
74	*Puntius fraseri*	Dharna barb
75	*Puntius gelius*	Glass Barb, Golden Barb
76	*Puntius hexazona*	Sixband Barb
77	*Puntius jayarami*	-
78	*Puntius lateristriga*	Spanner Barb
79	*Puntius manipurensis*	-
80	*Puntius nigrofasciatus*	Black Ruby Barb
81	*Puntius oligolepis*	Checker Barb
82	*Puntius padamya*	Odessa Barb
83	*Puntius partipentazona*	Partipentazona Barb
84	*Puntius pentazona*	Fiveband barb, pentazona barb
85	*Puntius phutunio*	Dwarf barb
86	*Puntius sarana*	Olive barb, Sar puti
87	*Puntius semifasciolatus*	Green Barb

Sl. No.	Scientific Name	Commom name / Local Name
88	*Puntius sophore*	Sona puti/ Pool barb
89	*Puntius stigma*	Stigma
90	*Puntius stoliczkanus*	Stoliczkae's Barb
91	*Puntius terio*	Onespot barb
92	*Puntius tetrazona*	Tiger Barb
93	*Puntius ticto*	Puti
94	*Puntius titteya*	Cherry Barb
95	*Puntius vittatus*	Greenstripe Barb
96	*Rasbora caverii*	Cauvery rasbora
97	*Rasbora daniconius*	Striped Rasbora
98	*Rhinomugil corsula*	Kharsula,Tarui
99	*Salmostoma bacaila*	Chala
100	*Salmostoma phulo*	Fine Scale Razor Belly Minnow, Chalake
101	*Schistura vinciguerrae*	-
102	*Setipinna phasa*	Phansa
103	*Sicamugil cascasia*	Chuno parsia
104	*Silonia silondia*	Silondia vacha
105	*Stigmatogobius sadanundio*	Knight goby
106	*Xenentodon cancila*	Gangdhara, Kanklesh

Proximate Composition of SIF

Table 2 : Proximate Composition of SIF

	Crude protein (%)	Crude Fat (%)	Ash (%)	Moisture (%)
Amblypharyngodon mola	18.46	4.10	1.64	76.38
Gudusia chapra	15.23	5.41	1.55	75.07
Chanda nama	18.26	1.53	3.92	65.88
Pseudeutropius atherinoides	15.84	2.24	3.29	73.32
Ailia coila	16.99	3.53	1.98	78.62
Puntius chola	14.08	3.05	1.19	74.43
Channa punctatus	19.84	3.15	1.00	75.80
Channa striatus	20.50	4.07	1.45	77.50
Puntius sarana	20.84	3.15	1.17	74.84
Heteropneustes fossilis	16.43	0.40	1.30	81.03
Barbus spp.	18.81	0.19	1.12	79.67
Mystus vittatus	18.90	1.63	1.19	77.50
Clarias batrachus	18.20	1.42	0.97	78.70
Ambassis sp.	18.63	1.28	1.12	79.72
Glossogobius giuris	16.35	0.25	1.25	79.10
Osteobrama cotio	16.90	5.96	3.06	74.58
Puntius Stigma	18.95	6.27	0.98	72.97
Mystus tengra	16.81	6.28	2.82	73.67
Xenentodon Cancila	21.70	2.82	1.11	73.90
Oreochromis niloticus	20.47	0.58	0.90	77.30
Etroplus suratensis	22.50	2.40	0.90	75.30

All values given are mg/100gm of tissues

Amino Acid Composition of SIF

Table 3 : Amino Acid Composition of SIF

Amino Acid	*A. mola*	*Ambassis spp.*	*Puntius sarana*	*H. fossilis*	*P. stigma*	*C. striatus*	*G. chapra*	*Chela phulo*	*O. noloticus*
Asp	9.82	9.52	9.63	6.33	2.80	10.74	3.53	3.78	12.91
Thr	5.72	3.23	4.79	4.29	1.68	4.24	1.93	1.87	5.32
Ser	6.68	2.34	3.48	2.41	1.30	3.60	1.43	1.40	4.05
Glu	16.31	14.88	20.31	10.79	5.76	21.6	6.72	6.96	17.05
Pro	0.38	3.29	4.61	3.86	2.31	4.0	2.30	2.25	4.07
Gly	13.74	3.31	4.47	4.74	3.22	3.75	3.22	2.99	6.68
Ala	10.50	4.39	6.47	4.47	2.88	5.49	3.03	2.93	7.36
Val	0.84	4.48	5.21	4.07	2.24	5.54	2.64	2.50	5.81
Cys	3.15	0.74	0.80	0.50	0.24	2.40	0.26	0.31	0.84
Met	1.72	2.05	1.83	1.34	1.22	2.47	1.49	1.46	2.97
Iso	5.45	4.22	3.07	4.56	2.02	4.50	2.31	2.35	6.58
Leu	9.62	7.05	8.05	6.92	3.00	8.76	3.48	3.51	9.83
Tyr	1.39	4.81	2.58	1.84	1.60	1.90	1.81	1.84	1.47
His	4.41	3.30	1.21	4.86	1.11	3.16	1.08	1.03	2.53
Lys	5.17	11.30	11.17	10.98	3.36	13.26	4.10	4.13	15.76
Arg	1.87	6.21	5.66	2.78	2.71	4.87	3.17	3.20	5.62
Try	1.73	1.12	1.13	1.38	—	—	—	—	—
Phe	1.5	—	—	3.84	1.85	2.91	2.13	2.07	3.10

All values are gm amino acid per 100 gm protein

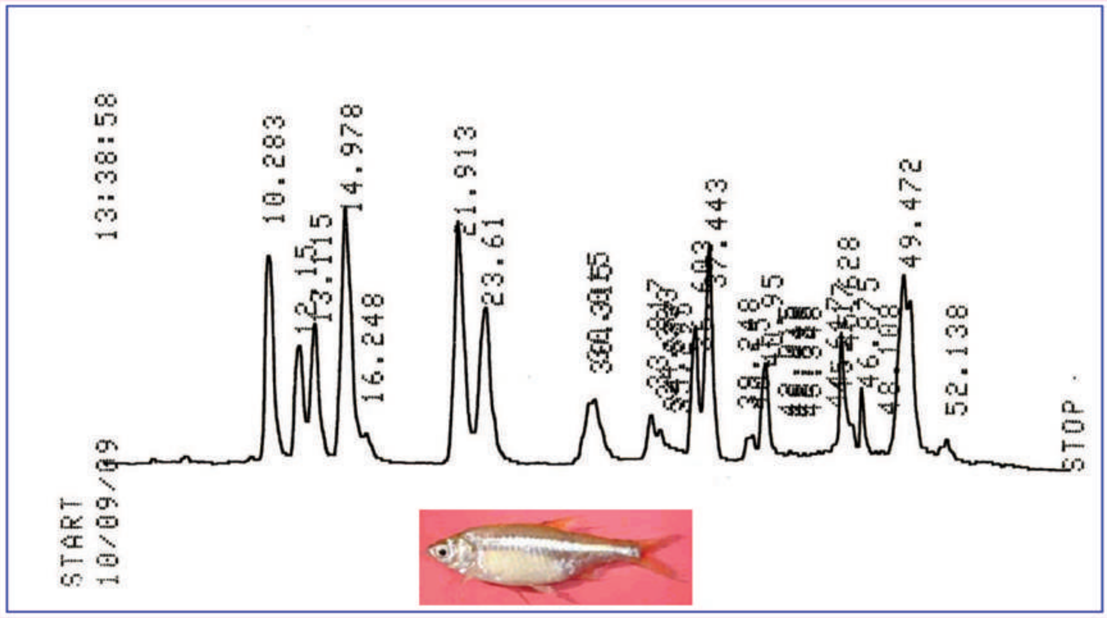


Figure 2 : Chromatogram showing amino acid profile of *Amblypharyngodon mola* (Cyprinidae)

(Source : Reference 19)

Some common Polyunsaturated Fatty Acids (PUFAs)

Table 4 : Some common Polyunsaturated Fatty Acids (PUFAs)

Commom Name	Omega	Delta	Abbre.
Linoleic Acid	18:2n-6	18:2 $\Delta^{9,12}$	LA
Arachidonic Acid	20:4n-6	20:4 $\Delta^{5,8,11,14}$	AA
Alpha-linoleic Acid	18:3n-3	18:3 $\Delta^{9,12,15}$	ALA
Eicosapentaenoic Acid	20:5n-3	20:5 $\Delta^{5,8,11,14,17}$	EPA
Docosahexaenoic Acid	22:6n-6	22:6 $\Delta^{4,7,10,13,16,19}$	DHA

Fatty Acid Composition of the Lipids of SIF

Table 5 : Fatty Acid Composition of the Lipids of SIF

Fatty Acid	*A. mola*	*Channa Punctatus*	*Etroplus maculatus*	*E. suratensis*	*H. fossilis*	*M. armatus*
Saturated						
C11:0	0.017	0.0	0.0		0.0	
C12:0	0.329	0.0	0.0	0.0	1.2	2.1
C13:0	0.157	0.3	0.2	1.0	1.4	0.7
C14:0	6.918	0.7	3.4	3.8	3.3	3.6
C15:0	1.955	2.1	1.1	2.8	2.2	3.0
C16:0	36.755	24.0	24.7	19.9	17..6	13.7
C17:0	1.568	3.0	2.8	0.4	2.5	3.8
C18:0	7.779	13.7	12.0	15.7	9.4	12.6
C19:0	0.000	1.3	0.9	0.0	1.6	1.8
C20:0	0.224	0.0	0.0	–	0.0	–
C22:0	0.143	0.0	0.0	–	0.0	–
Total	55.865	45.1	45.1	43.6	39.2	41.3
Monounsaturated						
C16:1 n7	0.618	5.8	6.3	11.1	16.5	7.5
C17:1 n7	0.372	2.0	1.2	0.4	0.0	1.1
C18:1 n9	18.100	14.0	13.7	20.3	15.3	20.4
C20:1 n9	0.818	0.7	0.9	1.6	0.0	1.0
C22:1 n9	0.046	0.3	0.7	1.0	0.9	0.5
Others	0.236	1.8	0.2	0.1	2.5	3.0
Total	20.190	24.6	23.0	34.5	35.2	33.5
Polyunsaturated						
C18:2 n6	4.846	3.8	2.1	7.6	4.1	8.2
C18:3 n3	9.362	0.5	0.6	5.5	0.9	1.9
C18:4 n3	0.000	1.8	3.6	2.4	1.7	1.6
C20:2 n6	0.362	0.2	1.0	0.0	1.0	0.0
C20:3 n6	1.300	0.2	0.7	0.0	2.1	1.5
C20:4 n6	3.569	6.1	3.0	3.5	6.3	7.1
C20:5 n3	4.504	6.0	2.2	0.5	3.8	1.2
C22:4 n6	0.000	2.4	5.9	0.0	0.9	1.3
C22:5 n3	0.000	2.2	5.1	1.0	0.5	0.3
C22:6 n3	0.000	6.7	8.0	1.0	0.3	2.2
Others	0.021	0.0	0.0	0.5	1.3	0.0
Total	23.945	29.9	32.2	22.0	22.9	25.3
Unidentified	**–**	**0.4**	**–**	**0.0**	**2.8**	**–**

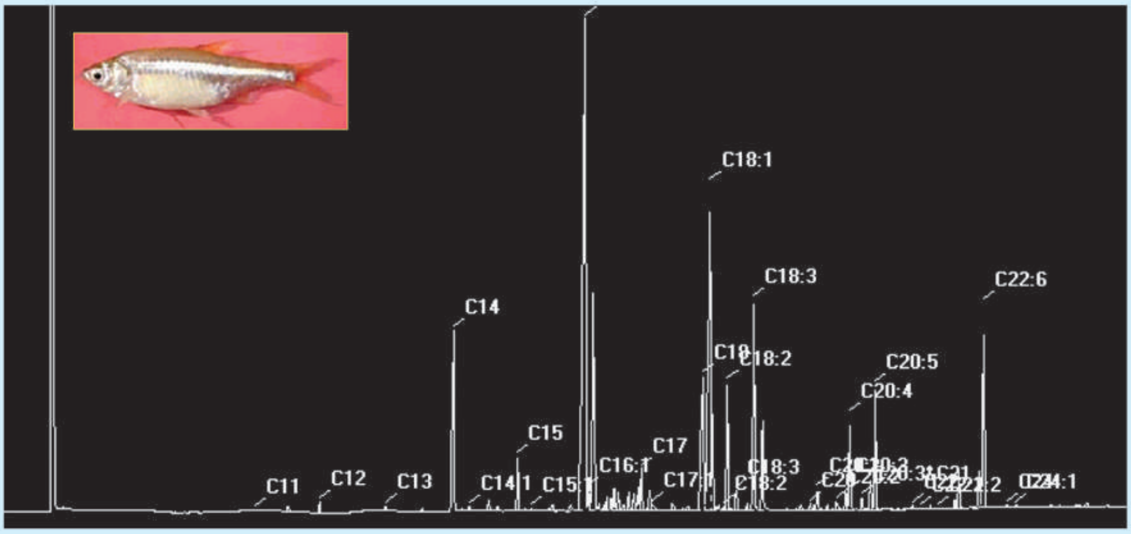


Figure 3 : Chromatogram Fatty Acids of *Amblypharyngodon mola*

(Source : Reference 19)

List of common n-3 and n-6 Fatty Acids found in nature

Table 6 : List of common n-3 and n-6 Fatty Acids found in nature

Common name	Lipid name	Chemical name	Abbr.
Common n-3 (ω-3) Fatty Acids			
α-Linolenic acid	18:3 (n-3)	all-cis-9,12,15-octadecatrienoic acid	ALA
Stearidonic acid	18:4 (n-3)	all-cis-6,9,12,15-octadecatetraenoic acid	STD
Eicosapentaenoic acid	20:5 (n-3)	all-cis-5,8,11,14,17-eicosapentaenoic acid	EPA
Docosapentaenoic acid	22:5 (n-3)	all-cis-7,10,13,16,19-docosapentaenoic acid	DPA
Docosahexaenoic acid	22:6 (n-3)	all-cis-4,7,10,13,16,19-docosahexaenoic acid	DHA
Common n-6 (ω-6) Fatty Acids			
Linoleic acid	18:2 (n-6)	9,12-octadecadienoic acid	LA
Arachidonic acid	20:4 (n-6)	5,8,11,14-eicosatetraenoic acid	AA
Docosadienoic acid	22:2 (n-6)	13,16-docosadienoic acid	DDA
Docosapentaenoic acid	22:5 (n-6)	4,7,10,13,16-docosapentaenoic acid	DPA

Mineral content of some SIF

Table 7 : Mineral content of some SIF

SIF	Ca (mg)	Fe (mg)	Zn (mg)	Na	K	P	Mn	Cu	Mg
Chanda nama	955	1.8	2.3	-	750	-	4.24	1.82	110
Gudusia chapra	1063	7.6	2.1	-	860	-	4.76	1.97	120
Etroplus. suratensis	315.30	1.80	-	126.90	296.70	251.00	-	-	-
Oreochromis. niloticus	585.20	1.50	-	-	-	235.00	-	-	-
Esomus danricus	891	12.0	2.1	-	-	-	-	-	-
Corica soborna	476	2.8	2.1	-	520	-	7.01	6.14	100
Amblypharyngodon mola	853	5.7	3.2	-	630	-	4.21	2.67	120
Puntius sophore *Puntius chola* *Puntius ticto*	1171	3.0	3.1	-	860	-	7.39	1.16	100
Channa punctatus	766	1.8	1.5	-	-	535.00	-	-	-
Channa striatus	82.20	1.88	-	44.86	153.80	198.28	-	-	-
Puntius sarana	30.32	2.55	-	34.36	121.28	268.20	-	-	-
Heteropneustes fossilis	42.61	4.86	-	57.58	247.29	135.94	-	-	-
Barbus spp.	47.96	0.84	-	76.98	244.93	118.48	-	-	-
Clarias batrachus	76.52	2.21	-	76.52	280.44	122.29	-	-	-
Osteobrama cotio	140	39.7	13.6	-	920	-	4.42	2.82	110
Mystus tengra	190	14.5	17.0	-	840	-	5.31	3.20	110
Puntius. stigma	120	32.6	11.3	-	650	-	5.68	3.98	110
Chela phulo	170	30.8	10.0	-	670	-	4.72	1.23	130
Chela bacaila	160	33.2	12.8	-	880	-	4.32	1.20	110
Chanda ranga	150	24.7	14.6	-	990	-	3.26	1.15	100
Pseudeutropius atherinoides	400	33.0	14.4	-	610	-	6.34	1.25	200

Vitamin content of some SIF

Table 8 : Vitamin content of some SIF

Fish Name	Vitamin-A Content	Category
Amblypharyngodon mola (2680) *Parambassis baculis*	>1500	Very High
Osteobrama cotio cotio(937) *Esomus danricus*	500-1500	High
Parambassis ranga *Chanda nama* *Mystus vittatus* Channa punctatus *Chela canchius*	100-500	Medium
Puntius chola *P. sophore* *P. ticto* *Lepidocephalus guntea* *Gudusia chapra* *Colisha fasciatus* *Colisha lalia* *H. fossilis* *Clarias batrachus* *Puntius sophore(55)* Clarias batrachus(30) *Corica soborna(87)*	<100	Low

RAE/100g raw cleaned parts*

**RAE: Retinol Activity Equivalent*

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Some Useful Bio-chemical informations

Table 9 : Abbreviation of Amino Acids

A	Ala	Alanine
B	Asx	Asparagine or Aspartate
C	Cys	Cysteine
D	Asp	Aspartate
E	Glu	Glutamate
F	Phe	Phenylalanine
G	Gly	Glycine
H	His	Histidine
I	Ile	Isoleucine
K	Lys	Lysine
L	Leu	Leucine
M	Met	Methionine
N	Asn	Aspargine
P	Pro	Proline
Q	Gln	Glutamine
R	Arg	Arginine
S	Ser	Serine
T	Thr	Threonine
V	Val	Valine
W	Trp	Tryptophan
X	-	Unknown or nonstandard amino acid
Y	Tyr	Tyrosine
Z	Glx	Glutamine or Glutamate

Asx and Glx are used in describing the result of amino acid analytical procedures in which Asp and Glu are not readily distinguished from their amide counterparts, Asn and Gln.

Table 10 : Elements Required in Human Nutrition

Bulk Element:
Calcium
Chlorine
Magnesium
Phosphorus
Potassium
Sodium
Trace Element:
Copper
Fluorine
Iodine
Iron
Manganese
Molybdenum
Selenium
Zinc
Other Trace Element known to be essential in animals and very likely essential for Human
Arsenic
Chromium
Nickel
Silicon
Tin
Vanadium

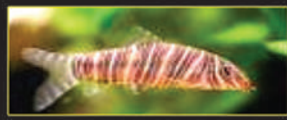


Table 11 : Some Inorganic Elements that Serve as Cofactors for Enzymes

Cu^{2+}	Cytochrome oxidase
Fe^{2+} or Fe^{3+}	Cytochrome oxidase Catalase, peroxidase
K^{+}	Pyruvate kinase
Mg^{2+}	Hexokinase
	Glucose 6- phosphate Pyruvate kinase
Mn^{2+}	Arginase
	Ribonucleotidase reductase
Mo	Dinitrogenase
	Nitrate reductase
Ni^{2+}	Urease
Se	Glutathione peroxidase
Zn^{2+}	Carbonic anhydrase Alcohol dehydrogenase Carboxypeptidases A & B DNA polymerase

Table 12 : List of Vitamins and Deficiency Diseases

Vitamin	Chemical Name	Source	Metabolic Function	Recommended Dietary Allowances (age 19-70)	Deficiency Diseases
Fat soluble Vitamins					
A	Retinol, Retinal, retinoic acid	Cod liver oil	Co-enzymatic Pro-hormonal	900μg	Night-blindness and keratomalacia
D	Ergocalciferol (D2) Cholecalciferol (D3)	Cod liver oil	Pro-hormonal	5.0-10 μg	Rickets and Osteomalacia
E	Tocopherol	Wheat germ oil and liver	H+/e- transfer	15.0mg	Mild hemolytic anemia in newborn infants
K	Phylloquinone (K1) Menaquinones (K2)	Alfalfa	Co-enzymatic H+/e- transfer	120 μg	Bleeding diathesis
Water soluble vitamins					
B1	Thiamine	Rice bran	Co-enzymatic	1.2mg	Beriberi
B2	Riboflavin	Eggs	Co-enzymatic H+/e- transfer	1.3mg	Ariboflavinosis
B3	Niacin Niacinamide	Liver	Co-enzymatic H+/e- transfer	16.0mg	Pellagra
B5	Pantothenic acid	Liver	Co-enzymatic H+/e- transfer	5.0mg	Paresthesia
B6	Pyridoxine Pyridoxamine Pyridoxal	Rice bran	Co-enzymatic	1.3-1.7mg	Anemia peripheral neuropathy
B7	Biotin	Liver	Co-enzymatic	30.0 μg	Dermatitis
B9	Folic acid, Folinic acid	Liver	Co-enzymatic	400 μg	Birth defects, neural tube defects
B12	Cyanacobalamine	Liver	Co-enzymatic	2.4 μg	Megaloblastic anemia
C	Ascorbic acid	Lemons	H+/e- transfer	90.0mg	Scurvy

Eutropiichthys vacha

Gudusia chapra

Puntius binotatus

Puntius sophore

Danio devario

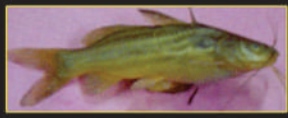
Pseudambassis lala

Puntius chola

Garra gotyla gotyla

Setipinna phasa

Puntius Jayarami



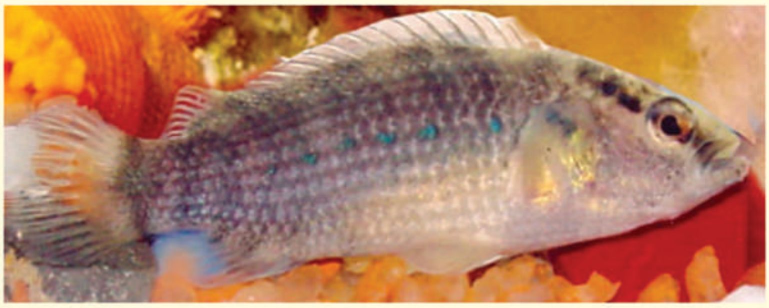
Barilius Barila

Channa striatus

Mystus cavasius

Heteropneustes fossilis

Channa orientalis



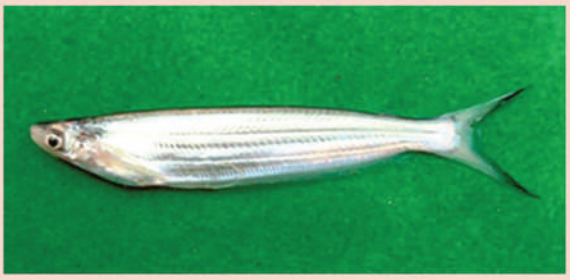
Esomus danricus

Nemacheilus corica

Badis badis

Corica soborna

Botia dario



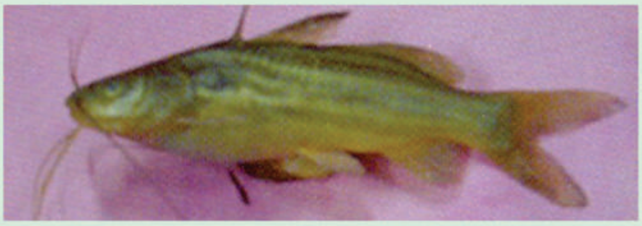
Botia lohachata

Pacudeupropius atherinoides

Anabas testudineus

Botia dayi

Ailia coila



Parluciosoma daniconius

Mystus vittatus

Batasio batasio

Rasbora daniconius

Puntius chagunio

Puntius titteya

Berilius barila

Salmostoma bacaila

Puntius conchonius

Aplocheilus panchax

Xenentodon cancila

Colisa lalia

Barilius bendelisis

Otolithoides biauritus

Deverio devario

Brachydanio rario

Lepidocephalus guntea

Aorichthys aor

Channa orientalis

Stigmatogobius sadanundio

Mastacembelus armatus

Amblypharyngodon mola

Puntius terio

Sicamugil cascasia

Boleopthalmus boddarti

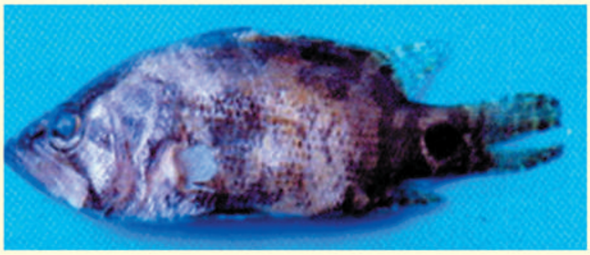
Ompok pabda

Puntius phutunio

Puntius sarana

Puntius oligolepis

Puntius semifasciolatus



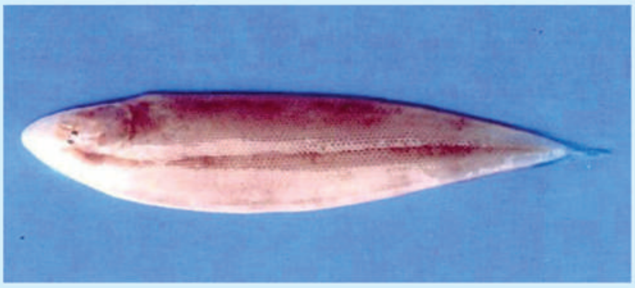
Puntius gelius

Channa punctatus

Nandus nandus

Gagata cenia

Clupisoma garua



Mystus gulio

Cynoglossus lingua

Osteobrama belangeri

Euryglossa orientalis

Pseudapocryptes lanceolatus

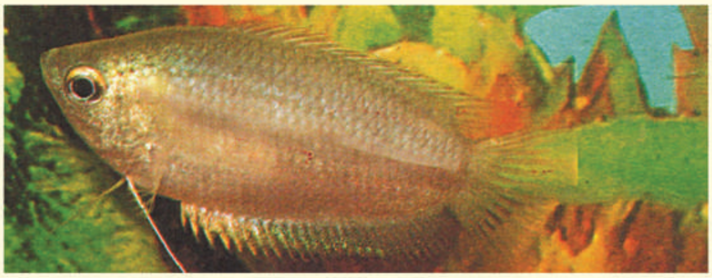
Channa punctatus

Silonia silondia

Pama pama

Laubuca laubuca

Puntius manipurensis



Mystus tengara

Colisa sota

Anodontostoma chacunda

Osteobrama neilli

Puntius lateristriga

Nangra viridescens

Puntius conchonius

Colisa fasciata

Puntius tetrazona
Pnntius pentazona
Osteobrama cotio
Polynemus paradiseus

Publications from Outreach Activity (#3):

Nutrient Profiling and Evaluation of Fish as a Dietary Component

Contribution No.	Publication details
1.	Fish as Health-Food (Folder), CIFRI, Barrackpore, 2010
2.	Nutritional Significance of Small Indigenous Fishes in Human Health. B. P. Mohanty, B. K. Behera and A. P. Sharma. Bulletin No. 162, CIFRI, Barrackpore. p.73. 2010. ISSN 0970-616X.
3.	Nutrient Profiling of Fish. T. V. Sankar, S. Mathew, R. Anandan, K. K. Asha and B. P. Mohanty. CIFT, Cochin. p.61. 2010. ISBN 978-81-905878-3-9.
4.	Therapeutic Value of Fish. B. P. Mohanty, D. Sudheesan, M. K. Das, A. P. Sharma. Bulletin No. 170, CIFRI. Barrackpore. 2011. ISSN 0970-616X.
5.	Indian Shad Hilsa: A Rich Source of ω-3 PUFAs. B. P. Mohanty, Soma Das, M. K. Das, U. Bhaumik and A. P. Sharma. Bulletin No. 171. CIFRI, Barrackpore. 2011. ISSN 0970-616X.