CHAPTER-I

Introduction

1.1 Introduction

Study of nutritional qualities of small fishes is an important aspect in context with life food security. Fish is one of the important sources of animal protein and also many nutrients which are essentially required in human diets (Fawolee et al., 2007). Fishes are consumed by large number of population throughout the world. Fish tissues contain fats, proteins, vitamins, minerals and many other vital components of balanced diet (Stancheva et al., 2010). Vital nutritional components of human body are provided by the fish food. Fishes play the key role of energy supplement for the human beings (Ojewola 2006; Suthershiny 2011). Fish proteins are easily digestible and stated to be the supplement of the protein needs of human body (Abdul et al., 2012). Nutritionists recommend that people should include fish in their daily diets (Blanchet et al., 2000; Balk 2004). Risks of life threatening diseases like cancer, dementia, Alzheimer's disease (Grant, 1997) are minimized by the regular consumption of fish. The defence mechanism for protection against invasion of human pathogens is increased by the intake of fish in human diet due to the presence of antimicrobial peptides (Ravichandran et al., 2010). Breast feeding mothers who consume fish regularly are blessed with babies having better eyesight. It may be due to the omega-3 fatty acids transmitted to breast milk. Fish foods prevent the cardiovascular diseases (Cahu et al., 2004). Fishes are enriched in vitamins and minerals equally required for both young and old age people (Edem 2009; Meghadedan et al., 2007). Fishes show an excellent role in the prevention of kwashiorkor and marasmus, a chronic disease originated by the protein-calorie malnutrition (Mahanty et al., 2012). Many of researchers studied that fish oil contain high amount of poly unsaturated fatty acids that are essential in lowering the serum cholesterol for the prevention of coronary heart diseases (Nordov et al.,2001; Turkmen et al.,2005).Many researchers concluded that fish oil may be used in the treatment of dis-lipidemia in diabetes. Consumption of fish during pregnancy plays the role of reducing the risk of delivering premature baby (Olsen & Secher, 2002). Fish food is enriched in good quality and highly digestible proteins made of ten essential amino acids in required quantities for human consumption. It had been scientifically inferred by many studies that fishes contain important omega-3 fatty acids ,vitamins A,B,D&E and also many vital minerals like iron, copper, iodine, calcium, zinc, potassium, phosphorus which are essential food supplements for adults as well as infants (Ackman et al.,1988; Huss,1988; Owaga et al., 2010;Salito et al.,1997). Fish industries might be assumed to contribute positively towards the prevention of food insecurity if they are scientifically developed (Owaga et al.,2010).

According to (CSIR, 1962) fish flesh contains upto 15-25% protein, 80% water,1-2% mineral matter. As per (FAO, 1991) report it was established that fish contains 72% water,19%protein & 5% calcium . In amounting the weight of food consumed, fish stands in the third position after rice and vegetables (Minkin et al., 1997; Hels et al.,2002). Rice donot contain the nutrients like Vitamin A and C. The minerals such as iron, calcium, zinc and iodine are also not obtained from rice. These must be obtained from other sources. Small fishes are eaten whole with bones and heads ,the organs rich in calcium iron and zinc..The small indigenous fishes were investigated to be the key source of vitamin A (Thilsted et al., 1997). They show a great importance as a vital source of micronutrients as like as calcium, zinc, iron and fatty acids (Roos et al., 2003) to the rural poor people as well as an opportunity for livinghood of many fishers. Nutritional and medicinal knowledge about these fishes are traditionally high amongst the villagers. Such species are considered as very important part of the diet for a pregnant lady or lactating mother in the rural area. The scientific information about the small fishes is most essential for quality control purposes in the processing industries (Ray et al., 2014). Fishes are not only used as food but also highly demanded for use as feed (Daniel et al., 2015). Fish meat is found to contain low lipid and high water as compared to the beef or chicken (Nestel et al., 2000). Fish lipids are prime source of long chain polyunsaturated fatty acids which cannot be synthesized by human body (Alasalvar et al., 2012) . These polyunsaturated fatty acids are reported to be effective in the prevention of arterial hypertension, cancers and inflammatory diseases (Turkmen et al., 2005). The analysis of biochemical composition of the freshwater fishes is very important for the nutritionists. They are in search of most abundant sources of foods of low cost and containing high protein as the fresh species of small fishes (Mozaffarian et al., 2003; Foran et al., 2005). The proper estimation of nutrients contained in the fishes are of high interest to the food scientists who undergo researches in developing them into high grade animal protein ensuring the best quality flavor, colour, odour, texture and safety obtainable with maximum nutritive value (Elagba et al.,2010). Proximate composition is the analysis of water, ash, protein and fat contents of fish (Ali ,2012) . For centuries, fishes are recognized as a perfect diet for human being because of having higher contents of unsaturated fatty acids, essential amino acids and important minerals for the formation of functional and structural proteins (Kumar, 1992) . Most of the essential nutrients for the high health status of human body are provided by fish (Andrew, 2001). In India fishes play a significant role for the livelihood baskets. Small indigenous fishes are very much enriched in nutrients. Previously these small fish species were overlooked for their low price and commercial unimportance. In present time, they receive good interests by the researchers and are included in planned farming as well. The small fishes are the source of protein and most of the fat soluble vitamins for the rural poor people (Hossain & Afsana, 1999).

The lacking in sufficient protein is the major nutritional deficiencies in many tropical countries (Eyo, 2001). Fish meat contains all of the essential amino acids. The protein content of fish have its importance in the qualitative analysis & texture of fish meat (Mozid , 2001).Fishes are energetic in the form of lipids. Good amount of polyunsaturated fatty acids in the fish oil help in reducing the serum cholesterol which prevent many coronary heart diseases. Generally marine fishes contain more minerals than fresh water fishes (Omotosho, 1995). The n-3 PUFAs are greatly used for neurodevelopment, brain functioning and eye health for the infants (Conner, 2000; Gokce, 2004). The fishes under the extensive and semi intensive conditions have higher nutritive values for human consumption in comparison to the ones found in the wild (Ahmed et al., 2012).

Fishes are one of the stable items in the diet of many people. India stands in the ninth position as the country of fresh water mega biodiversity (Mitterneier & Mittermeier, 1997). The northeastern region of India is declared to be one of the hotspots of fresh water fish biodiversity in the world (Kottelat & Whitten, 1996; Ramanujam et al., 2010). The state of Assam forms about 30% of the north east region and is enriched with Brahmaputra and Barak system with a number of tributaries.

Fish quality is measured by the nutritional excellence possessed by the fish (Kaiser et al., 2017). Fish have the energy gradient in the form of lipids. The amount of protein in fish muscle is generally 15 to 20 percent (Anusuya et al., 2014). Normally the nutritional values of a freshwater living fish detoriates when it is cooked with salt (Farid et al., 2016). A set of complex biochemical procedures occur during salt ripening of fishes and these physicochemical changes evaluate the total sensory qualities of salted fish products (Farid et al., 2016). Fish feed makes about halves of the total cost of fish production (Craig et al., 2002). Sustainability of the industry of aquaculture mainly depends on the sources of feeds and management (Magondu et al., 2016). Besides the nutritional value, fish is an excellent source of income (Teame et al., 2016). Generally, the knowledge about the chemical composition of fish species is essential to the concerned nutritionists with easily available sources of low fat, high protein foods. In general, the composition of live-weight, whole fish is 70-80% water 20-30% protein and 2-12% lipid (Das & Sahu, 2001). Quantification of the proximate profiles of a fish ensures their ability to meet up the need of food regulations and commercial specification. The scientific documentation of biochemical composition is very important to calculate the energy value of the fish such that properly planning is done for the sake of industrial us well as commercial processing (Tsegay Teame et al., 2016). Fish are one of the cheapest sources of protein enriched with almost all the essential amino acids (Funmilayo, 2016). The amino acids are vitally needed for foctal development and growth. Dietary protein and the amino acids are required mainly for growth, metabolism and maintenance especially in young ones (Adefemi, 2011). The essential amino acids are the first indicator of protein quality (Chukwuemeka, 2008). The nutritional as well as medicinal status of fish products are highlighted by the contents of proteins, lipids, minerals and vitamins (Njinkoue et al., 2016). The fair contents of protein present in the fish flesh make them Biologically valuable (Salma et al., 2015). Being one of the potentially significant sources of health nutrients, fish is vitally important for diversified and healthy diets (Karl et al., 2016). For the rapid rise in population and environmental fluctuations, the aquatic lives are in crisis. As a result the gap between the demand and supply of fish is maximized. The poor people can not include the fishes in their regular food item (Mazumder et al, 2016). Generally, fish is low in saturated fats, carbohydrates and cholesterol.

Fish species are able to increase the biomass within a shorter time period. Rather than omega-3- fatty acids, fish lipids also contain fat soluble vitamins which are exclusively provided by the fish food. Omega-3 and Omega-6 fatty acids jointly play a vital role in the development of brain function and acceleration of the normal growth. Polyunsaturated fatty acids (PUFAs) enhance skin and hair growth, smoothens bone and reproductive health and help in regulating metabolism process (Stancheva et al., 2010) . The nutritive qualities of the fishes are known by the knowledge of its amino acid composition (Romharsha, 2014). Fish also contains a good bundle of lysine which is low in cereal, milk or any other foods (FAO, 2005). Fish food provides the important minerals including selenium, calcium, iron, phosphorus etc.

Fish makes up almost half of the total number of vertebrates in the world. India is one of the mega biodiversity countries in the world (Mittermeier & Mittermeir., 1997). The northeast part of India has been specified as a hotspot of biodiversity by the World Conservation Monitoring Centre (WCMC, 1998). The hills and the undulating valley of the northeast region creates many torrential hills streams leading to popular large rivers that constitute part of the Ganga-Brahmaputra-Barak-Chindwin-Kolodyne-Gomatie-Meghna system (Kar., 2003).The conservation Assessment and Management Plan Workshop (Molur & Walker, 1993) made valuable contributions to assess the status of selected fishes of northeast India. However no detailed systematic fish inventory has been available on the ichthyo fauna of Kokrajhar district BTAD, Assam.

Adverse effect of environment, climate changes, increasing water temperature (Parihar & Dubey, 1995) are declining the water level of different rivers, ponds and other water bodies (Dubey et al., 2011).Tremendous use of pesticides and xenobiotic compound (Dubey,1995) negatively fall on the fish communities. The fisheries productivities are affected by the city garbages and garlanding in the aquatic bodies. The number of fish species in the aquatic ecosystem is declined. Recently many new species have been documented from the states of northeast India (Sen & Biswas, 1994; Biswas, 1997; Menon, et al 2000; Vishwanath & Shanta., 2004) opening the scope for exploring on the nutritional qualities of the fishes. The fish food is included in the diet of almost all the communities of all religions of the country. The analysis of the quality of fish food will ensure the people about their food values and the required quantities of consumption of fish foods in different age groups. Although many more researches have been done on the nutritional status of fish foods, but less studies have been reported so far on the small fish species.

The present study mainly aimed at the study of the nutritional contents of the small fish species available in the Korkrajhar district BTAD, Assam. These fishes are commercially unexploited. The well known popular large fishes are mostly attractive to study and also to exploit from the commercial point of view. Due to their high price they are not affordable by the common people, specially the poor villagers. They consume the small fishes deliciously and also sail in market to maintain their livelihood.

The nutritional composition of fish varies largely from one species to another species depending on age, feed intake, sex and sexual changes connected with spawning the environment and season. Fish belongs to high protein and low lipid class. According to the research studies fish foods contain low caloric content per unit of protein than do lipid and they provide the animal protein for use in contolled diets (Silva et al., 1991)

Small indigenous fish species are defined as these of having maximum length of 25cm (Felt et al., 1998; Roos et al., 2003). In many parts of the world including India, a large diversity of small fishes are found in open waters and closed water bodies. The small indigenous species are reachable to the poor and rural classes of the country due to their low price and maximum availability. Researchers suggest that these are major source of protein and micro-nutrients like calcium, zinc, iron and fatty acids (Roos et al., 2003). In many parts of our country basically amongst the rural societies, such species are often considered as essential part of the diet of pregnant woman and lactating mothers. Moreover the fish species also posses several antioxidant activity (Ray et al.,2014). The small fish species are thus excellent sources of nutrient and antioxidant. Fish flesh is easily digestible due to its long muscle fibres. Fish foods have been linked to health benefits like some types of cancer, including colon, breast and prostate (Marchioli et al., 2002; Sidhu et al., 2003).

1.2 Structure of fish muscle

Fish muscle is comprised of moisture, protein and fat as a major nutrient components and carbohydrates, vitamins and minerals as minor components. That is why most of the nutrient components essential for human body is found in fish muscle. Animal protein is associated with ten essential amino acids in desirable quantity for human consumption. Fish protein is enriched with such amino acid as methionine, lysine and low in tryptophan in comparison to mammalian protein (Nowsad, 2007).

The diagram of a cod fillet reveals the surface that is adjacent to the skeleton. The mechanical construction is typical of all white fish in which the fat is stored in the liver. The blocks of muscle forming the individual flakes in the cooked fish are separated by connective tissues.These are curved in the fillet running from the backbone to the skin. The muscle blocks in a fresh fish are tightly attached to the connective tissues and the surface of a cut fillet is finely smooth. There are also tiny blood vessels which run through the muscle .Out of the total weight of the muscle the connective tissue makes for only a small percentage .This may be the reason of why fish is softer to eat than meat.

There are two kinds of fish muscle , light muscle and dark muscle. In white fishes there is a small strip of dark or red muscle under the skin on both sides which run beneath the lateral line .In fatty fishes the strips of dark muscles are larger in proportion containing higher concentrations of fats and vitamins. When fishes are prepared for cooking it is not usually possible to separate the dark fatty muscle from light muscle.

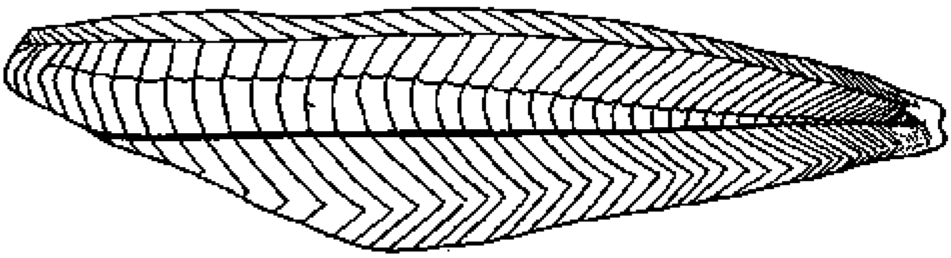


Fig.: 1.1 Fish muscle

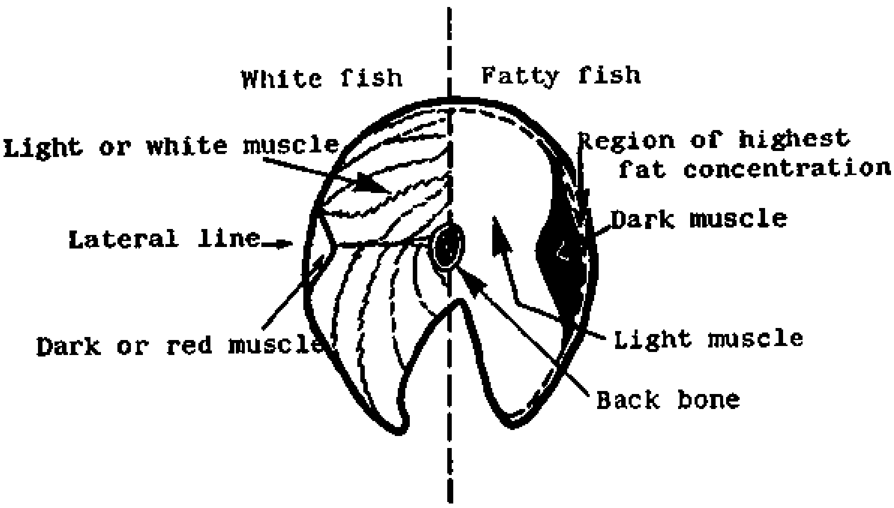


Fig. 1.2 White Fish muscle (FAO CORPORATE DOCUMENT REPOSITORY)

Fisheries especially provide food when other food sources are at a seasonal crisis (Babalola et al., 2011). Moreover, consumption of fish has been related to health benefits as the long chain PUFA is of great attention in the field of prevention of human coronary artery diseases, improvement of retina and brain development, decreased incidence of breast cancer, rheumatoid, arthritis, multiple sclerosis, asthma, psoriasis, inflammatory bowel disease and regulation of prostaglandin synthesis (Dhaneesh et al., 2012). Recent studies have shown that fish protein is said to be of excellent quality with a higher biological value. Fishes play a significant role in the development of neuron in infants and in fat glycomic control (Mozaffarian et al., 2005). It had been estimated that about 80% of the animal protein in our diet comes from fish (Begum M et al., 2010).

1.3 Principal components of fish muscle

The principal components of fish muscle are –

Water- Approximately 80% of the weight of a fresh fish fillet is constituted by water but average content of water of fatty fish is about 70%. In fresh fish muscle the water content is strongly bound to the proteins and cannot be easily removed even under higher pressure. However, some of the water contents may be lost which contains dissolved substances. When the spawning time approaches in the living fishes, water contents increases where as protein content decreases

Protein- Approximated protein contents in the fish muscle are usually 15 to 20%, but in some rare species the values are lower than 15% or higher than 28%. Some of the amino acids are essentially required in human diet for the good health. Moreover, for the economic utilization of a diet, amino acids must be present in requisite proportions. Fish proteins are generally enriched in two essential amino acids called lysine and methionine. Thus fish food provides good nutritional requirements to human diet and is favourably compared with that provided by meat, milk and eggs.

Fats- The ratio of highest to lowest fat values is more than 300 to 1 (FAO, 2001). Fatty fishes usually show remarkable seasonal variations in the fat content. The water content of a fish generally falls with the rise in fat content maintaining a constant value between the sum of water and fat values at about 80%. But the protein content of a fish is directly proportional to the fat content. The fat values of fatty fishes are not distributed uniformly throughout the flesh of the species. The fat content of the muscle of a white liver is usually below 1%.

The minor components of fish muscle includes-

(i) Carbohydrates
(ii) Minerals & vitamins

Carbohydrates- In white fish muscle carbohydrate content is generally too small to play a significant role in the human diet.

Minerals &Vitamins- Minerals & vitamins have vital importance in the human diet not only to upgrade a good health but also for the maintenance of life itself. Fish provides well balanced set of minerals in usable form. There are two groups of vitamins. Some are fat soluble such as Vit A, D, E & K and some are water soluble such as Vit B & C.More or less all the vitamins, required for the good human health are present in fish.

1.4 Proximate Composition of Fish:

Proximate analysis mainly focuses on the quantification of several nutritional contents of fish. The nature and quantity of nutrients in most animals is dependent on their feeding habits. The nutritional characteristics of fish product are of keen interest to consumers. The flesh of fish in good condition is consisted of five main chemical component as protein, lipid, water, mineral and vitamins.

Proximate analysis are experimented adopting several standard methods to estimate vital components of nutritional status of fish; such as moisture, protein lipid and ash. The nature and quantity of nutrients in most animals are dependent on their feeding habits. The nutritional characteristics of fish product are of keen interest to consumers.

Fish fillet is comprised of many components such as moisture, lipids, proteins, vitamins and minerals. All of them contribute towards the total meal composition. The composition of fish body is affected by both exogenous and endogenous factors (Huss, 1995). The exogenous factors affect the body composition as well as the diet of the fish (composition, frequency) and also their existing environment (salinity, temperature). A number of researchers examined the influence of temperature, light, pH and the oxygen concentration on the proximate composition of fish. The endogenous factors are genetic and linked to the life stage, size, age, sex and anatomical position in the fish (Huss, 1995).

1.5 Fatty acid Profile:

Fish gains importance from medical point of views also. Previous researchers reported the presence of high content of polyunsaturated fatty acids (PUFA) in the fish flesh and fish oil which make them beneficial in decreasing the serum cholesterol.(Stansby., 1985).The PUFAs are very much effective for an age related disease like macular degeneration(AMD) in elderly (Johnson et al.,2006).For the paediatric population, the PUFAs are essential in the prevention of asthma ,a major health problem (Artemis et al., 2002).Poly unsaturated fatty acids are also vitally important for another health problem ,attention–deficiency hypatic disorder (Meyer et al .,2009). Fish lipids are the prime sources of polyunsaturated fatty acids (PUFAs) especially eicosapentaenoic acid (EPA; C_{205}) and docosahexaenoic acid (DHA; C_{226}) (Osamam et al., 2015). These two essential fatty acids cannot be synthesized by human body and hence should be obtained from the diet.

Lipids & fatty acids play a vital role in membrane biochemistry and directly linked to the membrane-mediated process in human such as osmoregulation, nutrient assimilation and transport (Haliloglu et al., 2004). Lipids are major sources of metabolic energy and essential for the formation of cell and tissue membrane (Babu et al., 2010). Fatty acids in fish oil are vital source of omega-3-fatty acids, which play a significant role in human nutrition, disease prevention and health promotion (Frenous et al., 2014).

The specific knowledge of fish composition is essential for its scientific utilization. Fish meat contains significantly low lipids and higher water content than beef or chicken and hence favoured over other white or red meats (Neil, 1996; Nestel, 2000).

Many evidences suggested that fish meat and oil is enriched with high amount of polyunsaturated fatty acids which are important in lowering the serum cholestoral to prevent the coronary heart disease (Nordev et al., 2001; Turkmen et al., 2005). Consumption of fish promotes the defence mechanism for the protection against invasion of human pathogens because fish food contains antimicrobial peptide (Ravichandran et al., 2010). Fishes can reduce the risk of developing dementia, including Alzheimer’s diseases (Grant, 1997). Fish fed mothers can give birth to healthy babies. The omega-3-fatty acids are transmitted to breast milk. Fish oil holds good in treating dys-lipidemia in diabetes (Friedberg et al., 1998). Consuming fish during pregency reduce the risk of delivery of a premature baby (Olsen and Secher., 2002).

Polyunsaturated fatty acids (PUFA) have been recognized as important substances with beneficial properties for the improvement of visual function (Carlson et al., 2013).Fish oil is rich in (PUFA). Fish is referred to as the ‘rich food of the poor’ (Béné et al., 2005). India is one of the 17 global mega biodiversity hot spot. This country is native place to many freshwater fish species. About 450 species, out of the 765 fresh water species are categorized as small indigenous fishes, defined as fish that grow up to 25-30 cm in length. The small fish species are of huge demand of different communities of the country. In the last few years the interest for quality of food, dietary fats as well as their effects on human health has been significantly increased. It is commonly known that the diet having low fatty acids is always healthier but for the sake of both proper development and perfect functioning the human body is in need of a specific amount of fats (Bratu et al., 2013).

The intake of foodstuffs which include large contents of saturated fatty acids is associated with major health problems like as heart disease, diabetes, cancer, therefore the diet must contain unsaturated fatty acids. PUFA, especially W-3 fatty acids (DHA, EPA) are known as essential fatty acids as the human body cannot synthesize them and hence they must be provided from the diet (Fournier et Al., 2006). Fishes are regarded as the main natural source of essential fatty acids in human diet (especially EPA and DHA). Fish oil is studied to have the highest amount of w-3 PUFA (Rodrigueng et at., 2010; Mbatia et al., 2010; Russo et al., 2009).

1.6 Amino acid profile of Fish:

In most third world countries, food insecurity is one of the alarming issues of national concern (Owage et al., 2010). Fish food is enriched with high nutritive value especially high quality edible protein comprised of the ten essential amino acids in acceptable contents for the human consumption. Fish meal provides essential omega 3 fatty acids, vitamins A, B , D and a lot of minerals as like as Calcium, Potassium Phosphorous, iron, copper and iodine needed for both infant and adult food supplements. (Owaga et el., 2010; Saito et al., 1997).For this, the fish industries are regarded as very important sector. It contributes to the alleviation of food insecurity (Owaga et al., 2010). Incidentally, small fishes are admired in all classes of the society due to their good taste, high availability and definitely for their comparatively low price. These small fishes are nutrient dense and sometimes overlooked (Roos et al., 2007).

The fish products are the most important sources of animal proteins in the human diet. It includes all the ten essential amino acids in permitted quantity for human consumption. Fish protein is enriched with methionine, lysine and low with tryptophan compared to mammalian nutrients required for supplementing infant as well as adult diets (Abdullahi et al .,2001). Fish proteins are rich in essential amino acids (EAA) and needed for the acceleration of growth, reproduction and synthesis of vitamins

1.7 Mineral Profile :-

Developing countries face challenges by nutritional problems due to poverty, natural disasters, political imbalances (Mogobe et al., 2015). The chemical elements which are needed for the normal maintenance of the human body are known as essential elements in human nutrition (Jiang et al., 2015). These elements take part in many biochemical reactions viz Calcium, magnesium and phosphorus are vitally important in the formation of bones and teeth; sodium and potassium jointly work in the transmission of nerve impulses and controlling the electrolyte balance; zinc is mainly found as a cofactor in enzyme reactions, iron forms part of the haemoglobin molecule which carry oxygen throughout the body (Alas et al., 2014; Ansah et al., 2012). Human being may suffer from many diseases like anaemia, osteoporosis, goitre, stunted growth and genetic disorders etc. caused by mineral deficiencies (Bhandari & Banjara, 2014; Fumio et al., 2012; Asieh et al., 2011; Watanabe et al., 1997). As per the report of the WHO, about 2 billion of the world’s population are being suffered from mineral as well as vitamin deficiencies and the majority of them belong to the third world countries (FAO/WHO, 2001). Micronutrient deficiencies are highly pronounced in the populations of developing countries (Kawarazuka & Bene, 2011). Fish stores minerals in the head and viscera, so, the small fishes which are eaten whoel, may have a significant contribution towards micronutrients intakes (Mogobe et al., 2015).

1.8 Fish diversity

The Northeast India has a unique topography and watershed pattern and hence an attractive field for ichthyological studies. This part of India is identified as a global hot spot of freshwater fish diversity (Koltelate & Whitten, 1996). Recently many new species have been documented from the status of northeast India (Sen & Biswas, 1994; Biswas, 1997; Menon et al., 2000; Vishwanath & Shanta, 2004) opening the scope for exploring on the nutritional qualities of the fishes. The fish food is included in the diet of almost all the communities. A lot of works has been done on the nutritional status of fish, but only few attentions glimpsed on the small fish species. All around the country it is evidenced that the small fishes of low market cost, are consumed mostly by the common people due to their availabilities in all seasons.

In India rivers make the backbone of capture fisheries. Including major and minor, at least 113 rivers are there in this country (Baro et al., 2014). A mixture of distinctive habitats in a river qualify it one of the most productive eco system on the mother earth (Das & Sharma, 2012). Due to the presence of number of endemic fish species, the North East India is familiar as ‘Global hotspot’ for fish faunal diversity (Baro et al., 2014). An area of 101232 ha of Assam, India is covered with fresh water wet lands. The nearest wet lands are the only source of fish for the rural poor people (Baruah et al., 2000). The nutritional aspects of fish species available in the local wet lands were chosen for the topic of study in the present work. The proper information of the nutritional values of these small fishes may increase their market value and these might be commercially more exploited.

1.9 Scope of studies:-

The Kokrajhar district is enriched with many ponds, beels, wetlands and water tanks. The lion’s share of total fish production originates from diplaibeel, Gour beel, Haloidal beel and above all the Gauranga river. Its strategic location is blessed with beautiful forests with flora and fauna.

The knowledge of the nutritional quality of the small fishes will make the door open to study about the extent of potentiality of the small fish species. It will open the door to the researches to investigate the advantage and disadvantage of consuming the small fishes. The present work will make the local people aware of the nutritional values of the fishes they consume. The studies on nutritional contents of small indigenous fishes are important to assure the local people about the vital role of this small fish on the human health and also to highlight the excellence of these fishes as a useful product for commercialization. The small fishes are widely appreciated by the poor villagers due to ease of their availability in the local water bodies like ponds, beels and many other wet lands. The small species are sometimes overlooked and are not commercially explored to a large extent as compared to the costly popular large fishes. The health condition of the poor people is mainly concerned to the food values of the most available natural species. Quantification of the nutrients of small selected fishes will ensure the common people about their benefits. It will help the nutritionists and dieticians to provide 'dietary guidelines' for the well being of the society (Mahanty et al., 2011). The research work on this area will make the community forwarded to adopt the necessary measures for the sustainable development of the aquatic resources. The local people would become serious enough to take all the necessary measures to protect the tiny creatures.

1.10 Aims and objectives of the research:

The aims and objectives of the present work are pointed out as below:

(i) To study on the proximate composition of selected small fish species from Kokrajhar BTAD, Assam;

(ii) To estimate the amino acid profile of the selected fish species.

(iii) To find out the fatty acid, mineral and vitamin contents of the selected small fishes.

(iv) To study the diversities of small fish species in Kokrajhar BTAD, Assam and their habitat quality

(v) To highlight the nutritional importance of selected small fishes to the consumers.

CHAPTER-II

Review of Literature

2.1 Review of Literature:

Fish species had received tremendous attention to the researchers due to the excellence in its nutritional aspects. In the age of globalization the entire world speaks in harmony specially in the field of research works. Experimental horizon broadens the natural resources with a vision to construct a healthy world in a healthy environment.

Fish have high nutritive value enriched with essential nutrients, unique protein content of high quality and easy digestibility. Fish contains essential and non essential amino acids in desirable quantities. Important omega-3-fatty acids, vitamins A, B, D and a variety of minerals such as calcium, phosphorus, potassium, iron, copper and iodine needed for supplementing both infant and adult diets (Owaga et al., 2010). Fish meat and oil contains high amount of polyunsaturated fatty acids that are important in decreasing the serum cholesterol leading to prevent coronary heart diseases and lowering the risk of Alzheimer’s diseases and also the risk of developing dementia. Regular consumption of fish promotes the defence mechanism, against invasion of human pathogens due to the presence of antimicrobial peptide in the fish food. (Ravichandran et al, 2010)

2.2 Literature survey in International background:

Fish consumption is of growing importance because it provides the high content of health significant omega-3-PUFAs, particularly eicosapentaenoci acid (20:5n-3, EPF) and dicosahexaenoic acid (22:6n-3,DHA) (Elvevoll et al., 2000).

Varljen et al., 2003 studied on lipid classes and fatty acid composition of *Diplodus vulgaris* and *Conger canger* originating from the Adriatic Sea. Their study reported that both fish species contain appreciable levels of n-3-polyunsaturated fatty acids (PUFA) and would be suitable for highly unsaturated low fat diets.

Nazeer et al. 2008 reported that a major content of lipid was accumulated in liver (6.22%) when compared with remaining organs like muscle (2.7%) and skin (1.0%). However, the muscle contained more cholesterol than liver and skin. The vitamin contents and fatty acids composition of Rainbow Trout (*Ondorynchus mykiss*) from the region of Central Bulgaria was investigated by Starcheve et al., 2010. Their study revealed that the lipid fraction contains sustainable amounts of fatty acids and fair contents of fat soluble vitamins (A, E, D_3) in the fresh edible tissues of Rainbow trout.

Sutharshiny et al., 2011 studied on total lipid and cholesterol contents in the flesh of the five important commercial fishes from water bodies around Jaffna Peninsula, Sri Lanka. Similarly, Daniel et al., 2015 studied on proximate composition of three commercial fishes commonly consumed in Akwa IBOM state, Nigeria and pointed out that the studied fishes were rich in crude protein, lipid, moisture and ash needed for nutritional requirements of human being.

Ashraf and co-workers (Ashraf et al, 2011) worked on nutritional values of wild and cultivated silver Carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenapharyngodon idella*). Their study revealed that Grass Carp contained higher protein and lipid contents and lower moisture contents than Silver Carp.

Ahmed et al., 2012 worked on the nutrient composition of indigenous and exotic fishes of rainfed water logged paddy fields in Lakshmipur, Bangladesh. A comparative characterization of lipids and nutrient content of *Pangasius pangasius sutchi* available in Bangladesh was studied by Islam et al, 2012. Minar et al., 2012 studied on proximate composition of hilsa in laboratory condition and found higher fat contents in hilsa fish than many other freshwater fish species.

Chalamaiah along with his colleagues (Chalamaiah et al,. 2012 carried on literature survey on fish protein hydrolysates, proximate composition, amino acid composition, antioxidant activities and applications. The paper highlighted on the excellent fish protein with good amino acid balanced bioactive peptides.

Investigations on total lipid, phospholipid and cholesterol contents of six commercially important fishes of Tulicorin, South east coast of India were done by Immaculate and his coworkers (Immaculate et al., 2013). They ensured that the estimated lipid, phospholipid and cholesterol contents of he studied fishes carry nutritional values.

The identification of fatty acid profile, lipid characterization and nutritional status of *Clarius batrachus* was carried out by Islam and his team (Islam et al., 2013) .*The* result of their study concluded the fatty acid profile of *C batrachus* such that lauric acid (2.6%),palmitic acid (37.41%),oleic acid(49.1%) and stearic acid (3.6%),arachidic acid (3.04%),behanic acid(4.21%) respectively.

The study of proximate compostion and fatty acid profile in some commercially important fish species from lake Kainji, Nigeria was performed by Effiong et al. , 2013. Tasbozen and others (Tasbozen et al., 2013) worked on nutritional composition of spiny eel (*Mastacembelus mastacembelus*) caught from the Ataturk Dam Lake in Turkey .Their investigation concluded that spiny eel is a beneficial source of food supplement for the human health.

Agnes and his team (Agnes et al., 2013) studied on nutritional levels in edible marine fish Paratrnateus niger and its depletion during storage. The study reports revealed the cause of decrease in nutrition quality of the fishes due to microbial activity. Akhirebulu and his team (Akhirerbulu et al., 2013) worked on variation of amino acid and fatty acid profiles of parts of cultured *Helerobranchus bidorsalies* (Geoffroy Saint – Hilaire, 1809). The study revealed that the cultured cat fish should be consumed in whole for the sake of full nutritional benefits.

Abbas et al., 2013 worked on *Notopterus notopterus* and *Rita rita*, the two indigenous small fishes found in India, Bangladesh, Pakistan and other regions of Asia. Ali et al., 2013 went through a research on the biochemical variation among some pond fishes and observed the antioxidant enzyme activities of the fishes to establish environmental impact of toxic effect on anthrogenic pollution on pond.

Alfa in together with his colleagues (Alfa et al., 2014) studied on proximate composition and mineral components of some species of fish sold in Bida Fish market. The study reported a high contents of potassium (K) in the selectd fishes.

Firlianty along with other researchers (Firlianty et al., 2014) investigated on protein profile and amino acid profile of vacuum drying and freeze dying of Famiyhamidae collected

from Central Kalimantan, Indonesia. The study report concluded that the powder products possessed 14 complete important amino acid.

Zhang and colleagues (Zhang et al., 2014) investigated on the lipod contents fatty acid profiles and nutritional quality of nine wild caught freshwater fish species of the Yangze Basin, China. They reported that fatty acid profiles were different among the fish species and they experimentally established the potentiality of the fish species as dietary sources of essential fatty acids from the nutritional stand point.

The research report of Farid et al., 2014 on the fish species Shoal (*Channa striatus*) and Taki (*Channa punctatus),* revealed that studied fresh fish species contained high moisture and low protein contents.

Oromadike (Oromadike., 2015) investigated on the proximate compostion of wild African catfish *chrysichthys nigrodigitatus* (Lacepede 1802). He reported high protein contents and semi high oil contents of the studied species.

Bogard and the group (Bogard et al., 2015) worked on the nutritional composition of important fish species in Bangladesh and potential contribution to recommended nutrient intakes.

The nutrient composition of important fish species in Bangladesh and potential contribution to recommended nutrient intakes were investigated by Bogard and his colleagues (Bogard et al.,2015) The research work concluded significant contributions of small indigenous fishes containing rich nutrient profiles, to the pregnant as well as lactating mothers. Fish foods are beneficial in the development of neuron in infants and in fat glycemic control (Mozaffarian et al., 2015). Moreover, fish has a good contribution towards essential amino acids, specifically lysine which is low in cereals, providing nutritional balance in the quality of mixed diet (FAO, 2005).

Magondu and colleagues(Magondu et al., 2016) carried on growth performance of milkfish (*Chanos Chanos Forsskal*) fed on formulated and non formulated diets made from locally available ingredients in South Coast region, Kenya. The analysed result revealved that the fishes which were fed on formulated diet showed higher mean weight gain than them which were fed on non formulated diets.

Teame et al., 2016 studied on proximate and mineral composition of some commercially important fish species of Tekeze reservoir and lake Hashenge, Ethiopia. Kaisar and team (Kaisar et al., 2017) experimented on quality aspect and heavy metal contents of fresh and dry salted Hilsa (*Tenualosa ilisha*) of Bangladesh. Their work documented that the fish

species Hilsa can be regarded as a fatty fish. The concentrations of heavy metals in the studied fish species were found to be of acceptable range for human consumption.

2.3 Literature survey in National background:

In view of searching about the improvement of health status of the community and upliftment of the commercial potentiality it is important to estimate the nutritional profile of the food fishes available in the entire region of the country. A comparative study about the body composition of different small indigenous species, shoal fish and ilish were performed by Begam and her group (Begum et al.,2010) . They observed that the small fishes contained good nutritional value and not less than the larger fish helping to decresase the nutrient deficiency of the people.

To ensure the maximum utilization of the food fishes the world of biochemistry is investigating for their proximate contents (Ghelichpour and Shabanpour, 2011).

Fishes are highlighted as an important source of Vitamin A, D and E. There are large number of literatures reporting the significance of fish in brain development, and learning in children in protecting vision and eye health, decreasing incidence of breast cancer, rheumatoid arthritis, multiple sclerosis, asthma, psoriasis, inflammatory bowel disease and regulation of prostaglanding synthesis (Dhaneesh et al., 2012).

Jakhar and his team (Jakhar et al., 2012) Andhra Prades, India investigated on four common Indian fishes Catla *(Catla catla*), Rohu (*Labeo rohita),* Magur (*Clarius batrachus)* and Pangas (*Pangasian oclonhypophthalmus*). The result of their studies revealved the importance of fish nutrition in the human diet for preventing many life risk disease like heart problems, cholesterol and many nerve oriented problems. The study concluded that the lipid content of the fishes were inversely related to the moisture contents of the species.

The proximate compostion and macro and micro mineral elements of some smoke-dried hill stream fishes from Manipur, India were studied by Hei and his group (Hei et al., 2012). They documented that the fishes were good sources of minerals, protein and other nutrients needed for the balanced diet of human being.

The study reported that the proximate composition of fish depends on season and also on age, sex, reproducing cycle, breeding season and region of catch.Roy and her colleagues (Roy et al, 2012) studied the bioenergetics and microbial status of leaf fish *Nandus nandus* (Ham, 1822). The study concluded the presence of fair contents of protein in the fish *Nandus nandus.* The fish was documented to be in acceptable range as far as the total microbial flora in the fish is concerned. The fish species were found to feed more in summer than in winter.

The estimation of proximate, amino acids, fatty acids and mineral composition of mullet (*Mugil cephalus*) of Parangipettai, South east coast of India was carried out by Kumaran and co-researchers (Kumaran et al., 2012) . The study documented that the flesh of *Mugil cephalus* contained important w-3 and w-6 fatty acids and hence could be recommended for daily human consumption.

Marichamy and group (Marichamy et al., 2012) experimented on proximate and mineral composition of 12 edible fishes of Parangipettai coastal waters. They ensured the nutrient significance of the fishes for the sake of human health.

Sankar with his group (Sankar et al., 2013) studied the chemical composition and nutritional value of Anchory (*Stalephorus commersonil*) caught form Kerala coast, India. Their analysis demonstrated high nutrient contents of the studied species and also rich in PUFA & MUFA, low sodium, high potassium and calcium. Pawar and team (Pawar et al., 2013) studied on fish muscle protein, highest sources of energy .

The estimation of moisture content in fish species gives the amount of water contained by the fish body. One of the major proximate constituents is the quality of moisture content of the fish. According to Rahman and his group (Rahman et al., 2014) the moisture content was the most abundant composition of the *C. punctatus* and *A. mola* of ponds. The studies of Bijayalakshmi and group (Bijayalakshmi et al,2014) revealed the simalar report of moisture content on the same species.

Ramharsha with the team (Romharsha et al., in 2014) Manipur, India worked on the proximate compostion of some hill stream fishes viz, Neolissochilus stracheyi, Labeo pangusia and semi plotus manipurenls. They reported high protein contents of the species and justified the same by the omnivons feeding habit of the studied fishes species.

According to the research report of Bijayalakshmi and group (Bijayalakshmi et al., 2014) the small indigenous fish species namely *Channa striata, Trichogaster fasciatus* and *Puntuys sophore* contained higher lipid content than the other fish species.

Kumar with his colleagues (Kumar et al., 2014) worked on the evaluation of nutrients in Trash fish, Parangipettai (South east coast of India).Tthe result of the study concluded that fatty acids such as saturated, mono saturated and poly saturated fatty acids were highly present in *Leiognathus dussumiri.*

Ray and his team (Ray et al., 2014) investigated on antioxidant potential and nutrient contenst of selected small indigenous species of fish. The study suggested the presence of appreciable amount of nutrients and antioxidants in the fishes.

Palami and group (Palami et al., 2014) worked on proximate and major mineral compostion of 23 medium sized marine fin fishes landed in the Thoothkidi Coast of India. Their research work reported that most of fishes were rich sources of phosphorus.

Mahanty with the team (Mahanty et al., 2014) studied on proximate composition, amino acid, fatty acid and micronutrient profiles of small indigenous fish *Puntius sophore*:. Their work recorded that the studied fish species was rich in proteins and minerals. The essential amino acids, Histidine was most prominent in that species. Moreover the fish *Puncius sophore* was rich in unsaturated fatty acid, specially oleic acid.Mahanty with colleagues (Mahanty et al., 2014) studied on amino acid composition of 27 fishes and their importance in clinical nutrition. The experimental result showed that the cold water species were rich in lysine and aspartic acid. Marine fishes were rich in leucine while the small indigenous fishes, in histidine.

Vijayakumar and his colleagues (Vijaykumar et al., 2014) studied on the proximate composition of Clupeidae and Engraulidae. The study discussed on the variation of the nutritional contents from species to species.

Debnath and his team (Debnath et al.,2014) worked on protein and mineral compostion of some local fishes of Tripura, India. The selected fish species *Amblypharyngodon mola, Esomus. danricus, Puntius sophore, Channa fasciata, Labeo. bata, Catla catla, Labeo. rohita* and *Cirrhinus. mrigala* were analyzed and the reports concluded that all the fish species were nutritionally competitive even in their dried state. The study revealed that the small indigenous fishes were highly nutritive and these species can assure the nutritional security of the poor classes owing to their low cost and tremendous availability.

Gogoi and groups (Gogoi et al., 2015) studied on Morphometric and meristic study of *Amblypharyngodon mola* from different habitats of Assam. The report revealed no change in meristic counts with increase in body length of the studied fish species.

Anusuya and Hemlata (Anusuya & Hemalatha, 2016) in Tamil Nadu investigated on nutritive composition of *Channa striatus* fish after 2, 4-D pesticide treatment and concluded that there was a detorious effect of 2, 4-D usage in aquaculture vicinity.

CHAPTER-III

Materials and Methods

3.1 The Study Area:

The fisheries, ponds, beels including river of the Kokrajhar district constitute the study area of present work. The districts Kokrajhar covers an area of 3,169.2 Km^2 having a population of 8,86,999 according to census 2011 and population density of 280 per Km^2. Kokrajhar Town is the head quarter of the Bodoland Territorial Council (BTC) located in the extreme north on the north bank of the Brahmaputra river in the state of Assam, in north east region of India, by the foothills of Bhutan. Kokrajhar district is Located at Latitude-26.4^0, Longitude-90.2^0 and having elevation/altitude of 50-43 metres above the sea level. The district shares its border with Bongaigaon District to the East , Dhubri District to the South, Coachbehar District to the west . It is sharing Border with West Bengal State to the west.

Amongst the Tribal population Bodos, Rabhas and less quantity of Garos are the inhabitants in this area. The other communities like Rajbangshis, Sarania, Tea communities, Santhal, Oraon etc. are also resident of BTC. Moreover, other general communities like Bengali, Assamese, Nepali and few numbers of Hindi speaking people are also found in the area.

3.2 Survey on small fish species consumed by the Bodo communities

Some of the Bodo dominated areas of Kokrajhar district were surveyed to know about the small fish species which are popularly consumed by them as food. A set of questionnaires (Appendix-I) had been carried out by interactions with some of the villagers of different age groups. Same types of questions were asked to all of them to get steady information about the highly consumed small fishes.

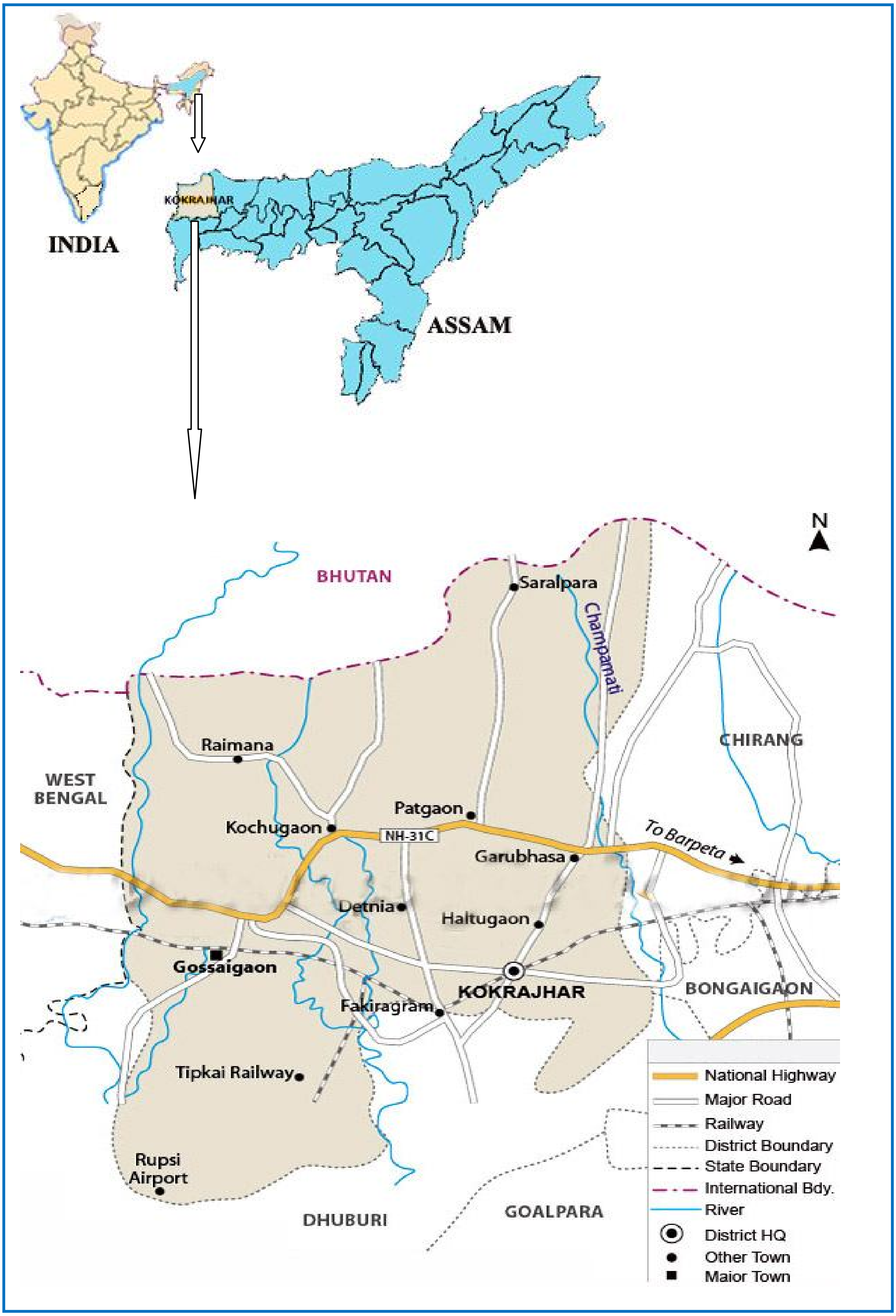


Fig.: 1.3 Map of Kokrajhar district

3.3 Description of the selected species:

i. **Boroli (*Barilius vagra*):** The colour of this fish with beautiful combination of different shades, is very attractive. It is fish of small size, growing up to 12.5 cm. This species is widely distributed in Asian countries, Afghanistan, Pakistan, India, Nepal, Bangladesh and Sri Lanka. Adults of this fish species live in hill streams with gravelly and rocky bottom (Talwar and Jhingran , 1991.)

ii. **Bothia (*Neoeucirrhichthys maydelli*):** This species have a quite variable colour pattern. It has dark spots on the caudal fin which are quite distinctive. A dark, white-ringed spot can be seen at the centre of the caudal fin. *N. maydelli* also have a truncate or rounded tail (Hamilton, 1822)

This species are distributed in India, Nepal and Bangladesh. In India it's known from the Teesta river system in North Bengal and the Garo Hills in Meghalaya.

iii. **Chanda (*Chanda nama*):** The elongate glassy perchlet, *Chanda nama* is a native to an area of south Asia from Pakistan to Burma, in the Indo-Malaya ecozone. It reaches a maximum overall length of 11 cm. The species inhabits canals, ponds, streams and flooded rice paddies, in both fresh and blackish water and is found in particular abaundance during the rainy season.

iv. **Cheng (*Channa gachua*):** It is a dwarf snakehead fish attains up to 20 cm. The species has an elongated lateral body. The dorsal of this species is greenish and the anal is dirty pale bluish-green; both are edged with black. The upper edge has a red lateral margin and the lower a white sideward band. The caudal fin is rounded and marginally edged, first with black and then red with blue-green interspaces. This species is found in Asian countries from Pakistan to Indonesia. It is found in almost all wetlands in canals, rivers and lakes and especially in muddy water.

v. **Darikana (*Rasbora daniconius*):** The species, *Rasbora daniconius* has an elongated body, oblong and compressed with small mouth (Talwar and Jhingran 1991.). This species is widely distributed in Asia mainly in Mekong, Chao Phraya and Salween basins, northern Malay Peninsula, westwards to the Indus and Sri Lanka (Rainboth, 1996). The species is found in a variety of habitats like ponds, canals, haors, streams, rivers and inundated fields.

vi. **Goroi (*Channa punctatus*):** It is commonly known as spotted snake head. *Channa Punctatus* are small fishes with smaller eyes allocated on the anterior of head. Fish body is slight brown on the back which is faded beneath.

vii. **Kholihona (*Trichogaster fasciata*):** The fish body is strongly compressed dorsal and abdominal profile is equally convex. It is one of the most colourful fish species of the region. Available in both lentic and lotic systems.

viii. **Kokila (*Xenentodon cancila*):** *Xenentodon cancila* (freshwater garfish) is a species of needlefish. This species has an elongate body with long, beak-like jaws filled with teeth. The dorsal and anal fins are positioned far back along the body close to the tail. *(Sterba, 1962).* The body is silvery-green, darker above and lighter below with a dark band running horizontally along the flank. The male fish often having anal and dorsal fins with a black edge. It can reach upto a length of 40 cm

The freshwater garfish is widely distributed across South and Southeast Asia from India and Sri Lanka to the Malaysian Peninsula *(Riehl, R; Baensch, H 1996).* The species eats animals such as fish and frogs.

ix. **Mola (*Amblypharyngodon mola*):** It is known as Indian Carpet. The body of *Amblypharyngodon mola* is laterally compressed and dorsal. Their caudal fin is deeply forked with pointed lobes. Dark markings are traced in dorsal and anal fins. The body colour of the fish is light greenish on black and silvery at sides and beneath. Maximum body length is reported to be 8cm (Bhuiyan, 1964) 20 cm (Talwar and Jhingran, 1991) 9.2 cm (Hussain, 1999). There is a conspicuous silvery lateral bound running from gill covers to base of caudal fin.

x. **Turi (*Macrognathus pancalus*):** It is commonly known as Stripped spiny eel. The species inhabits in slow and shallow water of rivers of plains and estuaries. It is a common food fish in the region and also a potential aquarium fish.

3.4 Study of Fish diversity:

A detailed survey of various water bodies of the Kokrajhar district was carried out for one year. Locally used fish traps like *Jekhai*, *Sen*, *Khoka* etc. as well as several fishing gears such as, gill nets, cast net, hooks and lines were used to collect various small fishes from their habitats. All of the species were photographed in fresh condition and then preserved in 10% formalin solution. The fish species were identified following Talwar and Jhingran (1991) and Vishwanath et al. (2007). The vernacular names of the species were collected by questionnaires with the local people and fisherman and also from the Department. of Fisheries, Kokrajhar branch. Mean total length, breadth and somatic weight of the species were noted down (Table 1.2).

3.5 Preparation of samples:

The muscle for selected fishes was separated from their body just after washing. A sharp blade of stainless steel was used for dressing the fish species except *A. mola* due to the smaller size of the species. *A. Mola* was used in whole for the parameters of samples. The samples were dressed, beheaded, deskinned and filtered as per manual followed by thorough washing with distilled water. The fillet of the fish samples were minced, homogenized, packaged, labelled and stored frozen until analysis. Fishes were thawed and the bone and skin were separated from the flesh to carry on the proximate analysis.

3.6 Proximate composition:

The chemical composition of fish varies significantly between species and also among the individual fishes within the same species with the variation of age, sex, and season. Protein and ash content do not show much variation. The detailed protocols applied in the present study for the analysis of proximate composition of the studied fish species are given below

3.6.1 Moisture:

The moisture content of the fish species was determined by FSSI Lab. Manual.

Procedure: The ground fish sample was taken in a clean dry petri dish and kept in an oven at 105ºC for 2 hours. It was then cooled in a desiccators and weighed (w1).About 10 gm portion of the sample (w2) was taken in the preweighed petri dish and then kept in the oven at 105˚C overnight .The dish was cooled in a desiccator and weighed again (w3).Once again the petri dish was kept in the oven for half an hour and cooled as before and finally weighed to obtain the reproducible weights .

$$\text{Moisture content (\%)} = \frac{(W_2 - W_3)}{(W_2 - W_1)} \text{X } 100$$

3.6.2 Ash:

The ash content of the fish species was determined by FSSI Lab. Manual.

Procedure: Silica crucible was heated to 600 ºC in a muffle furnace for one hour, cooled in a desiccator and weighed (W_1). 2g of dried sample was weighed accurately in to a crucible and heated at low flame by keeping on a clay triangle to char the organic matter (W_2). The charred material was then placed inside the previously set (600 ºC) muffle furnace and heated for 6-8 hrs which gave a grayish white ash. The crucible was cooled in a desiccator and weighed (W_3). The crucible was heated again for further 30 mins to confirm completion of ashing, cooled and weighed again.

Calculation:

$$\text{Ash content (g/100g)} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where,

W_1= Weight of crucible,

W_2 = Weight of dry matter and crucible,

W_3 = Weight of crucible after ashing

3.6.3 Whole Protein:

The protein content of the fish species was determined by method IS:7219:1973 (RA 2005)

Principle: The nitrogenous compounds in the sample are converted in ammonium sulfate by boiling with concentrated sulfuric acid. Upon distillation with excess alkali, the ammonia is liberated which is estimated by titration with standardized sulfuric acid.

Procedure:

Exactly 0.1-0.2 g of wet sample was weighed in to a Kjeldahl flask. A pinch of digestion mixture (copper sulphate and potassium sulphate were mixed in the ratio 1:8 and finely powdered) and 10 ml of concentrated sulphuric acid was added. It was then digested over a sand bath by heating slowly till the solution starts boiling and then vigorously until the solution becomes colourless. The sample was then cooled and made up to the desired volume (100ml).

A conical flask containing 10 ml of boric acid with few drops of boric acid indicator (pink in colour) was placed at the receiving end of the distillation apparatus in such a way that the tip of the condenser is slightly immersed in boric acid. 5ml of the made up sample was pipetted out in to the distillation apparatus. 10ml of 40% NaOH as shown excess by phenolphthalein indicator was added in to the distillation unit followed by rinsing with little distilled water. The unit was made air tight. The content was steam distilled for 5minutes. The colour of the solution turns green. The flask was lowered and the condenser tip was washed with little water.

The green solution in the receiving flask is green at this stage. The content was titrated against N/100 sulphuric acid until the original pink colour was restored. The volume of acid used for titration was noted. The distillation and titration process was repeated to get concordant value.

Calculation

1000ml 1N H_2SO_4 =14g N_2

1ml 1 N H_2SO_4 = 0.014g N_2

1ml 0.01 N N/100 H_2SO_4= 0.00014g nitrogen or (0.14/1000)

$$\text{Protein content (\%)} = \frac{\text{(Sample T.V - Blank T.V) x 1.4007 Normality x Protein factor}}{\text{Wt. of Sample}}$$

3.6.4 Crude Lipid:

The crude fat content of the fish species was determined by FSSI Lab mannual.

Procedure:

10 gm of dried fish sample (W_1) was placed in a thumble placed in a soxhlet apparatus and approximately 200ml ether was added and distilled for 16 hrs. After cooling the apparatus, the solvent was filtered in to a pre-weighed conical flask (W_2). The ether was then removed by evaporation and the flask with lipid was dried at 80-100 ºC, cooled in a desicator and weighed (W_3).

Calculation:

The fat content was then calculated using the formula

Fat content (g/100g) = (W_3-W_2)/ W_1 x 100

3.6.5 Carbohydrates:

The carbohydrate content was determined according to AOAC (1995) and it was calculated using the formula:

Carbohydrate content = 100 – (protein (%) + moisture (%) + fat (%) + ash(%))

3.7 Amino acid analysis:

High Performance Liquid Chromatography (HPLC) (method QA.16.5.10/AOAC 19th edition) was employed for determination of amino acid contents of the fish samples.

Preparation of hydrolysed amino acid Sample: About 100 mg of homogenized fish mince was weighed in to a test tube filled with nitrogen and digested at 120 º C for 24 hrs in an oven. The contents of the test tube was cooled and filtered using Whatman No 1 filter paper. The filtrate was then evaporated in a vacuum flash evaporator. The contents were made acid free by repeated washing with distilled water and subsequent evaporation.

HPLC analysis: 20 µL of the hydrolyzed sample was injected in HPLC (1260 Infinity) equipped with a C18 reverse phase (RP) column and a fluorescence detector. The amino acids were identified the concentration of each type of Amino acids were calculated using the formula-

$$\frac{\text{Area of Spl x Std. Conc. x Vol. x Dil x P}}{\text{Wt of Sample x Area of Std x 1000000}}$$

3.8 Fatty acid analysis:

Gas Chromatography- Mass Spectrometry (GC/MS) (method QA.996.06/AOAC 19th edition) was employed to determine the Fatty acid contents in the fish samples.

3.8.1 Preparation of fatty acid methyl ester (FAME):

5g of lipid was taken in a round bottom flask (125mL) and saponified with alcoholic KOH solution (50mL). The mixture was then refluxed for 45 minutes on a water bath. The reaction mixture was then allowed to cool and then neutralized by HCl (5N). Alcohol was removed from the neutralized solution by evaporation over a steam bath. The pH of the solution was adjusted by adding concentrated HCl. The acidified aqueous mixture was then extracted three times with 20 mL ether in a separating funnel. Ether was then removed from the extract to give a fatty acid mixture which was then esterified with methanolic solution of sulphuric acid (0.25 M) After esterification, the mixture was dissolved in ether (25mL) and washed with dilute sodium carbonate solution in a separating funnel until effervescence ceased. It was then washed with water, dried over anhydrous Na_2SO_4 and finally ether was removed to give fatty acid methyl ester (FAME) mixture.

3.8.2 GC/MS Analysis of the methyl esters of lipids:

The FAMEs were quantified by injecting 1 µL (30:1 split ratio) into GC-MS. The fatty acids were identified and quantified using a GC (Trace GC Ultra, Thermo Scientific) The MS conditions were as follows; ionization voltage 70 eV, Mass range of 45-600 and the scan time equal to the GC run time.

The fatty acids in the mixture were identified by comparing its relative retention volume (Clark JM, 1964) The area of each chromatogram peak was determined by multiplying the height of the peak by width of the peak at one half of the height. The percentage of fatty acid contribution to each peak was calculated. After that response factor (R_i) for each fatty acid was calculated by the following equation.

$R_i = (P_{Si}/ Ps_{C11:0})$ x $(W_{C11:0}/W_i)$

Where, P_{Si} = Peak area of individual fatty acid in mixed FAME standard solutions, $Ps_{C11:0}$ = peak area of $C_{11:0}$ fatty acid in mixed FAMEs standard solution, $W_{C11:0}$ = Weight of internal standard in mixed FAMEs standard solution and W_i = Weight of individual FAME in mixed FAMEs standard solution.

The amount of the individual triglycerides, W_{TG} of each samples were then calculated using the following formula.

$$W_{FAMEi} = \frac{Pt_i \text{ x } W_{C11:0} \text{ x } 1.6007}{Pt_{C11:0} \text{ x } R_i}$$

$W_{TGi} = W_{FAMEi}$ x f_{TGi}

Where, P_{ti} = Peak area of fatty acid I in test portion, $Wt_{C11:0}$ = weight of $C_{11:0}$ internal standard in test portion, 1.0067 = conversion of internal standard from TG to FAME, $Pt_{c11:0}$ = peak area of $C_{11:0}$ internal standard in test portion and f_{TG} = conversion factor for FAME to TGs for individual fatty acid.

Retention time of fatty acid of known standards and conversion factor for FAMEs to TGs for individual fatty acids were listed in Appendice-II.

3.9 Mineral Analysis

3.9.1 Analysis of Fe, Zn & Ca:

Atomic Absorption Spectroscopy (AAS) **(**method AOAC 19th edition) was employed for quantitative determination of Fe, Zn and Ca in the fish samples.

Procedure: Chemical analysis for the estimation of the trace elements (Fe, Zn and Ca) in fishes were performed with the Flame Atomic Absorption Spectrophotometer (AAS). The technique involved the following steps:

The stock standard solutions of 100 ppm of Fe, Ca, Zn, salts with deionized water were prepared. Standard solutions of these metal ions were prepared by suitable dilution of the stock standard solutions. The samples of the fish were diluted to a known volume and both the samples and the standard solutions were analysed by a Flame AAS (Model: AAS 280(000)).

Calculation :

The concentration of metal is detected in mg/l and

$$\text{Metal mg/100g} = \frac{\text{Concentration of metal in ppm x volume made}}{\text{weight of sample}}$$

3.9.2 Analysis of Phosphorous:

UV-Visible Spectrophotometer (UV-VIS) (Method IS:1482.8:200) was employed for quantitative determination of Phosphorous content in the fish samples.

Procedure: The ash obtained from the crude ash content analysis was mixed with 5 mL water and 5 mL HCl and boiled for 5 minutes on hot plate. The solution was then cooled to room temperature and brought to sign at 50 mL water. In parallel a procedural blank was also prepared. 10 mL of the prepared solution were transferred into 50 mL calibrated flask and 20 mL of molybdate-ascorbic acid solution was added. Five standard solution of Phosphorous were prepared and 20 mL of molybdate-ascorbic acid solution was added and the sample prepared along with the standard solutions were placed in a metal basket and it was immersed in a boiling water bath for 15 minutes. The flasks were then cooled to room temperature and the colour of the solutions turned blue.

Phosphorous calibration curve solutions

Standard solutions	Blank	Std 1	Std 2	Std 3	Std 4	Std 5
Concentration (mg/L)	0.0	5.0	10.0	20.0	40.0	50.0

The absorbance of the standard solutions and sample solutions were read at wavelength 430 nm in a UV-VIS Spectrophotometer (Cary 60 Model No 2.00)

The Phosphorous content were expressed in mg/100g and was calculated using the formula

Phosphorous content (mg/100g) = (V_2/V_1)xC_{read} x 50 / m

Where, m = Weight of sample, V_1 = Volume of solution utilized for colour reaction, V_2= Volume where the ash was brought to 50 mL and C_{read}= Amount of phosphorous from calibration curve.

3.10 Vitamin Analysis:

High Performance Liquid Chromatography (HPLC) (Method QA:16.5.3/AOAC 19th edition) was employed for determination of Vitamin A and D in the fish samples.

Procedure: Oil extracted from fish meat as described (Folch et al., 1957) earlier under fatty acids was used for analysis of fat soluble vitamins. About 0.15 g fish oil was refluxed with 25 mL methanol and 150% potassium hydroxide (KOH) in water bath for 30 min. It was then extracted with 50 mL petroleum ether. The petroleum ether layer was collected, concentrated and dissolved in 5mL acetonitrile (ACN). 100 µL of sample is then injected in a HPLC (HPLC 1260 Infinity) equipped with C18 RP column and UV detector. The fat soluble vitamins A&D were identified and quantified by comparing retention times and peak area with those of vitamins standards respectively (R7632, C9756, T3251 and M5625, Sigma-Aldrich).

Then the concentration of each type of Vitamin were calculated using the formula-

$$\frac{\text{Area of Spl x Vol x Dil x Std. Conc. x 100}}{\text{Wt of Sample x Area of Standard}}$$

3.11 Analysis of some water quality paramaters:

3.11.1 Collection, pre-treatment and preservation of samples

Water samples were collected randomly from three beels and one river surrounding the Kokrajhar town during January-March of 2016. They were stored in pre-cleaned 250 ml polyethylene bottles and BOD bottles in triplicates and brought to laboratory for further analysis. The samples were collected from 12-15 cm beneath the water surface. All the precautionary measures were adopted during sampling.

3.10.2 Physico-chemical analysis

The collected samples were experimented to analyse different physic-chemical parameters such as pH, temperature, TDS, alkalinity, BOD, COD, DO, turbidity and salinity by following the standard protocols as per APHA 22nd Edition (2012). Samples were analyzed immediately for parameters like temperature, which need to be determined instantly.

A quality controlled procedure was steadily maintained throughout. The instruments were recalibrated. All chemicals and reagents used were of analytical grade. For all solutions distilled water was used. The standard solutions were made by diluting the stock solution.

3.11 Statistical analysis

Simple correlation and regression equations were applied for analysis of certain biological parameters. The statistical packages viz., MS Excel, Minitab 11 were used in the entire experiments of the present study.

CHAPTER-IV
Result & Discussion

4.1 Analysis of Fish diversity

In the present work, the study of Ichthyofaunal diversity of the fish species reported that quantitatively seventy seven ichthyospecies belonged to 53 genera, 26 families and 9 orders from the different water bodies of Kokrajhrar District of BTAD, Assam, India. Table 1.11 illustrates the biological classification of the fish species including their scientific names, order, family, vernacular name (*Assamese* and *Bodo*), food status and conservation status (IUCN).

All the fish species were broadly categorized into seven groups. They are namely, Indian major/minor carps, Exotic carps established in Assam, Live fishes, Cat fishes, Feather back, Ornamental fishes and River fishes representing 10, 4, 10, 23, 2, 18 and 10 species respectively. Out of the nine orders, the most dominant was cypriniformes with thirty one species (40.26%) followed by Siluriformes with twenty three species (29.87%) (Fig 1.4a). The results were agreed to the previous reports (Chakravartty et al., 2012; Das and Sarmah, 2014). The order Perciformes, Synbranchiformes, Clupeiformes, Osteoglossiformes was represented by 12, 3, 3, 2 species respectively. Only one species had been recorded from the order Beloniformes, Cyprinodontiformes and Tertaodontiformes. Among the 26 families, Cyprinidae with 26 ichthyospecies (37.66%) was the most diverse followed by Bagridae with 7 species (9.09%) (Fig 1.4b). Dubey et al., 2012; Baro and Sharma, 2014; Das and Sarmah, 2014 had also similar observation. Channidae possesed six species. Four species belonged to Siluridae family whereas families Sisoridae and Schilbeidae contained three species each .Only two species were lodged by five families viz. Clariidae, Clupeidae, Mastacembelidae, Notopteridae and Osphronemidae. *Labeo* genus possessing seven species was highlighted to be the most diverse followed by the genus *Channa* with six species. Amongst the 77 recorded species, 74 were considered as food fish while only three species viz. *Erethistes pusillus, Tetraodon cutcutia* and *Aplocheilus panchax* as not food fishes. It was found that 36 fish species were recorded to be commercially important food fish (Biswas and Sugunan, 2008). In addition to the commercial importance *Chitala chitala* and *Tor tor* had sport values (Biswas and Sugunan, 2008)

Table 1.1: Showing the diversity of fishes with special reference to their taxonomic distribution, vernacular name, habitat and conservation status

Family	Name of the Species	Bodo name	Assamese name	Habitat/Water bodies	Con. status*
Cyprinidae	*Labeo rohita* (Hamilton, 1822)	Rhou	Rhou	Rivers/beels/tanks & ponds	LC
Cyprinidae	*Labeo bata* (Hamilton, 1822)	Bata	Bata	Rivers/beels/tanks & ponds	LC
Cyprinidae	*Labeo calbasu* (Hamilton, 1822)	Bahu	Kalbasu	Rivers/beels/tanks & ponds	LC
Cyprinidae	*Labeo gonius* (Hamilton, 1822)	Kursa	Gonia	Rivers/beels/tanks & ponds	LC
Cyprinidae	*Bangana dero* (Hamilton, 1822)	Maso	Gorea	River running water	Vu
Cyprinidae	*Labeo dyocheilus* (McClelland, 1839)		Lasu	Brahmaputra river	LC
Cyprinidae	*Labeo pangusia* (Hamilton, 1822)		Nandani	Rivers/beels/tanks & ponds	NT
Cyprinidae	*Gibelion catla* (Hamilton, 1822)	Catla	Catla	Rivers/beels/tanks & ponds	LC
Cyprinidae	*Cirrhinus mrigala* (Bloch, 1795)	Mirkha	Mirika	Rivers/beels/tanks & ponds	LC
Cyprinidae	*Cirrhinus reba* (Hamilton, 1822)	Lasim	Laseem	Rivers/beels/tanks & ponds	LC
Cyprinidae	*Cyprinus carpio* (Hamilton, 1822)	Common carp	Common carp	Rivers/beels/tanks & ponds	Vu
Cyprinidae	*Ctenophryngodon idella* (Valenciennes, 1844)	Grass carp	Grass carp	Rivers/beels/tanks & ponds	NE
Cyprinidae	*Hypothalmichthys molitrix* (Valenciennes, 1844)	Silver carp	Silver carp	Rivers/beels/tanks & ponds	NE
Cyprinidae	*Hypothalmichthys nobilis* (Richardson, (1845)	Popular large head carp	Popular large head carp	Rivers/beels/tanks & ponds	NE
Channidae	*Channa punctata* (Bloch, 1793)	Gwri	Goroi	Beels/low-lying area/tanks / ponds	LC
Channidae	*Channa striata* (Bloch, 1793)	Shol	Shol	Beels/low-lying area/tanks / ponds	LC
Channidae	*Channa gachua* (Hamilton, 1822)	Nasrai	Cheng	Beels/low-lying area/tanks / ponds	LC
Channidae	*Channa marulius* (Hamilton, 1822)	Nasrai nisla	Chengeli	Beels/low-lying area/tanks / ponds	LC
Channidae	*Channa stewartii* (Hamilton, 1822)	Sal	Sal	Beels/low-lying area/tanks / ponds	LC
Channidae	*Channa barca* (Hamilton, 1822)	Nasrai Borkhaw	Garaka cheng	Beels/low-lying area/tanks / ponds	DD
Synbrachidae	*Monopterus cuchia* (Hamilton, 1822)	Cuchia	Cuchia	Beels/low-lying area/tanks / ponds	LC
Mastacembelidae	*Mastacembelus armatus* (Hamilton, 1822)	Bami	Bami	River/beels/low-lying area/tanks / ponds	LC

Family	Name of the Species	Bodo name	Assamese name	Habitat/Water bodies	Con. status*
Mastacembelidae	*Mastacembelus pancalus* (Hamilton, 1822)	Thuri	Tura/Tora	River/beels/low-lying area/tanks / ponds	NE
Actinopterygii	*Anabus testudineus* (Bloch, 1792)	Kawai	Koi	Beels/low-lying area/tanks / ponds	NE
Siluridae	*Wallago attu* (Bloch and Schneider, 1801)	Borali	Borali	River/beels/low-lying area/tanks / ponds	NT
Siluridae	*Ompok pabo* (Hamilton, 1822)	Phabo	Pabhoh	River/beels/low-lying area/tanks / ponds	NT
Siluridae	*Ompok pabda* (Hamilton, 1822)	Phabo	Pabda	River/beels/low-lying area/tanks / ponds	NT
Siluridae	*Ompok bimaculatus*(Bloch, 1794)	Phabo	Pabhoh	River/beels/low-lying area/tanks / ponds	NT
Bagridae	*Mystus tengra* (Hamilton, 1822)	Thengana	Tingorah	River/beels/low-lying area/tanks / ponds	LC
Bagridae	*Mystus cavasius* (Hamilton, 1822)	Thengera gidid	Bor Singorah	River/beels/low-lying area/tanks / ponds	LC
Bagridae	*Mystus vittatus* (Bloch, 1794)	Thengera khujri	Haru Tingorah	River/beels/low-lying area/tanks / ponds	LC
Bagridae	*Hemibagrus menoda* (Hamilton, 1822)		Gagol	River/beels/low-lying area/tanks / ponds	LC
Bagridae	*Aorichthyus aor* (Hamilton, 1822)	Aari	Aari	River/beels/low-lying area/tanks / ponds	NE
Schilbeidae	*Eutropiichthyus vacha* (Hamilton, 1822)		Basa	River/beels/low-lying area/tanks / ponds	NE
Pangasiidae	*Pangasius pangasius* (Hamilton, 1822)	Pangas	Pangas	River/beels/low-lying area/tanks / ponds	LC
Clariidae	*Clarias batrachus* (Linneaeus, 1758)	Magur	Magur	Beels/low-lying area/tanks / ponds	LC
Clariidae	*Clarias gariepinus* (Burchell, 1822)	Thailand magur	Thailand magur	Beels/low-lying area/tanks / ponds	LC

Family	Name of the Species	Bodo name	Assamese name	Habitat/Water bodies	Con. status*
Heteropneustidae	*Heteropneustes fossilis* (Bloch, 1794)	Singi	Singi	Beels/low-lying area/tanks / ponds	LC
Sisoridae	*Gagata cenia* (Hamilton, 1822)		Keyakatta	Beels/low-lying area/tanks / ponds	LC
Sisoridae	*Gagata gagata* (Hamilton, 1822)		Keyakatta	Beels/low-lying area/tanks / ponds	LC
Sisoridae	*Bagarius bagarius* (Hamilton, 1822)		Garua	River/beels/low-lying area/tanks / ponds	NT
Schilbeidae	*Cluisoma garua*(Hamilton, 1822)		Neria	River/beels/low-lying area/tanks / ponds	NE
Chacidae	*Chaca chaca* (Hamilton, 1822)		Kurkuri	River/beels/low-lying area/tanks / ponds	LC
Bagridae	*Rita rita* (Hamilton, 1822)	Ritha	Ritha	River/beels/low-lying area/tanks / ponds	LC
Erithistidae	*Erithistes pusillus* (Bleeker, 1854)		Sakmaka	River/beels/low-lying area/tanks / ponds	NE
Bagridae	*Batasio batasio* (Hamilton, 1822)		Batachi	River/beels/low-lying area/tanks / ponds	LC
Schilbeidae	*Ailia coila* (Hamilton, 1822)		Kadali	River/beels/low-lying area/tanks / ponds	NT
Notopteridae	*Chitala chitala* (Hamilton, 1822)	Sital	Chital	River/beels/low-lying area/tanks / ponds	NT
Notopteridae	*Notopterus noptopterus* (Pallas, 1769)		Kanduli	River/beels/low-lying area/tanks / ponds	NE
Osphronemidae	*Trichogatser fasciata* (Bloch & Schneider,1801)		Kholihana	Beels/low-lying area/tanks / ponds	NE
Osphronemidae	*Trichogatser colisa* (Hamilton, 1822)		Bhasaylee	Beels/low-lying area/tanks / ponds	NE
Tetraodontidae	*Tertradon cutcutia* (Hamilton, 1822)	Gangatopa	Gangatope	Beels/low-lying area/tanks / ponds	NE
Ambassidae	*Chanda nama* (Hamilton, 1822)	Chanda	Chanda	Beels/low-lying area/tanks / ponds	LC
Cichlidae	*Oreochromis mossambicus* (Peters, 1852)	Japani Kawai	Japani Koi	Beels/low-lying area/tanks / ponds	NT
Cobitidae	*Neoeucirrhichthys maydelli* (Hamilton, 1822)	Bala Bothia	Botia	Beels/low-lying area/tanks / ponds	LC

Family	Name of the Species	Bodo name	Assamese name	Habitat/Water bodies	Con. status*
Botiidae	*Botia dario* (Hamilton, 1822)	Bala Khwa	Rani botia	Beels/low-lying area/tanks / ponds	LC
Cyprinidae	*Pethia ticto ticto* (Hamilton, 1822)	Pitikri	Puthi	Beels/low-lying area/tanks / ponds	LC
Cyprinidae	*Systomus sarana* (Hamilton, 1822)	Chinese puthi	Cheniputhi	River/beels/low-lying area/tanks / ponds	LC
Cyprinidae	*Barbonymus gonionotus*	Jaba puthi	Java puthi	Beels/low-lying area/tanks / ponds	LC
Cyprinidae	*Rasbora daniconius* (Hamilton, 1822)	Donkina	Darikona	Beels/low-lying area/tanks / ponds	LC
Cyprinidae	*Rasbora elanga* (Hamilton, 1822)	Eleng	Eleng	Beels/low-lying area/tanks / ponds	NE
Cyprinidae	*Danio dangila* (Hamilton, 1822)		Laupati	Beels/low-lying area/tanks / ponds	LC
Cyprinidae	*Amblypharyngodon mola* (Hamilton, 1822)	Mawa	Mola	Beels/low-lying area/tanks / ponds	LC
Cyprinidae	*Aspidoparia morar* (Hamilton, 1822)	Boirali	Boriala	Beels/low-lying area/tanks / ponds	LC
Nandidae	*Nandus nandus* (Hamilton-Buchanan 1822)	Thothajambhi	Bhetki	Beels/low-lying area/tanks / ponds	LC
Clupeidae	*Gudusia chapra* (Hamilton, 1822)	Korti	Karoti	Beels/low-lying area/tanks / ponds	LC
Engraulidae	*Setipinna phasa* (Hamilton, 1822)		Salo/Chato	Beels/low-lying area/tanks / ponds	LC
Clupeidae	*Tenualosa ilisha* (Hamilton, 1822)	Ilish	Ilish	Brahmaputra river	LC
Cyprinidae	*Chela atpar* (Hamilton, 1822)		Selkona	Brahmaputra river	NE
Cyprinidae	*Chela cachius* (Hamilton, 1822)		Laupati	Brahmaputra river	LC
Cyprinidae	*Oxygatser gora* (Hamilton, 1822)		Gora Chela	Brahmaputra river	NE
Cyprinidae	*Tor tor* (Hamilton, 1822)		Pithia	River running water	NT
Cyprinidae	*Tor putitora* (Hamilton, 1822)	Jonga	Jonga pithia	River running water	EN
Belonidae	*Xenentodon cancila* (Hamilton, 1822)	Khankhila	Kokila	River/beel/tanks & ponds	LC
Aplocheilidae	*Aplocheilus panchax* (Hamilton, 1822)		Kanopna	River	LC
Cyprinidae	*Barilius barna* (Hamilton, 1822)		Balisonda	River	LC
Cyprinidae	*Barilius bendelisis* (Hamilton, 1807)			River running water	LC

Con. Status: Conservation status based on IUCN report (2010); EN: Endangered; Vu: Vulnerable; NT: Near threatened; LC: Least concern; NE: Not evaluated; DD: Data deficient

As per the conservation status (IUCN), *Tor putitora* was found to be the only fish species that placed under endangered category. Out of the remaining 76 recorded species *Bangana* (*Labeo) dero* was marked as vulnerable (Vu) (2.60%), 10 near threatened (NT) (12.99%), 47 least concerned (LC) (61.04%), 16 not evaluated (NE) (20.78%) and the single species *Channa barca* was recorded to be data deficient (Fig 1.4c).

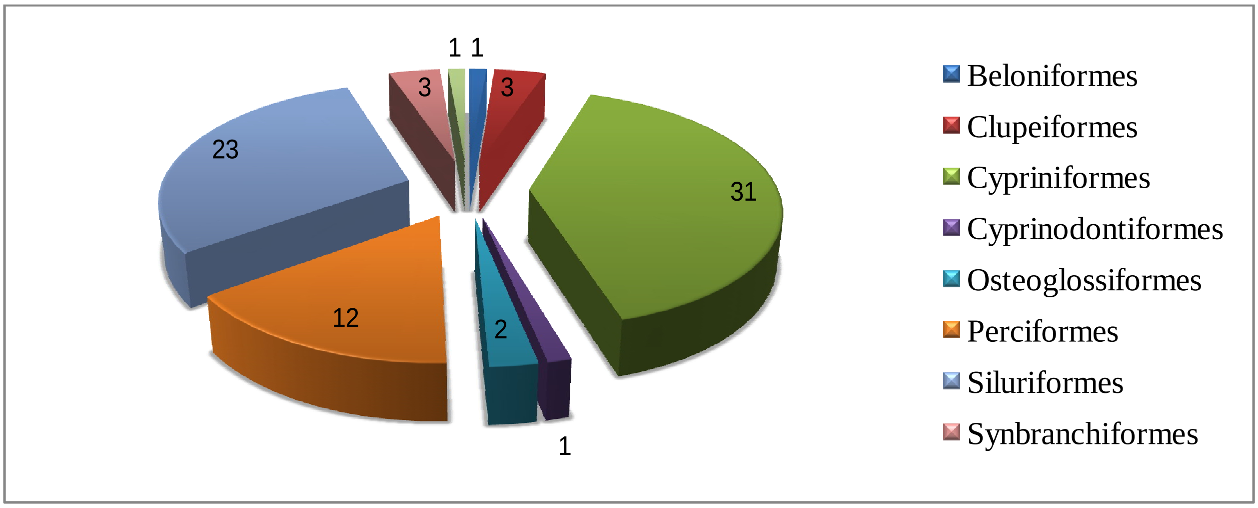


Fig.: 1.4a Number of species under various orders

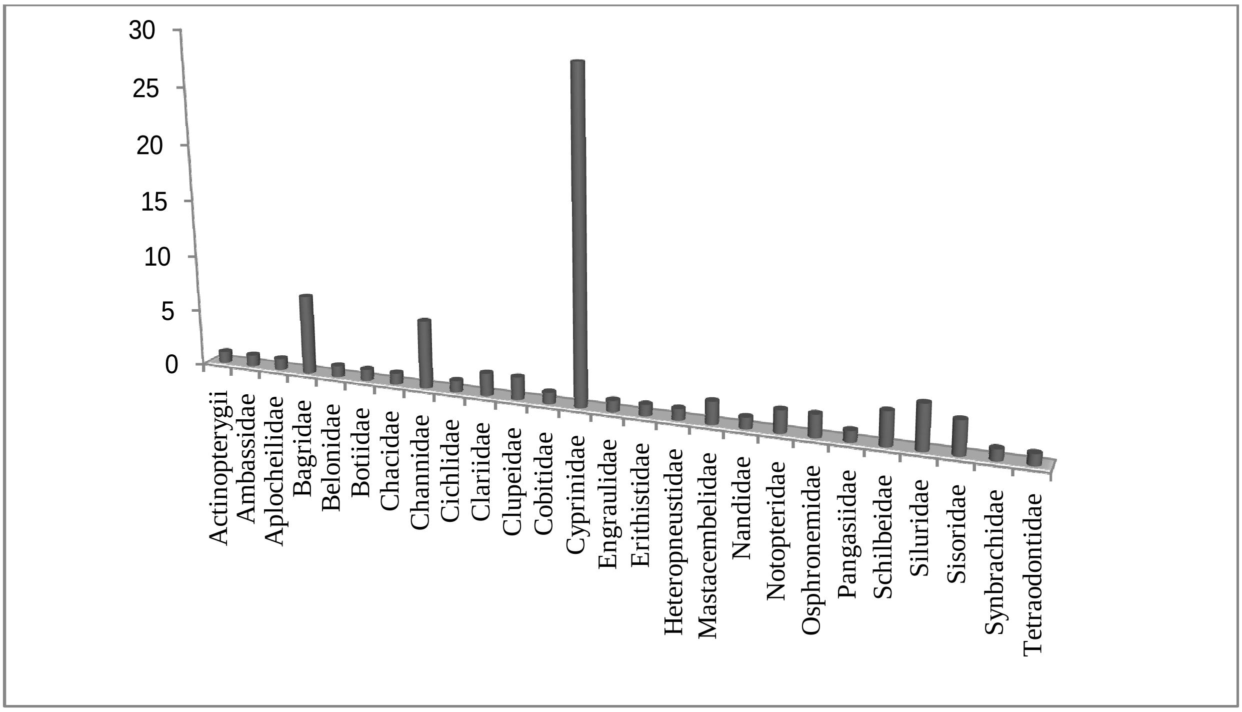


Fig.: 1.4b Number of species distributed under each family

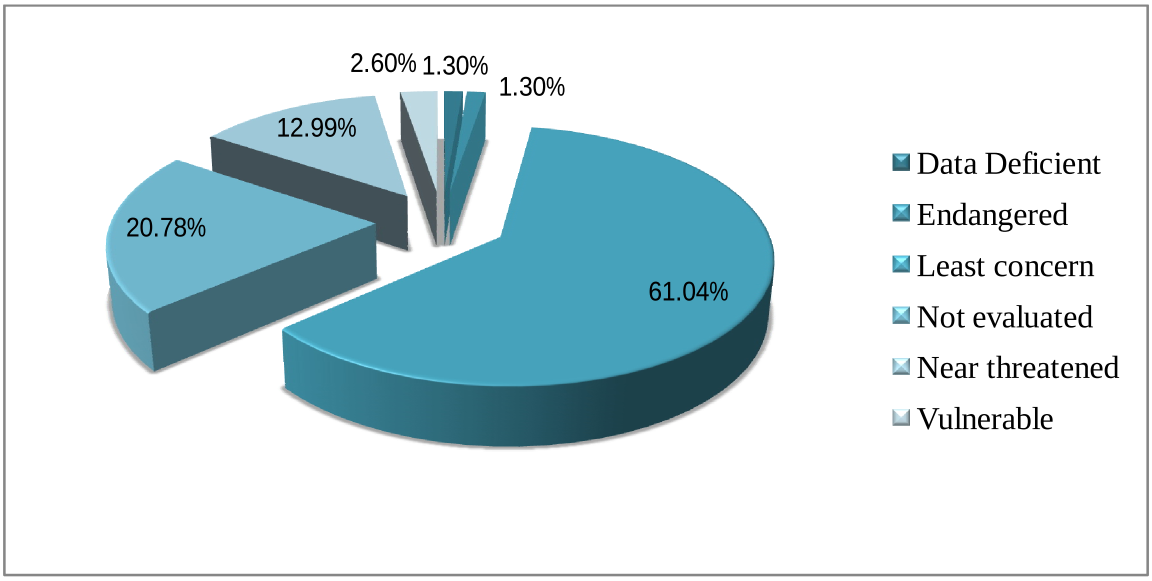


Fig.: 1.4c Percentage of species under various categories as per IUCN status

4.2 Survey on fish species consumed by the Bodo communities:

The response of the field survey was positive. People were very much interested regarding catching the small fishes available in nearby river, beel and other wetlands. They consume these small fishes in their daily diet. The responses are summarized below:-

(i) What are the different types of fishes available in the water bodies of your locality?
Ans: The small fishes like moa, puthi, bothia, borali, chanda, ptimutura, kawai, cheng, goroi, kokila, darikona, turi, kholihona, tengera etc. are very much available in the local ponds and nearby wetlands.

(ii) How do you catch the fish for your dietary item?
Ans: We use different gears of bamboo.

(iii) What fishes you generally prefer in your daily diet?
Ans: Local small living fishes are very much appreciated in our daily diet.

(iv) Whether the popular large fishes are used in your regular diet?
Ans: We cannot afford to purchase the popular large fishes regularly.

(v) What are the small fishes you consume regularly?
Ans: The small fishes like cheng, goroi, mola, chanda etc. are commonly included in our regular meal.

(vi) Whether the small fishes which you consume have any commercial value?
Ans: The fishes which we regularly consume are having very less commercial value

because these are accepted mainly by the poorers.

(vii) Where from you collect the small fishes for regular consumption?

Ans: The fishes are easily collected from ponds, ditches, small rivers and the nearby waterlogged areas.

After analyzing the survey report it is justified that the small fishes available in the local area were of keen interest to the Bodo communities. Due to their extreme availability and lower market price these fishes are regularly included in their diet. The local people cannot afford to the costly popular large fishes which are well known to be one of the good supplement for the protein and many other health nutrients. Keeping in mind about the specific time period of the research work, out of these available fishes only ten small fishes were selected for study in the current work. These fishes are widely consumed by the local Bodo people. The selected species were enlisted in table 1.2 below.

Table: 1.2 List of fish species selected for the present work

Sample No	**Scientific name of species**
1	*Barilius vagra* (Hamilton, 1822)
2	*Neoeucirrhichthys maydelli* (Hamilton, 1822)
3	*Chanda nama* (Hamilton, 1822)
4	*Channa gachua* (Hamilton, 1822)
5	*Rasbora daniconius* (Hamilton, 1822)
6	*Channa punctatus* (Bloch, 1793)
7	*Trichogaster fasciata* (Bloch & Schneider,1801)
8	*Xenentodon cancila* (Hamilton, 1822)
9	*Amblypharyngodon mola* (Hamilton, 1822)
10	*Macrognathus pancalus* (Hamilton, 1822)

Fig.:1.5.1 Fish Catching area in Diplai Beel

Fig.: 1.5.2 People catching fish in Gaurang river

Fig.: 1.5.3 People catching fish in wetlands

Fig.: 1.5.4 Some fish gears commonly used by bodo people

Fig.: 1.5.5 *Chanda nama* collected at fishing sites

Fig.: 1.5.6 Some fishes selling in village market

4.3 Description of the selected fish

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Cypriniformes
Family: Cyprinidae
Genus: Barilius
Scientific Name: *Barilius vagra* (Hamilton, 1822)
Local Name: Boroli

Fig.: 2.1.1 *Barilius vagra*

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Cypriniformes
Family: Cobitidae
Genus: *Neoeucirrhichthys*
ScientificName: N. Maydelli (Hamilton, 2822) Local Name: Bothia

Fig.:2.1.2 *N. maydelli*

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Perciformes
Family: Abassidae
Genus: Chanda
Scientific Name: *Chanda nama* (Hamilton, 1822)
Local Name: Chanda

Fig.: 2.1.3 *Chanda nama*

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Perciformes
Family: Channidae
Genus: Channa
Scientific Name: *Channa gachua* (Hamilton, 1822)
Local Name: Cheng

Fig.: 2.1.4 *Channa gachua*

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Cypriniformes
Family: Cypriniformes
Genus: Rasbora
Scientific Name: *Rasbora daniconius* (Hamilton, 1822)
Local Name: Darikana

Fig.: 2.1.5 *Rasbora daniconius*

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Perciforms
Family: Channadae
Genus: Channa
Scientific Name: *Channa punctatus* (Bloch, 1793)
Local Name:Goroi

Fig.: 2.1.6 *Channa punctatus*

Kingdom: Animalia
Phylum: Chordata
Class: Osteichthyes
Order: Perciformes
Family: Anabantidae
Genus: Colisa
Scientific Name: *Trichogaster fasciata* (Bloch & Schneider,1801)
Local Name:Kholihona

Fig.: 2.1.7 *Trichogaster (Colisa) fasciata*

Kingdom: Beloniforms
Phylum: Chordata
Class: Actinopterygii
Order:
Family: Belonidae
Genus: Xenentodon
Scientific Name: *Xenentodon cancila* (Hamilton, 1822)
Local Name:Kokila

Fig.: 2.1.8 *Xenentodon cancila*

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Cypriniformes
Family: Cyprinidae
Genus: Amblypharyngodon
Scientific Name: *Amblypharyngodon mola* (Hamilton, 1822)
Local Name:Mola

Fig.: 2.1.9 *Amblypharyngodon mola*

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Synbranchiformes
Family: Mastacembelidae
Genus: Macrognathus
Scientific Name: *Macrognathus pancalus* (Hamilton, 1822)
Local Name:Turi

Fig.: 2.1.10 *Macrognathus pancalu*

The mean total length, breadth and somatic weight of all the species were noted down and reported in table 4.3.

Table 1.3. Measurement of length, breadth and weight

Sl No	Scientific name of species	Local Name	Length(cm)	Breadth(cm)	Weight(g)
1	*Barilius vagra*	Bhoroli	7.2 ± 0.6	1.3 ± 0.2	3.22 ± 0.40
2	*N. maydelli*	Bothia	8.4 ± 0.5	1.4 ± 0.3	5.21 ± 0.75
3	*Chanda nama*	Chanda	6.6 ± 0.4	2.1 ± 0.2	2.06 ± 0.51
4	*Channa gachua*	Cheng	11.3 ± 0.8	1.7 ± 0.05	13.41 ± 0.63
5	*Rasbora daniconius*	Darikana	4.5 ± 0.5	0.8 ± 0.02	0.85 ± 0.07
6	*Channa punctatus*	Goroi	12.6 ± 0.6	2.1 ± 0.2	17.15 ± 0.42
7	*Trichogatser fasciata*	Kholisa	6.3 ± 0.4	2.4 ± 0.2	5.44 ± 0.34
8	*Xenentodon cancila*	Kokila	18.1 ± 1.4	1.8 ± 0.3	18.79 ± 1.61
9	*Amblypharyngodon mola*	Mola	6.8 ± 0.4	1.9 ± 0.4	13.58 ± 0.52
10	*Macrognathus pancalus*	Turi	11.8 ± 0.8	1.7 ± 0.2	10.06 ± 1.05

4.4 Proximate composition

The proximate composition of all the fish species selected for the study are shown in table:4.4 below

Table 1.4 Proximate Composition of the selected fish species

Sl no.	Scientific name of species	Protein (g/100g)	Crude Lipid (g/100g)	Moisture (g/100g)	Ash (g/100g)	Carbohydrate (g/100g)
1	*Barilius vagra*	17.30±0.02	5.19±0.02	73.89±0.08	3.36±0.01	5.20±0.08
2	*N. maydelli*	16.72±0.02	3.42±0.02	76.71±0.06	2.85±0.03	0.40±0.06
3	*Chanda nama*	14.86±0.02	11.09±0.01	68.12±0.12	5.59±0.02	0.33±0.04
4	*Channa gachua*	19.85±0.01	3.53±0.02	73.05±0.08	3.26±0.01	0.35±0.04
5	*Rasbora daniconius*	15.35±0.01	2.82±0.01	77.21±0.05	4.22±0.02	4.31±0.06
6	*Channa punctatus*	17.48±0.02	4.92±0.03	75.50±0.10	1.73±0.02	0.37±0.03
7	*Trichogatser fasciata*	17.22±0.04	5.84±0.03	73.51±0.15	2.95±	0.48±0.03
8	*Xenentodon cancila*	17.41±0.01	1.58±0.01	77.07±0.05	3.55±0.02	0.30±0.03
9	*Amblypharyngodon mola*	15.43±0.02	2.94±0.02	71.50±0.12	3.94±.003	6.19±0.06
10	*Macrognathus pancalus*	14.26±0.02	5.08±0.04	70.96±0.05	5.79±0.04	3.91±0.04

Amongst the ten fish species, *Channa gachua* (Cheng) contained the maximum content of protein (19.85 g/100g) whereas the lowest value (14.26g/100g) of the same was possessed by *Macrognathus pancalus*. The amount of protein content ranged from 14.26 to 19.85g/100g. All the fish species were rich in protein and can be regarded as vital source of protein for human nutrition. The value of the protein contents of the selected fish species did not differ too much. It might be due to their similar absorption capability and conversion potentials of essential nutrients from the local environment (Adewole et. al., 2003). The good amounts of protein indicated that the small fishes are also beneficial for meeting our daily requirements of protein provided they are having a balanced amino acid. Fishes are advantageous due to their proteins of high digestibility (Albert, 1998). Several researchers have found richer protein contents when they investigated on fresh water fish species collected from different countries of the world (Aboluade & Abdullahi, 2005). For daily consumption, 24-56 g, 13-19 g and 71 g proteins are required by adult pregnant and lactating mothers respectively (Anon, 2002). It has been found that protein-calories malnutrition stands as primary factor responsible for nutritional pathology (Roger et al., 2005).

Fig.: 2.2.1 Proximate composition (%) of *Barilius vagra*

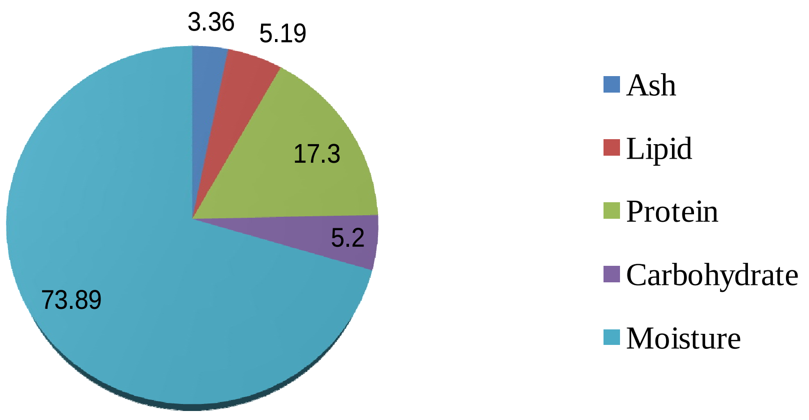


Fig.: 2.2.2 Proximate composition (%) of *N maydelli*

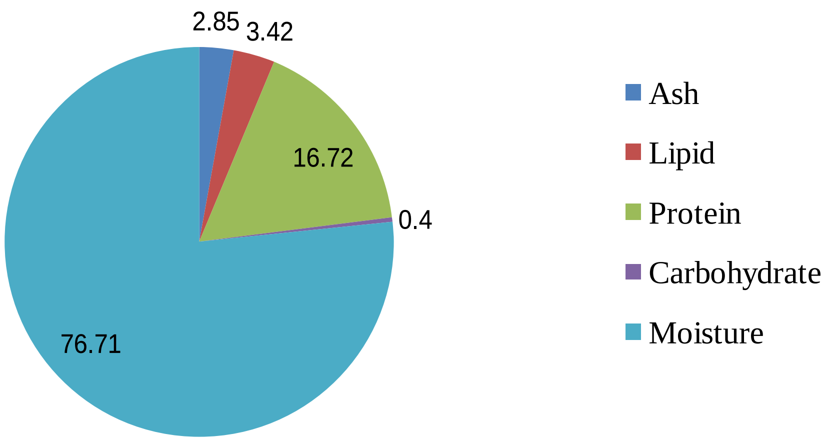


Fig.: 2.2.3 Proximate composition (%) of *Chanda nama*

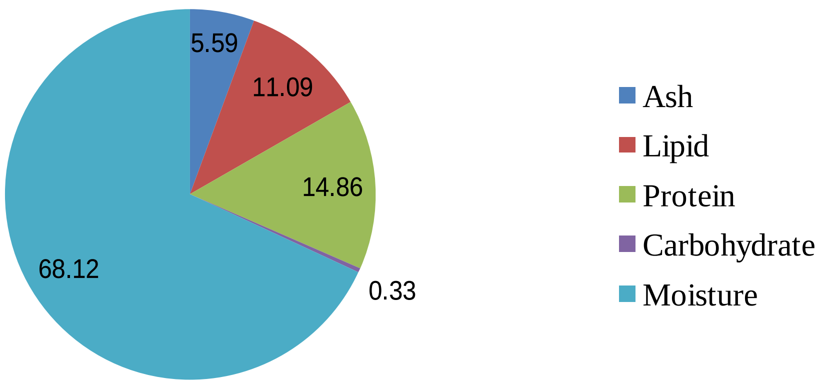


Fig.: 2.2.4 Proximate composition (%) *Channa gachua*

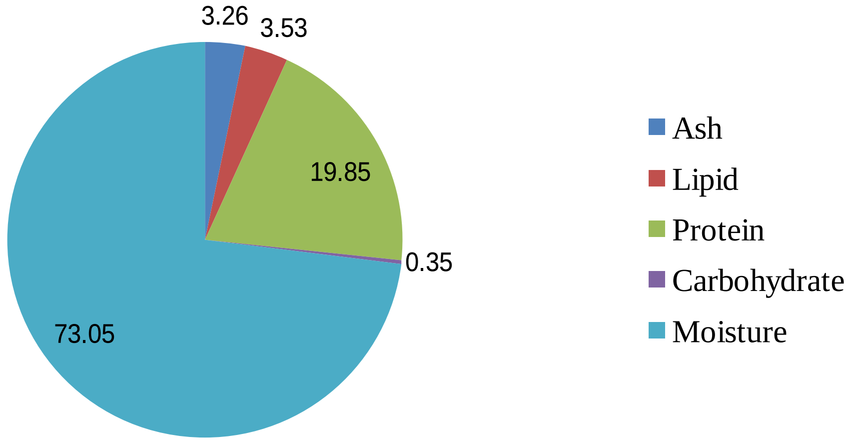


Fig.: 2.2.5 Proximate composition (%) of *Rasbora daniconius*

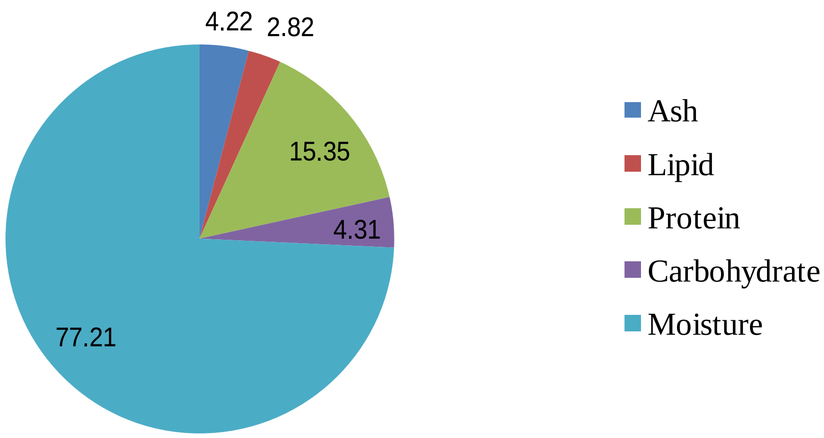


Fig. 2.2.6 Proximate composition (%) of *Channa punctatus*

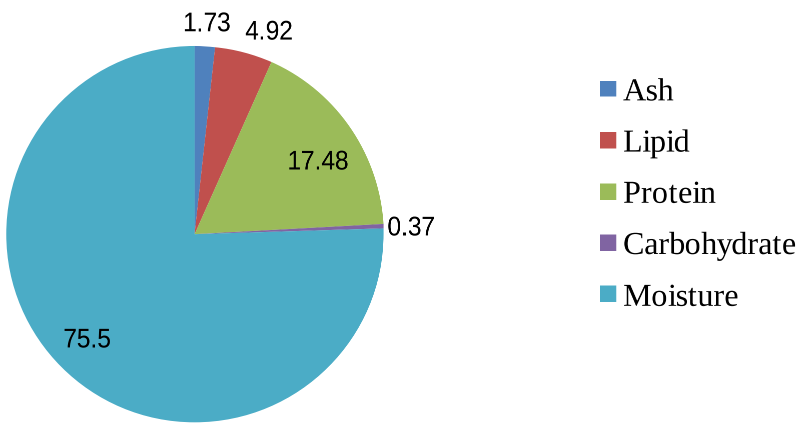


Fig.: 2.2.7 Proximate composition (%) *Trichogatser fasciata*

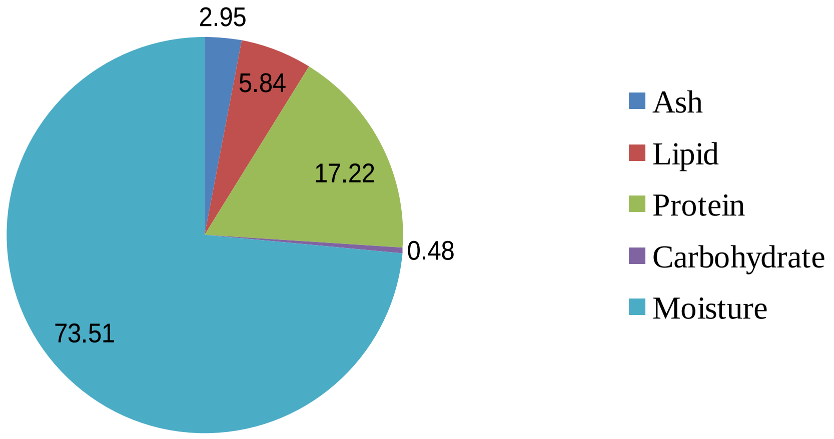


Fig.: 2.2.8 Proximate composition (%) of *Xenentodon cancila*

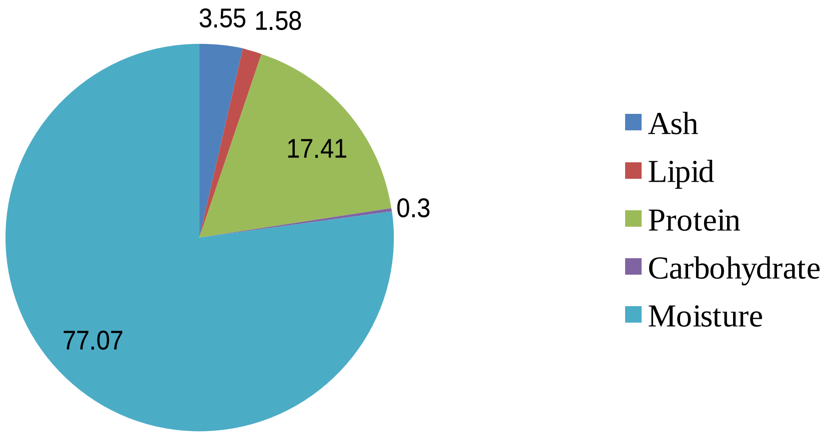
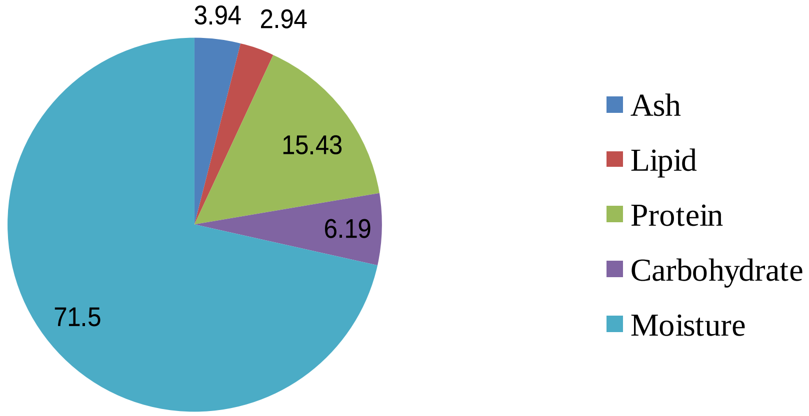
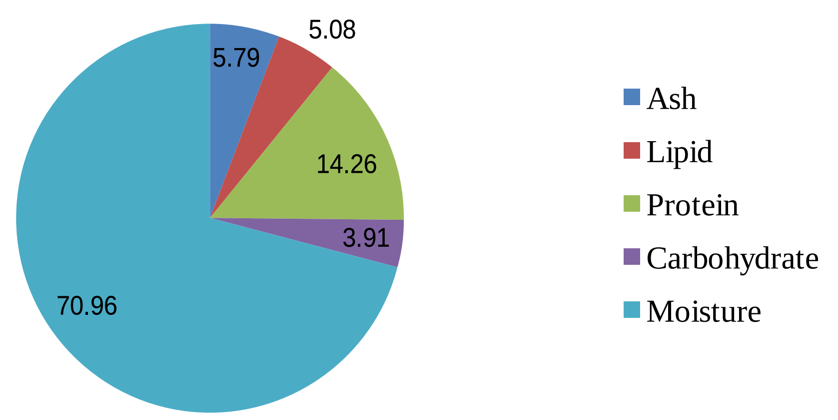


Fig. 2.2.9 Proximate composition (%) of *Amblypharyngodon mola*



Fifg.: 2.2.10 Proximate composition (%) of *Macrognathus pancalus*



The lipid contents of the fish species experimentally ranges from 1.58 to 11.09 g/100g. The highest amount of lipid was shown by *Chanda nama*. Amongst them, *Xenentodon cancila* (Kokila) fish possessed the least amount of lipid. The difference in the lipid contents may be explained by the fact that the fishes show variations in their nutrition contents with the variation of season, species and geographical changes. Moreover, age variation and maturity in the same species may highlight significant changes in the total lipid (Piggot and Tucker, 1990). Usually the fat content changes more than any other proximate components of fish and it flashes on the variation in the way of storing fat in the particular species and the content are varied by the changing lifecycle and the availability of food of the species at the time when, sampled (Ababouch, 2005). The species of indigenous major carps are familiar as lean fish which store fat on the liver (Abobouch, 2005), whereas the migratory fishes like Ilish having high amount of dark muscle are said to be highly fatty (Alamentals, 2012). High lipid content of *H. Ilisha* was reported by many workers (Rao et al., 2012, Mohanty et al., 2012). The higher lipid content of *Chanda nama* could be attributed to relative feeding habits (Orban et al., 2007). Lipids and fatty acids play a vital role in membrane biochemistry and membrane mediated processes like as osmoregulation, nutrient assimilation and transport in fishes. The amount of lipids in fish also changes within species and habitat (Kumaran et al., 2013 and Das et al., 1978).

The amount of lipid contents in fishes differ greatly from species to species which is keenly related to food intake, sexual changes in context to spawning (Oduor-Odote et al, 2008). Within different parts of body also lipid contents show variation and even in different seasons the contents of lipid are differed. Higher lipids may be caused due to preparation for spawning. It was reported by Asma and Ashraf (2010) that there exists a linear relation between protein and age/size of fish in three carnivorous fish species (*Wallagn altu, Mystus seenghala* & *Channa morutius*) but totally opposite in case of lipid contents as there was steady decline in this parameter with increase in size.

The lipid contents of fish species were enormously varied as documented by many workers. Hossain et al. (2015) reported that *Amblypharyngodon mola* showed the maximum (6.28 ± 0.75) lipid content but in present study the same fish species possessed only 2.94% of lipid. The difference in value might be justified by different geographical positions. The highest lipid contents of *Chanda nama* (11.09%) followed by *Macrognathus pancalus, Trichogaster fasciata*, *Barilius vagra*, *N. maydelli* and *Channa gachua* indicated the particular small indigenous species to be nutritionally enriched and decent food suppliments.

The moisture contents of the small fish species under experimentation ranged from (68.12%) to (77.21%). The highest moisture value was contained by *Rasbora daniconius* and the lowest in *Chanda nama*, The moisture contents of the selected fishes were negatively correlated with the lipid contents and this fact was agreed with many previous researches (Jessica R. Begard et al, 2015). According to the study of Mazumder et al, the fish moisture steadily decreases with increase in body lipid. As per the report of Marichamy et al 2012, the value of moisture content of marine fishes averaged (74%). Generally freshwater fishes were experimentally established to have low lipid content (Zhimin Jhang et al. 2014) and high moisture contents. Present study revealed the finding of previous researchers to highlight good moisture contents of all the selected small fishes for study.

The ash contents of the fishes under study ranged from (1.73 %) to (5.79 %). The present report revealed the findings of previous researchers. According to the research work of Mazumder et al, 2008, the ash contents of *A. Coila* and *Amblypharyngodon mola* were also varied within (1.6 % to 3.2 %. Lower values of ash contents were reported in the experiment of Devadsan et al. (1978) on six freshwater fishes, *L. rohita* (1.31%), *Catla Catla* (0.93%), *Cirrihinus cirrhosus* (0.91%) and *Wallagn atta* (0.72%). The ash content of *Macrognathus pancalus* fish revealed fair amount which supported FAO (2005) report. Ash contents reflect the mineral concentration present in the fish species (Eddy et al., 2004, FAO, 2005).

All the ten fish species under study showed low carbohydrate contents except *Amblypharyngodon mola* (6.19%), *Barilius vagra* (5.20%), *Rasbora daniconius* (4.31%)and Macrognathus *pancalus* (3.91%) and. Usually fishes have very low carbohydrate contents

(USDA 2010). The poor contents of carbohydrates in the fishes may be attributed to the fact that glycogen has not much contribution to the reserves in the tissues of fish body (Das and Sahu, 2001 & Jayasre et al., 1994). There are very few fish species which are having higher values of carbohydrate contents. In the research report of Kumar et al., 2014, *Sardinella longiceps* & *Stolephorus* were having the values of carbohydrate contents 0.358% and 0.332% respectively. The present report of the lower carbohydrate contents of the studied fish species agreed with the research finding of S. Sutharsiny et al 2011. As a whole the proximate composites of fishes are widely varied with variations of enviormental conditions (Boran and Karacham, 2011).

4.5 Amino acid profile

The following are the HPLC Chromatogram of amino acid profile of standard amino acid solutions along with those of the different fish samples.

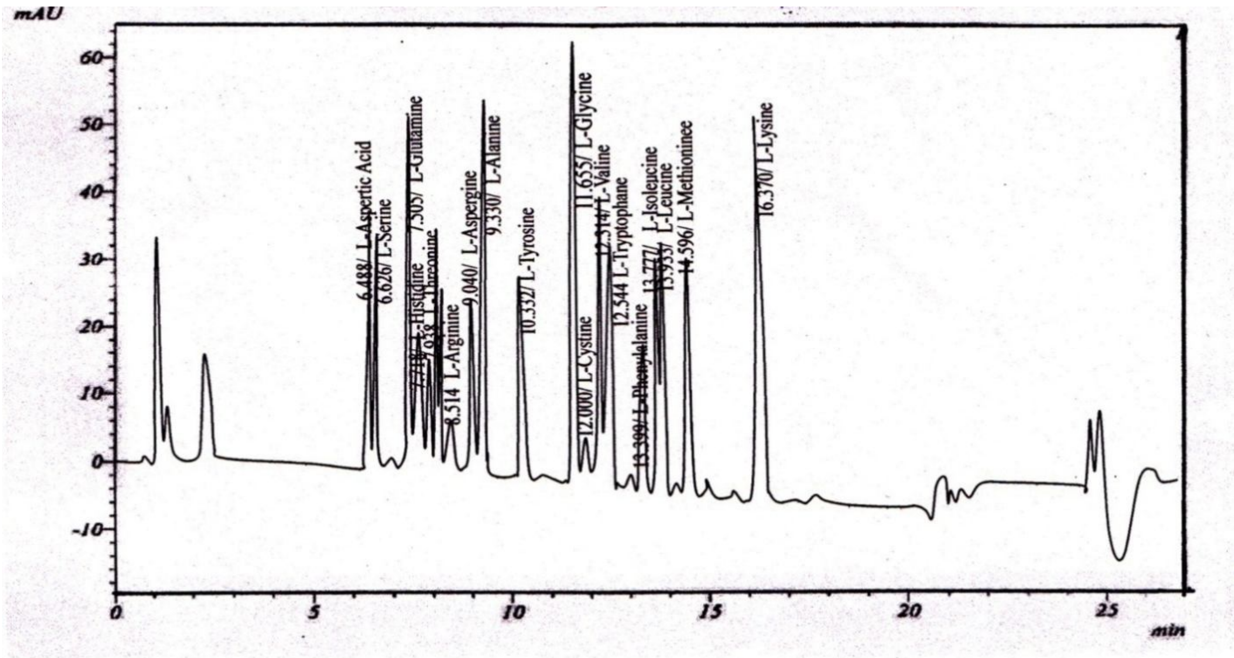


Fig.: 2.3.1 HPLC Chromatogram of Amino acids of Standard Amino acid solution

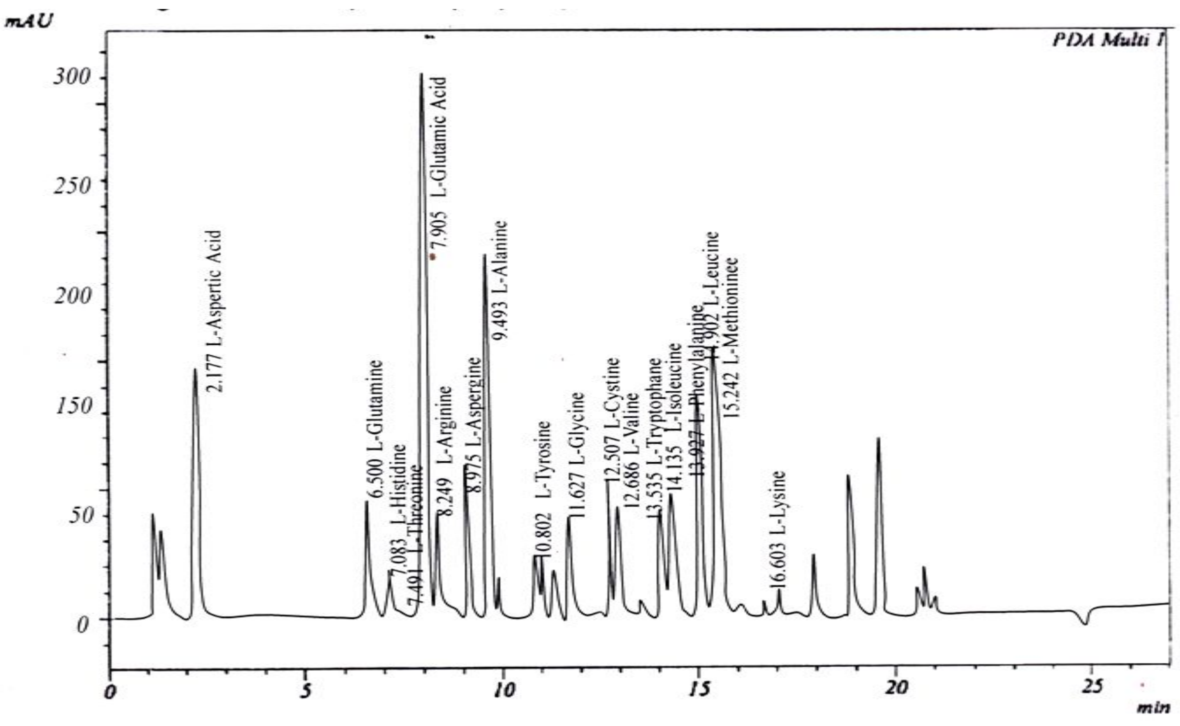


Fig.: 2.3.2 HPLC Chromatogram of Amino acids of *Barilius vagra*

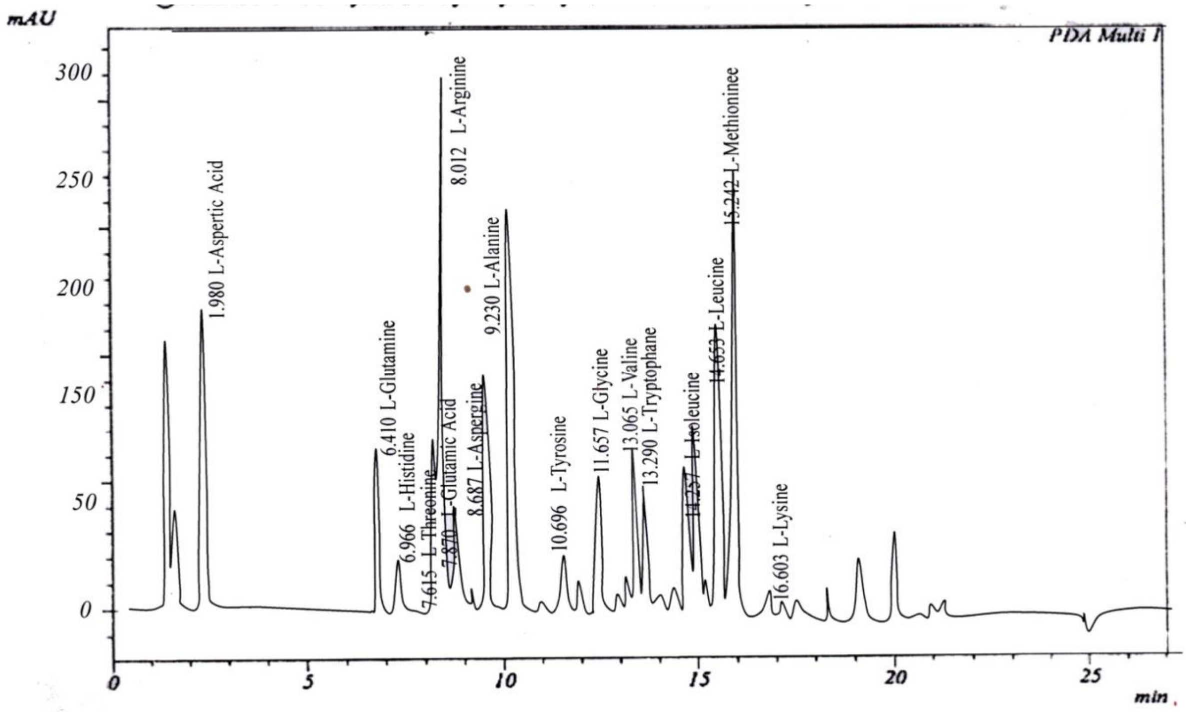


Fig.: 2.3.3 HPLC Chromatogram of Amino acids of *Neoeucirrhichthys maydelli*

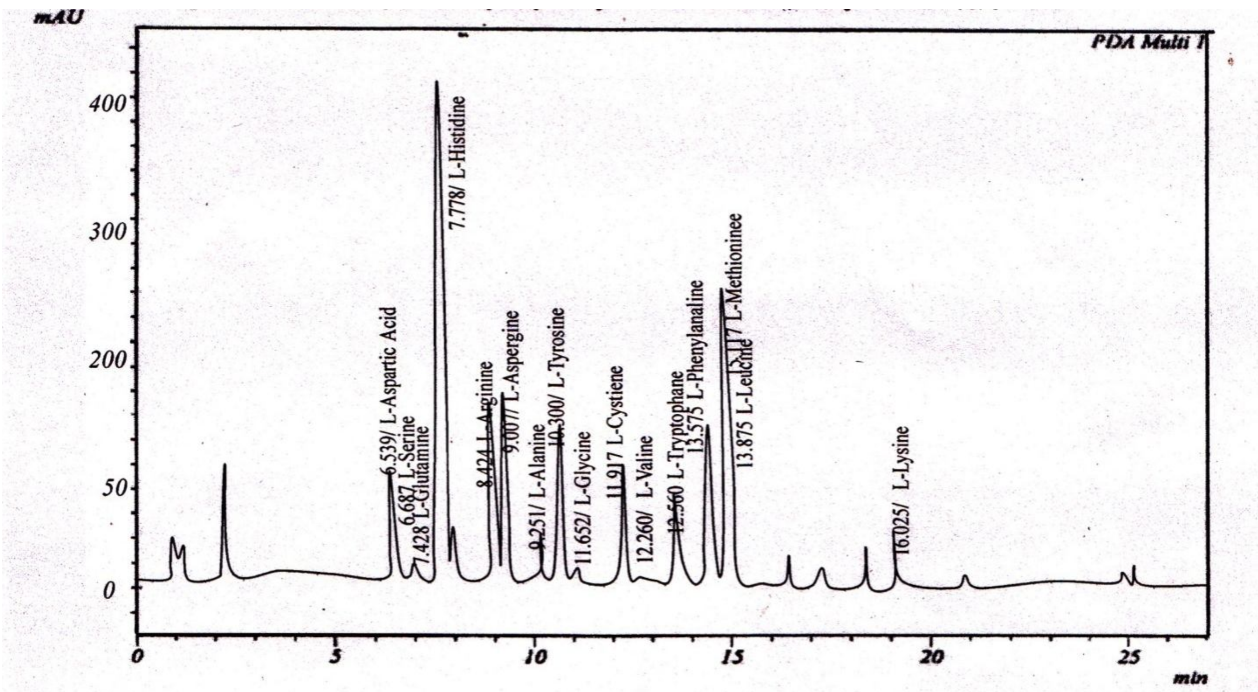


Fig.:2.3.4 HPLC Chromatogram of Amino acids of *Chanda nama*

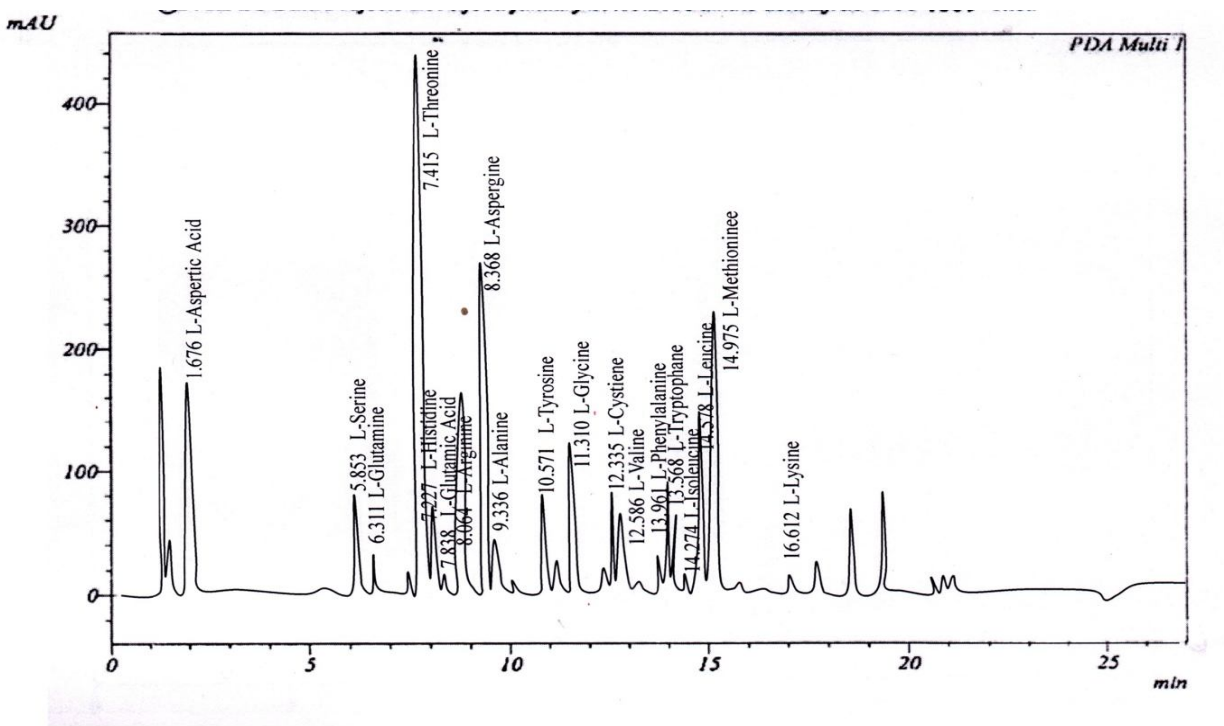


Fig.: 2.3.5 HPLC Chromatogram of Amino acids of *Channa gachua*

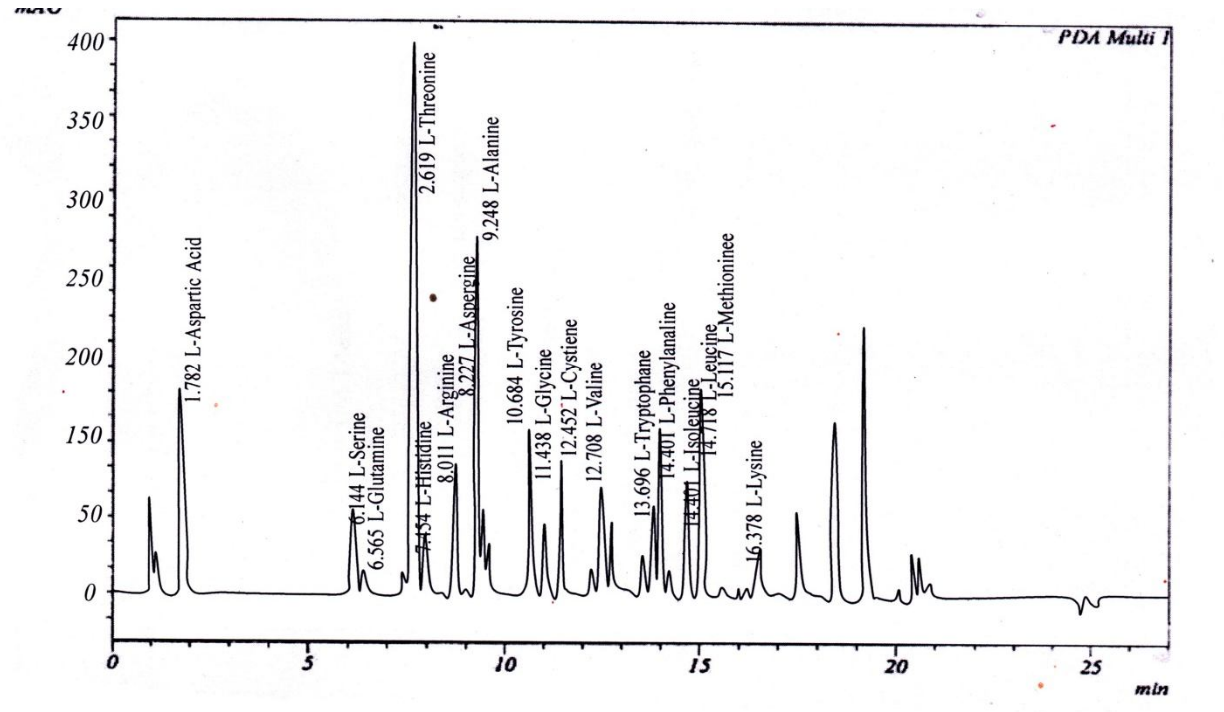


Fig.:. 2.3.6 HPLC Chromatogram of Amino acids of *Rasbora daniconius*

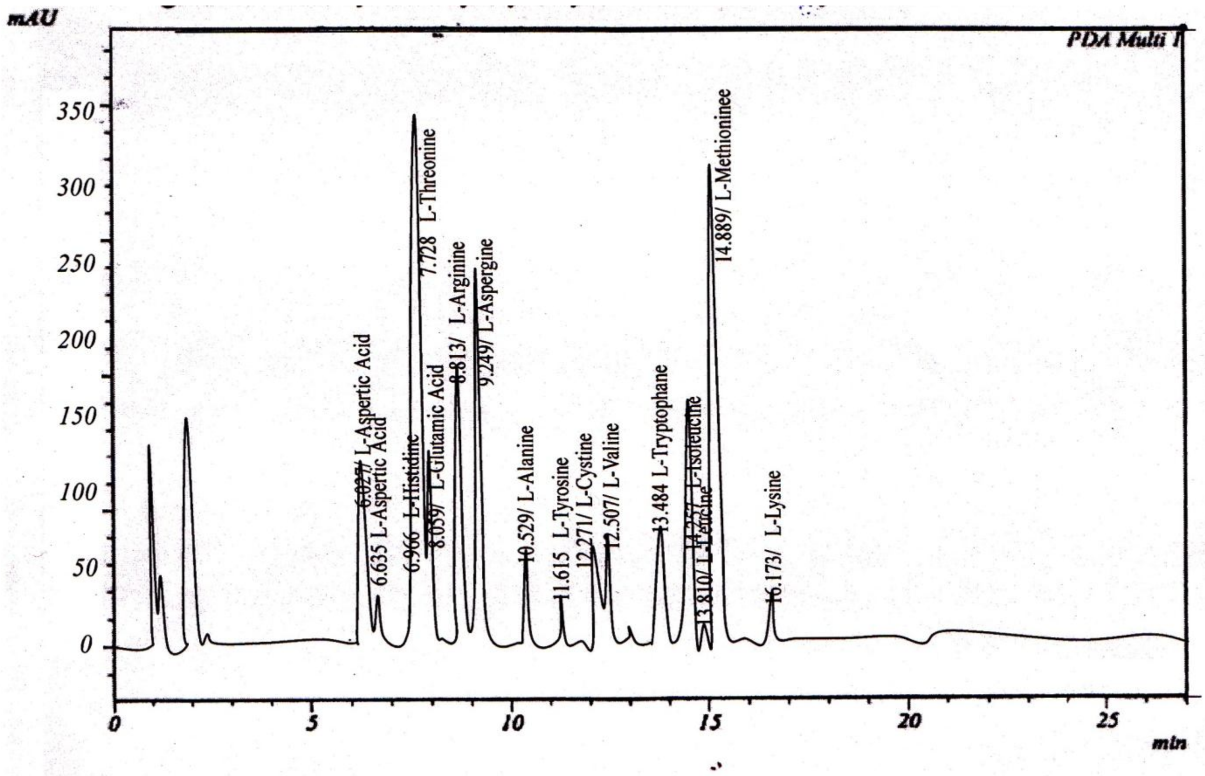


Fig.: 2.3.7 HPLC Chromatogram of Amino acids of *Channa punctatus*

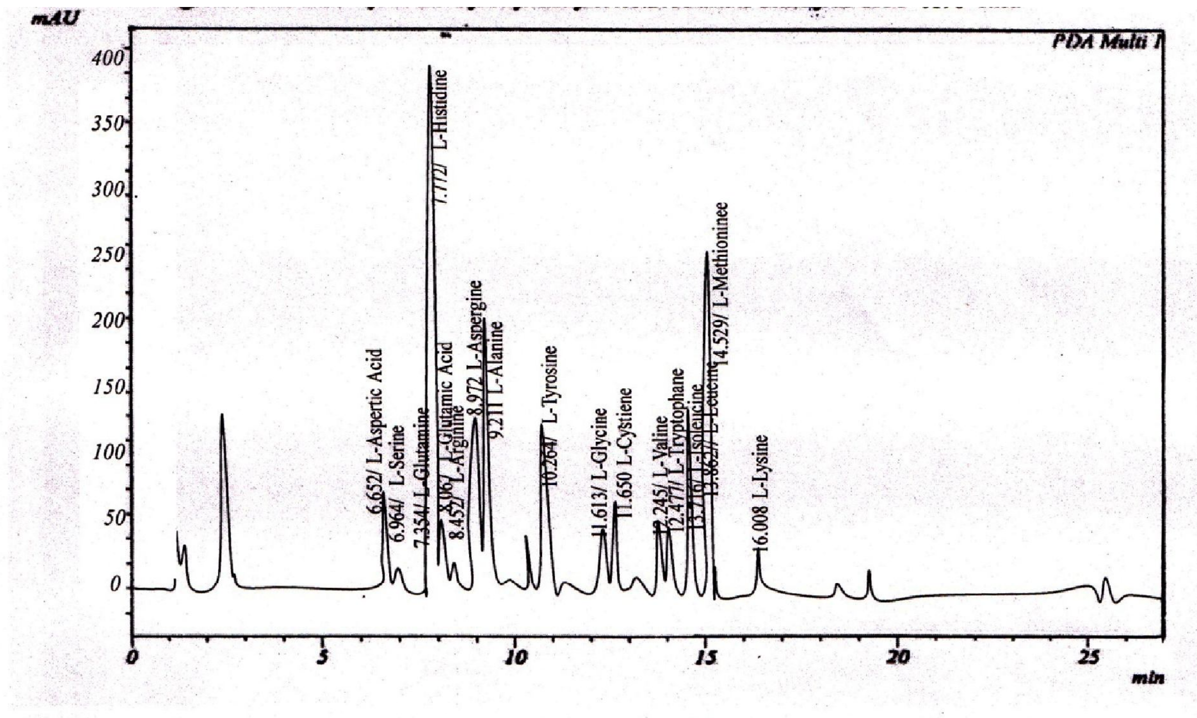


Fig.:. 2.3.8 HPLC Chromatogram of Amino acids of *Trichogaster fasciata*

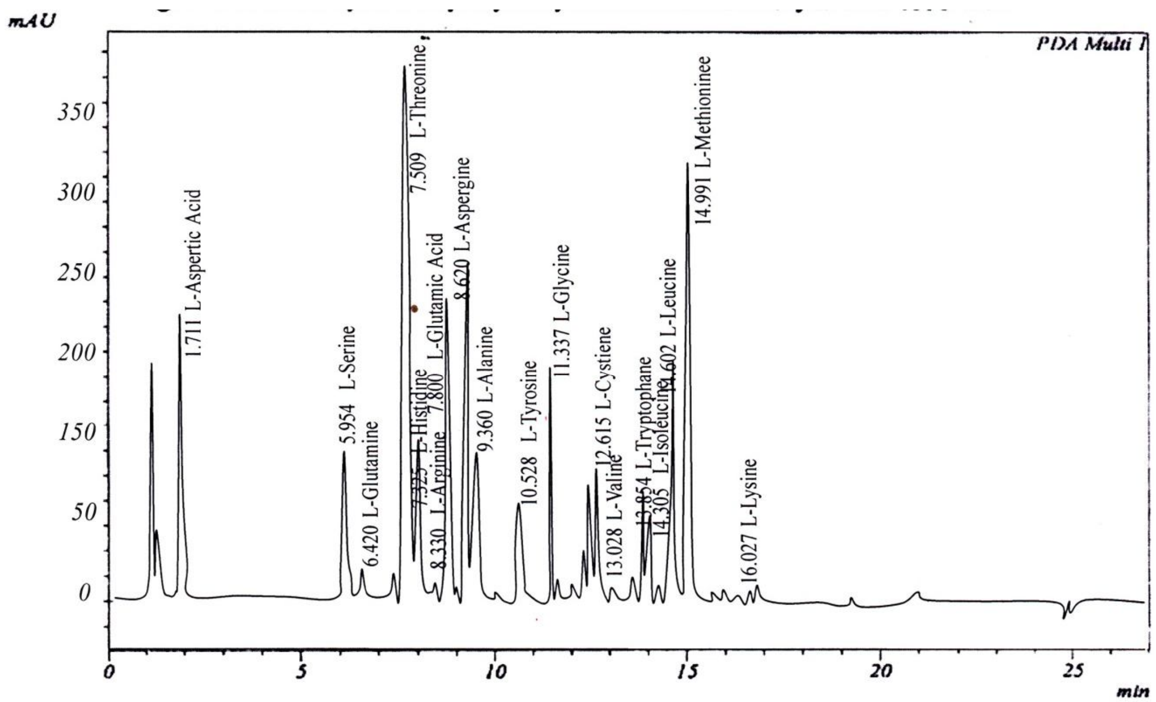


Fig.:2.3.9 HPLC Chromatogram of Amino acids of *Xenentodon cancila*

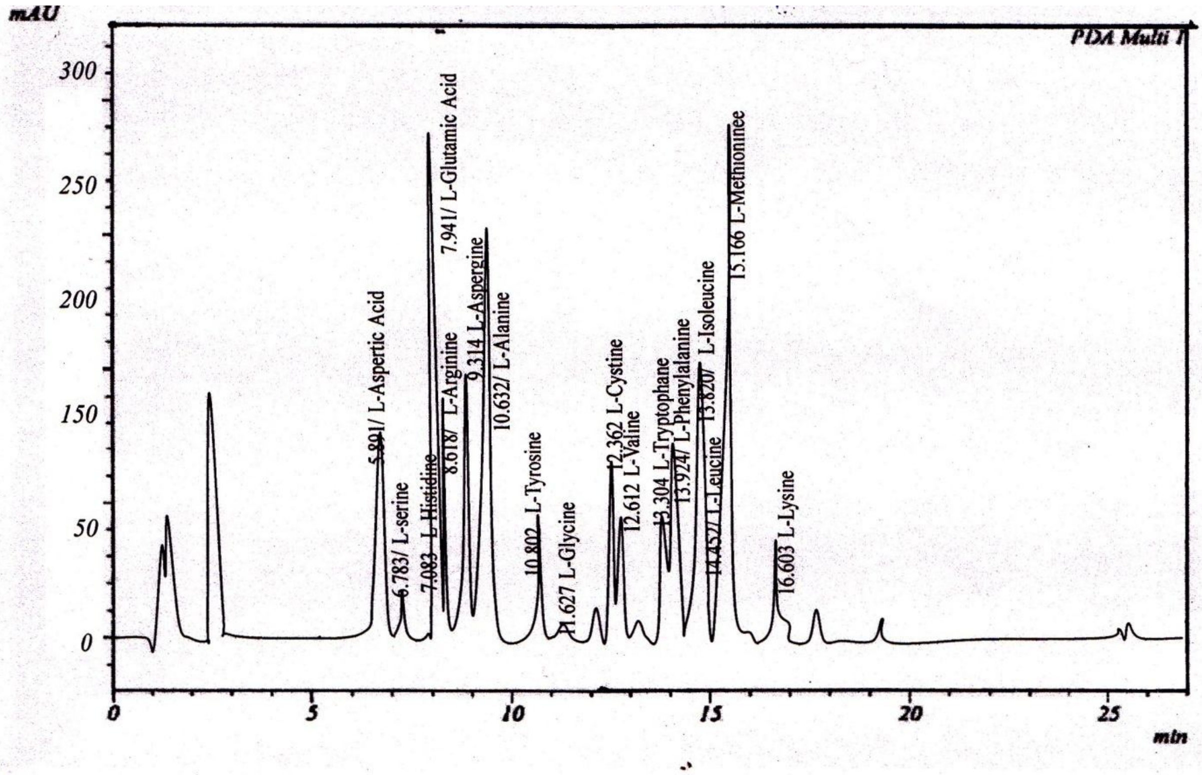


Fig.: 2.3.10 HPLC Chromatogram of Amino acids of *Amblypharyngodon mola*

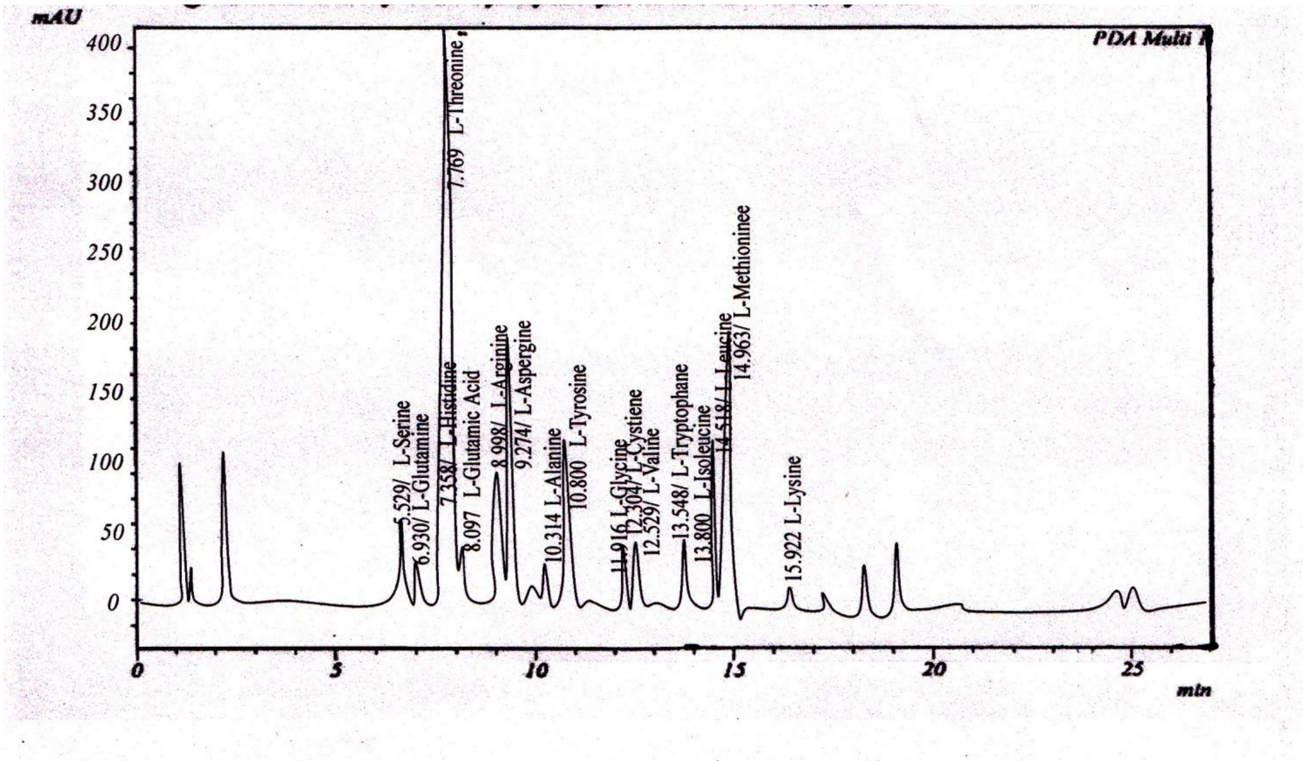


Fig.: 2.3.11 HPLC Chromatogram of Amino acids of *Macrognathus pancalus*

The data obtained from the HPLC chromatogram of standard amino acid solutions along with those of the different fish samples are shown in the following tables.

Table: 1.5 PeakTable for HPLC Data of amino acid/Mix std 10ppm solution

Peak#	Name	Ret. Time	Area	Area %
1	L-Aspertic acid	6.488	205025	5.706
2	L-Serine	6.628	177134	4.930
3	L-Glutamine	7.502	252449	7.026
4	L-Hisidine	7.718	102270	2.846
5	L-Threonine	7.938	84588	2.354
6	L-Glutamic acid	8.158	201573	5.610
7	L-Arginine	8.514	74724	2.080
8	L-Aspergine	9.040	156411	4.353
9	L-Alanine	9.330	301622	8.394
10	L-Tyrosine	10.332	146217	4.069
11	L-Glycine	10.655	362129	10.078
12	L-Cystiene	12.000	47427	1.320
13	L-Valine	12.314	256453	7.137
14	L-Tryptophane	12.544	205993	5.733
15	L-Phenylalanine	13.399	111644	3.107
16	L-Isoleucine	13.777	191301	5.324
17	L-Leucine	13.933	193695	5.390
18	L-Methionine	14.596	207553	5.776
19	L-Lysine	16.370	315002	8.767
Total			3593175	100.000

Table: 1.6 PeakTable for HPLC Data of amino acid of *Barilius vagra*

Peak #	Name	Area	Area %
1	L-Alanine	1686235	6.574
2	L-Arginine	581975.1	2.269
3	L-Asperginine	1104260	4.305
4	L-Aspartic acid	2327900	9.075
5	L-Cystine	89534.63	1.349
6	L-Glutamic acid	7834280	30.541
7	L-Glutamine	671509.7	2.618
8	L-Glycine	343216.1	1.338
9	L-Tyrosine	417828.3	1.629
10	L-Histidine	223836.6	0.873
11	L-Isoleucene	596897.5	2.327
12	L-Leucine	1477321	5.759
13	L-Methionine	7311995	28.505
14	L-Phenylalanine	149224.4	0.582
15	L-Valine	835656.5	3.258
Total		25651671	100.000

Table: 1.7 PeakTable for HPLC Data of amino acid of *Neoeucirrhichthys maydelli*

Peak #	Name	Area	Area %
1	L-Alanine	880423.8	1.999
2	L-Arginine	5610837	12.741
3	L-Asperginine	149224.4	0.339
4	L-Aspartic acid	3148634	7.150
5	L-Glutamic acid	268603.9	0.610
6	L-Glutamine	1149028	2.609
7	L-Glycine	104457.1	0.237
8	L-Histidine	343216.1	0.779
9	L-Isoleucene	19399169	44.053
10	L-Leucine	850579	1.932
11	L-Methionine	10147258	23.043
12	L-Tryptophan	940113.6	2.135
13	L-Valine	1044571	2.372
Total		44036114	100.000

Table: 1.8 PeakTable for HPLC Data of amino acid of *Chanda nama*

Peak #	Name	Area	Area %
1	L-Alanine	1999607	8.634
2	L-Arginine	238759	1.031
3	L-Asperginine	1581778	6.830
4	L-Aspartic acid	119379.5	0.515
5	L-Glutamic acid	417828.3	1.804
6	L-Proline	298448.8	1.289
7	L-Serine	969958.5	4.188
8	L-Tyrosine	492440.5	2.126
9	L-Histidine	12475158	53.866
10	L-Isoleucene	701354.6	3.028
11	L-Leucine	432750.7	1.869
12	L-Lysine	432750.7	1.869
13	L-Phenylalanine	1716080	7.411
14	L-Threonine	149224.4	0.644
15	L-Tryptophan	552130.2	2.384
16	L-Valine	581975.1	2.513
Total		23159624	100.000

Table: 1.9 PeakTable for HPLC Data of amino acid of *Channa gachua*

Peak #	Name	Area	Area %
1	L-Alanine	208914.1	0.712
2	L-Asperginine	1432554	4.885
3	L-Aspartic acid	1566856	5.344
4	L-Cystine	432750.7	1.475
5	L-Glutamic acid	999803.3	3.410
6	L-Glutamine	179069.3	0.611
7	L-Glycine	537207.8	1.832
8	L-Serine	805811.6	2.748
9	L-Tyrosine	925191.1	3.155
10	L-Histidine	119379.5	0.407
11	Leucine	1074416	3.664
12	L-Methionine	6849399	23.359
13	L-Phenylalanine	552130.2	1.883
14	L-Threonine	12937754	44.122
15	L-Tryptophan	298448.8	1.018
16	L-Valine	402905.8	1.374
Total		29322590	100.000

Table: 1.10 PeakTable for HPLC Data of amino acid of *Rasbora daniconius*

Peak #	Name	Area	Area %
1	L-Alanine	1313175	5.110
2	L-Arginine	343216.1	1.336
3	L-Asperginine	880423.8	3.426
4	L-Aspartic acid	1432554	5.575
5	L-Cystine	358138.5	1.394
6	L-Glutamine	89534.63	0.348
7	L-Glycine	417828.3	1.626
8	L-Serine	522285.3	2.033
9	L-Tyrosine	1283330	4.994
10	L-Histidine	134301.9	0.523
11	L-Leucine	805811.6	3.136
12	L-Methionine	4043981	15.738
13	L-Phenylalanine	3715687	14.460
14	L-Threonine	9714507	37.805
15	L-Tryptophan	328293.6	1.278
16	L-Valine	313371.2	1.220
Total		25696438	100.000

Table: 1.11 PeakTable for HPLC Data of amino acid of *Channa punctatus*

Peaks	Name	Area	Area%
1	L-Aspertic Acid	10661	1877
2	L-Serine	726918	124491
3	L- Glutamine	7208	1533
4	L- Histidine	118965	26831
5	L- Glutamic Acid	456009	95177
6	L- Arginine	822052	190481
7	L- Aspergine	1873421	267301
8	L-Alanine	299843	64764
9	L-Tyrosine	7448	1504
10	L- Glycine	28736	6432
11	L- Cystiene	563620	96844
12	L- Valine	364923	74289
13	L- Tryptophane	52106	9022
14	L- Phenylalanine	444185	82791
15	L- Isoleucine	399426	70377
16	L- Leucine	1156676	179436
17	L- Methionine	2122639	344415
18	L- Lysine	13773	2277
19	L- Threonine	2748204	373777
Total		12216812	2013619

Table: 1.12 PeakTable for HPLC Data of amino acid of *Trichogaster fasciata*

Peaks #	Name	Area	Area%
1	L-Aspertic Acid	557604	5.445
2	L-Serine	73029	0.713
3	L- Glutamine	3882	0.038
4	L- Histidine	3750594	36.624
5	L- Glutamic Acid	291258	2.844
6	L- Arginine	56746	0.554
7	L- Aspergine	835431	8.158
8	L-Alanine	1586643	15.494
9	L-Tyrosine	250786	2.449
10	L- Glycine	4334	0.042
11	L- Cystiene	9535	0.093
12	L- Valine	541874	5.291
13	L- Tryptophane	360751	3.523
14	L- Phenylalanine	62757	0.613
15	L- Isoleucine	385485	3.764
16	L- Leucine	321482	3.764
17	L- Methionine	1135823	11.091
18	L- Lysine	12658	0.123
Total		10240670	100.000

Table: 1.13 PeakTable for HPLC Data of amino acid of *Xenentodon cancila*

Peak #	Name	Area	Area %
1	L-Alanine	447673.1	1.713
3	L-Asperginine	1611623	6.168
4	L-Aspartic acid	1507166	5.768
5	L-Cystine	402905.8	1.542
6	L-Glutamic acid	1089338	4.169
7	L-Glutamine	89534.63	0.343
8	L-Glycine	626742.4	2.399
10	L-Serine	865501.4	3.312
11	L-Tyrosine	492440.5	1.885
12	L-Histidine	119379.5	0.457
14	L-Leucine	1119183	4.283
16	L-Methionine	8580402	32.838
17	L-Phenylalanine	895346.3	3.427
18	L-Threonine	7729823	29.583
19	L-Tryptophan	552130.2	2.113
Total		26129189	100.000

Table: 1.14 PeakTable for HPLC Data of amino acid of *Amblypharyngodon mola*

Peaks	Name	Area	Area%
1	L-Aspertic Acid	6380	0.000
2	L-Serine	4554	0.000
3	L- Glutamine	49764	0.000
4	L- Histidine	1911	0.000
5	L- Glutamic Acid	110495	0.000
6	L- Arginine	1901102	0.000
7	L- Aspergine	23662	0.000
8	L-Alanine	1653280	0.000
9	L-Tyrosine	333664	0.000
10	L- Glycine	2961	0.000
11	L- Cystiene	602640	0.000
12	L- Valine	379990	0.000
13	L- Tryptophane	53454	0.000
14	L- Phenylalanine	18344	0.000
15	L- Isoleucine	367135	0.000
16	L- Leucine	31106	0.000
17	L- Methionine	1883656	0.000
18	L- Lysine	30757	0.000
Total		7454856	

Table: 1.15 PeakTable for HPLC Data of amino acid of *Macrognathus pancalus*

Peaks #	Name	Area	Area%
1	L-Serine	514099	4.149
2	L- Glutamine	89692	0.724
3	L- Histidine	2728	0.022
4	L- Threonine	4239364	34.210
5	L- Giutamic Acid	227660	1.837
6	L- Arginine	702832	5.672
7	L-Aspergine	1766264	14.253
8	L-Alanin	186753	1.507
9	L- Tyrosine	774386	6.249
10	L- Glycine	5530	0.045
11	L- Cystiene	401298	3.283
12	L- Valine	282856	2.283
13	L-Trytophane	58992	0.476
14	L- phenylanine	360275	2.907
15	L- Isoleucine	251355	2.028
16	L- leucine	1000536	8.074
17	L-Methionine	1514883	12.225
18	L- Lysine	12533	0.101
Total		12392037	100.000

Table: 2.1a Amino acid profile of the selected fish species

Sl. No.	**Fish species**	L-Alanine g/100g	L-Arginine g/100g	L-Asparagine g/100g	L-Aspartic acid g/100g	L-Cystine g/100g	L-Glutamic acid g/100g	L-Glutamine g/100g	L-Glycine g/100g	L-Proline g/100g	L-Serine g/100g
1	*Barilius vagra*	1.13	0.39	0.74	1.56	0.06	5.25	0.45	0.23	BDL	BDL
2	*N. maydelli*	0.59	3.76	0.10	2.11	BDL	0.18	0.77	0.07	BDL	BDL
3	*Chanda nama*	1.34	0.16	1.06	0.08	BDL	0.28	BDL	BDL	0.20	0.65
4	*Channa gachua*	0.14	BDL	0.96	1.05	0.29	0.67	0.12	0.36	BDL	0.54
5	*Rasbora daniconius*	0.88	0.23	0.59	0.96	0.24	BDL	0.06	0.28	BDL	0.35
6	*Channa punctatus*	0.26	0.72	0.78	BDL	0.31	0.31	BDL	0.14	0.12	0.47
7	*Trichogatser fasciata*	1.43	0.21	1.46	0.74	BDL	0.39	BDL	BDL	0.24	0.11
8	*Xenentodon cancila*	0.30	BDL	1.08	1.01	0.27	0.73	0.06	0.42	BDL	0.58
9	*Amblypharyngodon mola*	0.37	BDL	0.89	BDL	0.43	1.66	BDL	0.43	1.66	BDL
10	*Macrognathus pancalus*	0.09	1.33	1.59	BDL	1.19	0.16	BDL	BDL	0.11	0.41

Table: 2.1b Amino acid profile of the selected fish species

Sl. No	**Fish species**	L-Tyrosine (g/100g)	L-Histidine (g/100g)	L-Isoleucine (g/100g)	L-Leucine (g/100g)	L-Lysine (g/100g)	L-Meth--ionine(g/100g)	L-Phenyl--alanine (g/100g)	L-Threonine (g/100g)	L-Trypto-phan (g/100g)	L-Valine (g/100g)
1	*Barilius vagra*	0.28	0.15	0.40	0.99	BDL	4.90	0.10	BDL	BDL	0.56
2	*N maydelli*	BDL	0.23	0.13	0.57	BDL	6.80	BDL	BDL	0.63	0.70
3	*Chanda nama*	0.33	8.36	0.47	0.29	BDL	1.15	0.10	BDL	0.37	0.39
4	*Channa gachua*	0.62	0.08	BDL	0.72	BDL	4.59	0.37	8.67	0.20	0.27
5	*Rasbora daniconius*	0.86	0.09	BDL	0.54	BDL	2.71	0.49	6.51	0.22	0.21
6	*Channa punctatus*	BDL	0.18	0.24	2.68	BDL	9.42	0.30	3.27	0.06	0.23
7	*Trichogatser fasciata*	0.47	10.0	0.51	0.45	BDL	1.49	0.15	BDL	0.48	0.58
8	*Xenentodon cancila*	0.33	0.08	BDL	0.75	BDL	5.75	0.60	5.18	0.37	BDL
9	*Amblypharyngodon mola*	BDL	0.16	BDL	BDL	BDL	0.29	BDL	0.17	0.07	0.31
10	*Macrognathus pancalus*	0.75	BDL	0.19	0.73	BDL	1.03	0.46	7.07	BDL	1.03

BDL=Below Detectable Limit

The amino acid contents of the fish species selected is shown in table 1.4 (a) and 1.4 (b) Dietery protein provide substrates needed for synthesizing body proteins and also other nitrogen-containing compounds and the amount of amino acid contents in food proteins determine the nutritional quality of protein (Young et al., 1994). In the present study the amount of almost all the essential and non essential amino acids in the selected fish species were recorded. The presence of non essential amino acids like Alanine, Aspartic acid, glycine, serine, Tyrosine were recorded to be in less quantity in the fish species. Fair content of glutamic acid in *Barilius vagra* was resulted by the present study. The highest contents (10.0%) of essential amino acid histidine was found in *Trichogatser fasciata* which was followed by (8.36%) in *Chanda nama* . Another essential amino acid Methionine was highly quantified (9.42%) in *Channa gachua* followed by (6.80%) & (5.75%) in N. maydelli and *Xenentodon cancila* respectively. Threonine, the another non essential amino acid was high in *Channa gachua* (8.67%) followed by (7.07%), (6.51%) & (5.18%) in *Macrognathus pancalus* , *Rasbora daniconius* and *Xenentodon cancila* respectively. Body composition is found to be changing from one species to another species and also habite (Ashraf et al., 2011).

As per the report of Joint FAO/WHO/UNU Expert consultation on protein and amino acid requirements in human nutrition, WHO Technical Report Series No. 935, 2007, the necessary amounts of amino acid required by healthy living of an adult body are as follows : Histidine (15), isolucine (30), Leucine (59), lysine (45), methionine (16), cystine (6), threonine (15), tryotophan (60) and valine (26). Oluwaniyi et al., 2009 found the presence of higher amount of glutamic acid in their four studied species Clupea harengus, Scomber scombrus, Trachurus trachurus and Urophycis tenuis. This result shows similarity with the present work that among all the non essential amino acids, glutamic acid was highlighted in all the ten studied species. In the language of Ashraf et al., 2011, the amount of phenylalanine, valine, arginine, lysine and tyrosine were in higher contents in grass carp whereas the contents of alanine, glutamic acid, and methylalanine and valine were mostly prominent in silver carp. This was justified by limiting feeding scope of grass crap than silver carp. It was concluded the grass crap ws superior to silver crap. The fishes which feed on low protein diet get more effected by essential amino acids than the fishes which consume high protein diet (Ashraf et al., 2011).

Fish muscle is made of very good composition of amino acid. It is the vital source of nutrients as well as requisite contents of amino acid that are easy to digest by all age groups of human being (Venugopal et al., 1996 & Yanez, et al., 1976). Fish bodies are covered by a shawl of water mass, hence the muscle fibres need lesser structural support compared to the muscles of land animals (Huttin et al., 1976). In the present work of the essential amino acids like phenylalanine, valine, tryptophan, threonine, isolucine, methionine, histidine, arginine, leucine and lysine were detected.

Methionine is one of the most important amino acid lacking of which shows deficiency symptoms prominently. It helps in the production of sulphur which helps normal metabolism. It is also required for the synthesis of haemoglobin and glutathione which fight against free radicals (Akhirevbulu et al., 2013). The dominating amino acids of proteins are known to be the precursors of several coenzymes, hormones , nucleic acids and other molecules which meet the essential requirement for life. A sufficient intake of dietary protein is needed to strength cellular integrity and function and also for good health and reproduction (Haeaibam Romsharsha et al., 2014).

As per the data the Hawaibam Romharsha et al., 2014, glutamic acid was amounted to be the highest (20.04%) in semiplotus manipurensis in comparison to other two studied fish species *N. stracheyi* & *L. pangusia*. In the present study, *Barilius vagra* contained the highest content of glutamic acid (5.25 gm) amongst the ten studied species. Aspartic acid was recoded to be in significant contents in all the studied fish species in the work of Hawaibam et al 2014. But in the present work the said non essential amino acid, was found to be of lower amounts. It may be explained by the differences in their feeding habits. The essential amino acids like Methionine, Thremine, Valine, Histidine, Phenylalanine, Leucine were recorded to be present in more or less good amounts. Histidine was recorded to be highest in *Trichogatser fasciata* (10.0) followed by *Chanda nama* (8.36). Threonine was found to be mostly contained by *Channa gachua* (8.67) which was followed by *Macrognathus pancalus* (7.07), *Rasbora daniconius* (6.51) and *Xenentodon cancila* (5.18). Threonine is widely used for the treatment of nerve disorders including spinal spasticity, multiple sclerosis familial spastic paraparesus and also amyotrophic lateral sclerosis (K. Hyland, 2007). In accordance with the result analysis of Mahanty et al., 2014, amongst 27 food fishes, the species *S. Waitei* contained the highest content of Threonine. From the present investigation it may be concluded that the small food fish *Channa gachua* of BTAD, Kokrajhar area can be used to serve as a natural supplementation for threonine. Another very important branched chain amino acid, isoleucine is required for the formation of muscle as well as propagation of the normal growth of the same (Charlton, 2006). Although in lesser amount, Isoleucine was found to be present in all the studied species. The patients having chronic renal failure face the complicacy of low plasma level of the branched chain amino acids like leucine, isoleucine and valine when they are under hemodialysis. The crucial abnormalities in the plasma amino acid pool can be recovered with the proper high protein supplementation

(Bordin et al., 2013). The studied food fishes can be recommended as ideal dietary supplementations for human health.

4.6 Fatty acid Profile

The following are the GC-MS Chromatogram of fatty acids profile of the different fish samples.

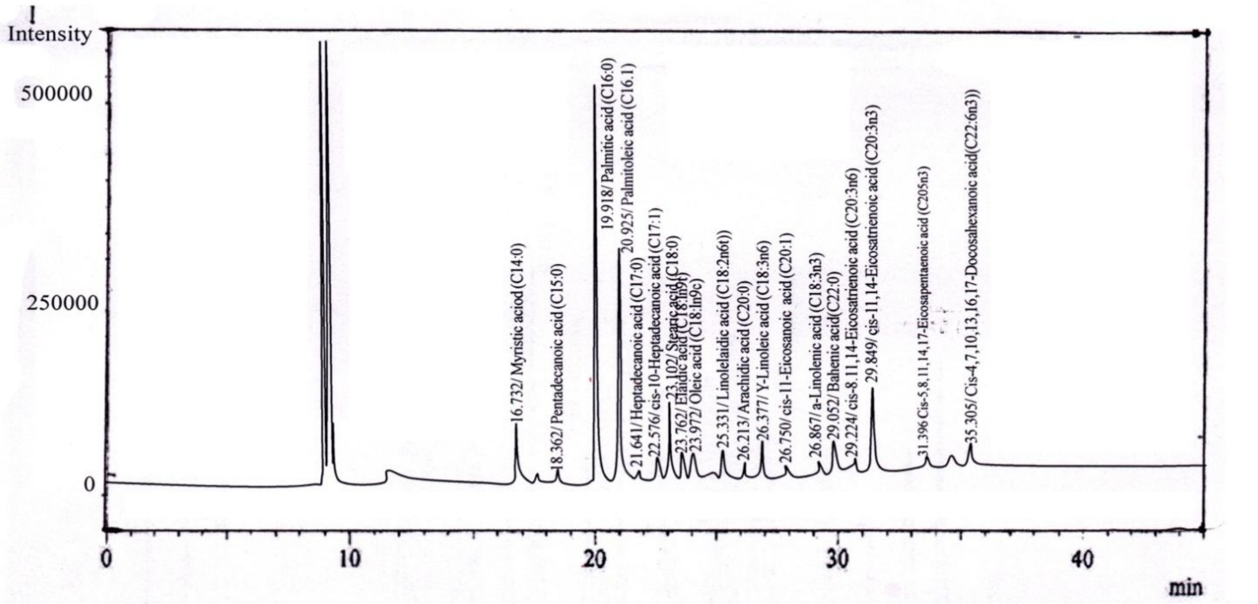


Fig.: 2.4.1 GC-MS Chromatogram of Fatty acids in *Barilius vagra*

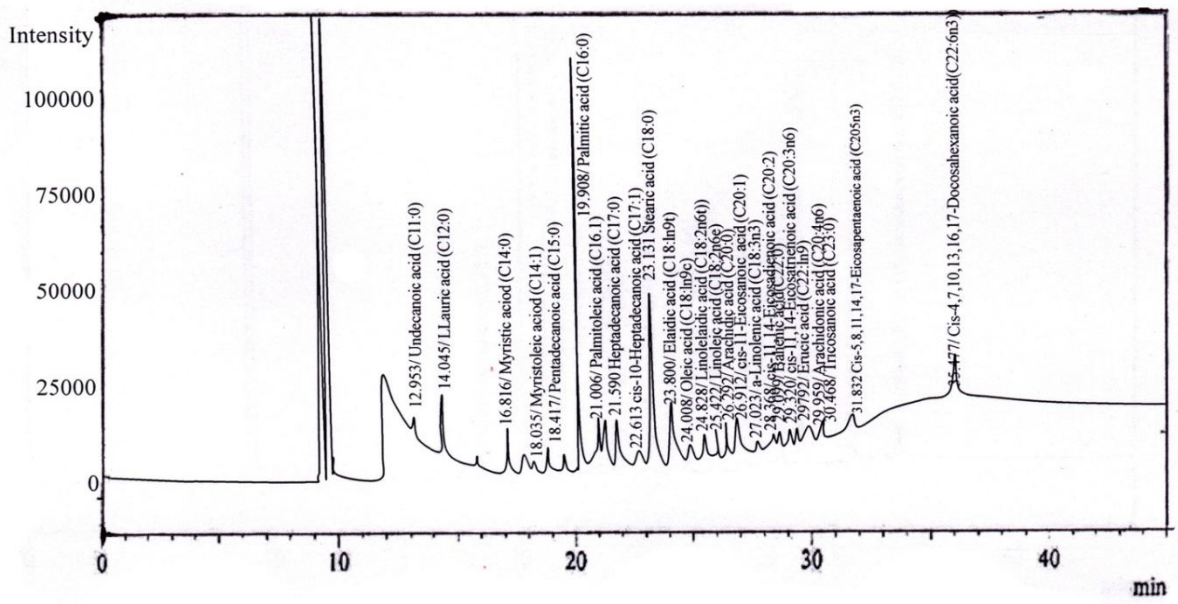


Fig.: 2.4.2 GC-MS Chromatogram of Fatty acids in *Neoeucirrhichthys maydelli*

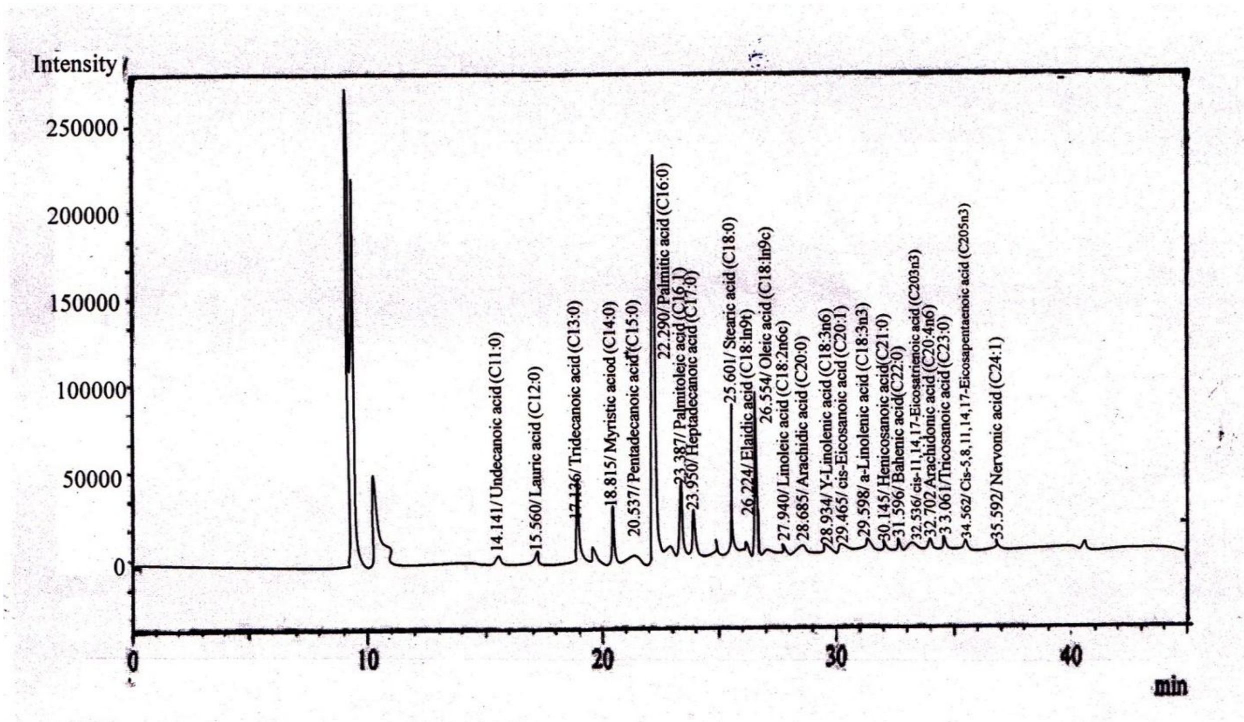


Fig.: 2.4.3 GC-MS Chromatogram of Fatty acids in *Chanda nama*

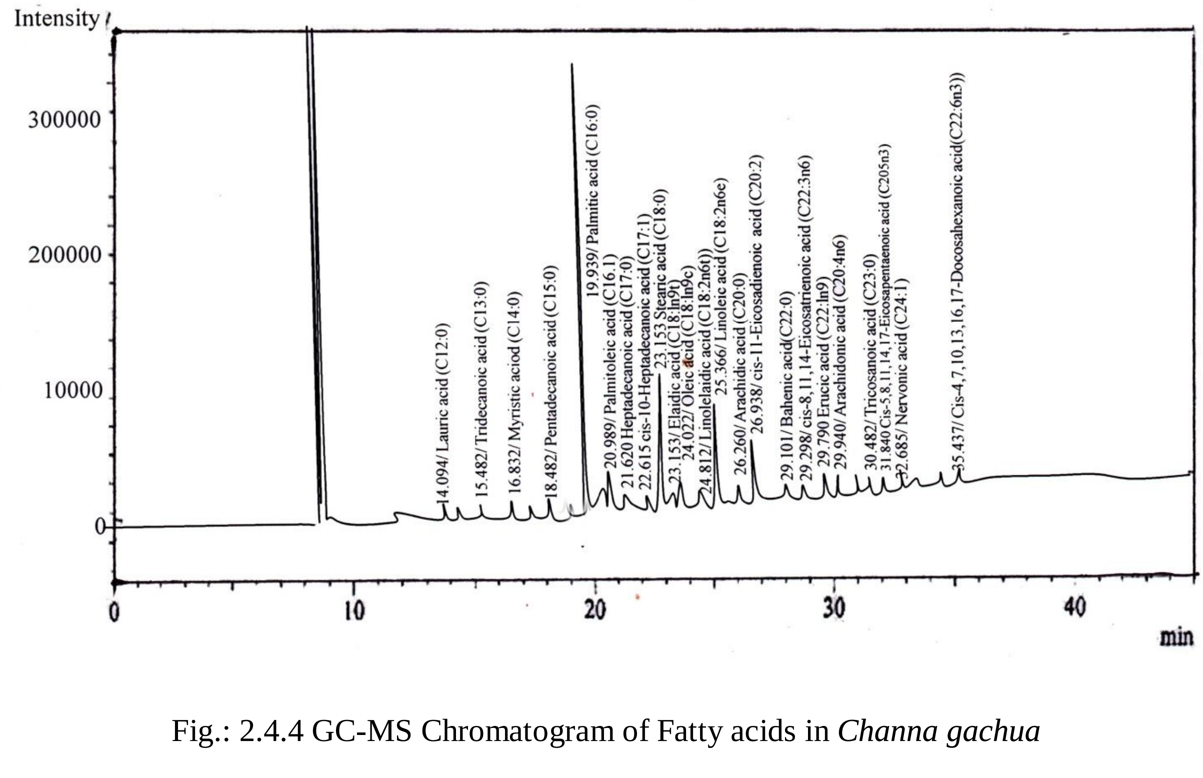


Fig.: 2.4.4 GC-MS Chromatogram of Fatty acids in *Channa gachua*

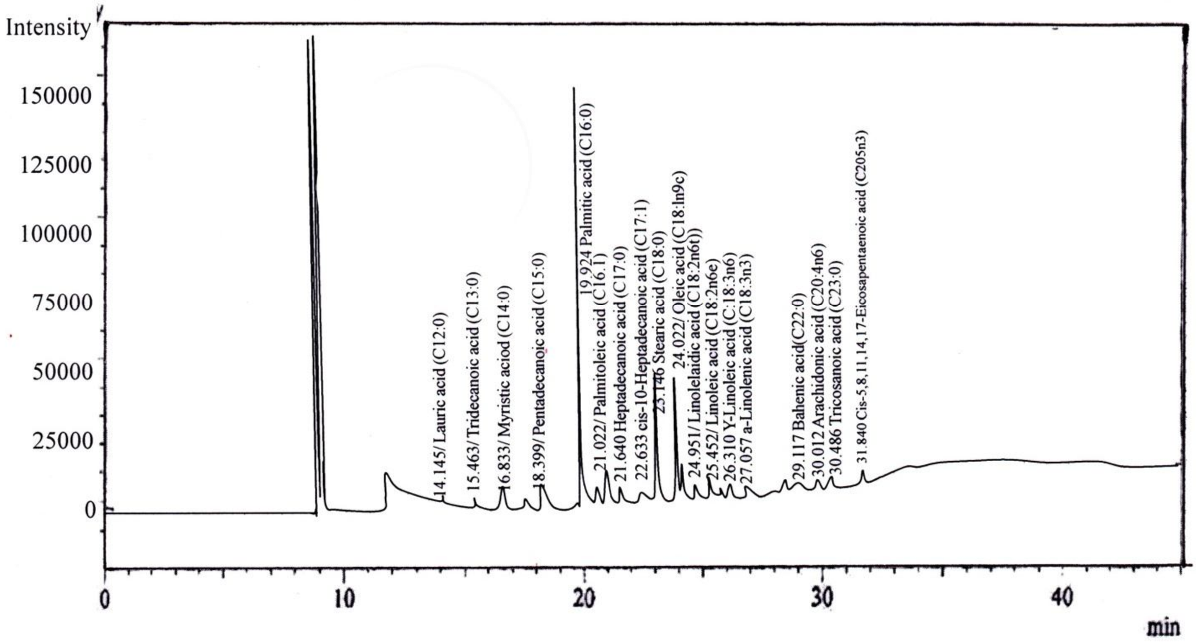


Fig.: 2.2.4 GC-MS Chromatogram of Fatty acids in *Rasbora daniconius*

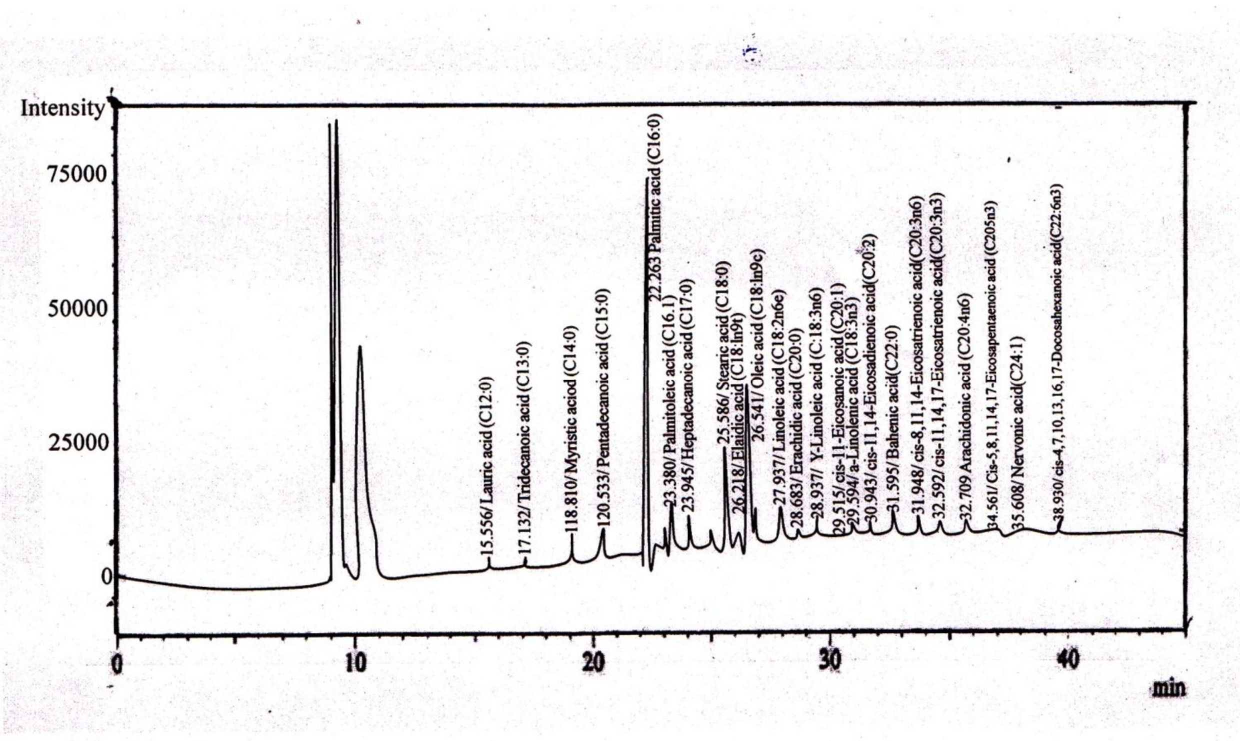


Fig.: 2.4.6 GC-MS Chromatogram of Fatty acids in *Channa punctatus*

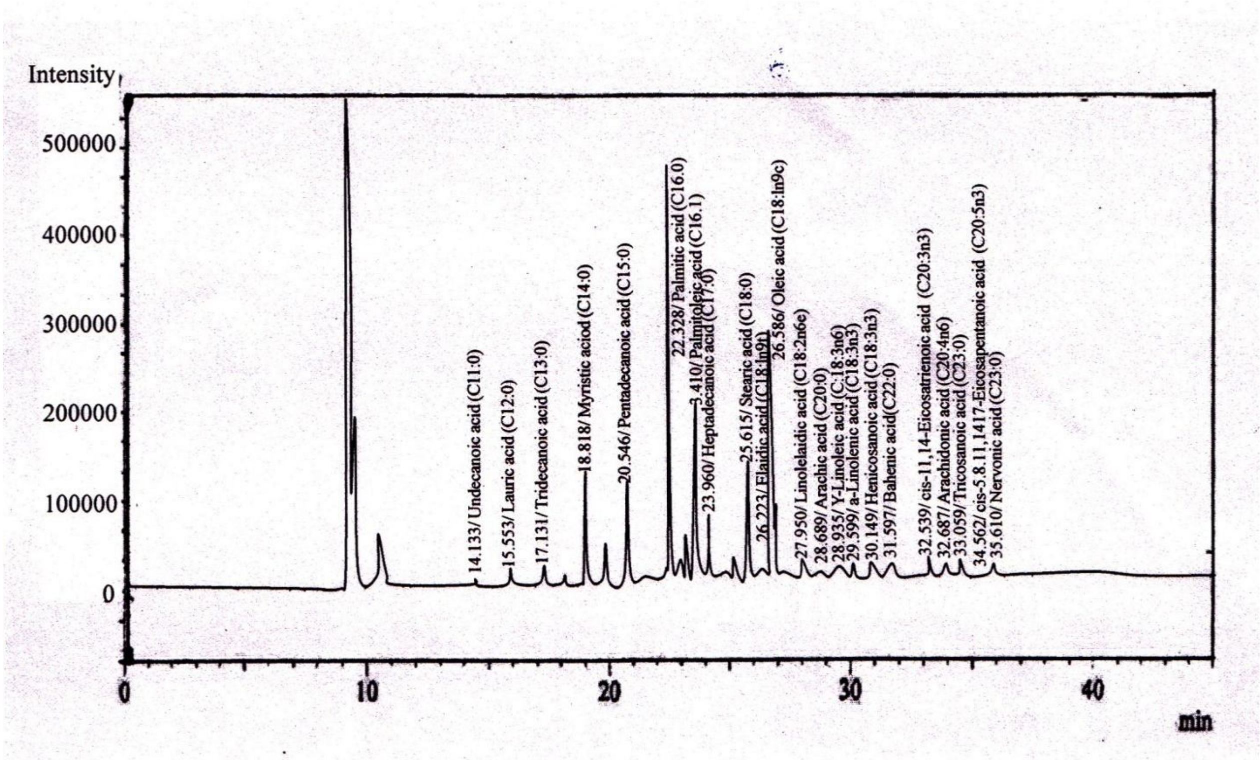


Fig.: 2.4.7 GC-MS Chromatogram of Fatty acids in *Trichogaster fasciata*

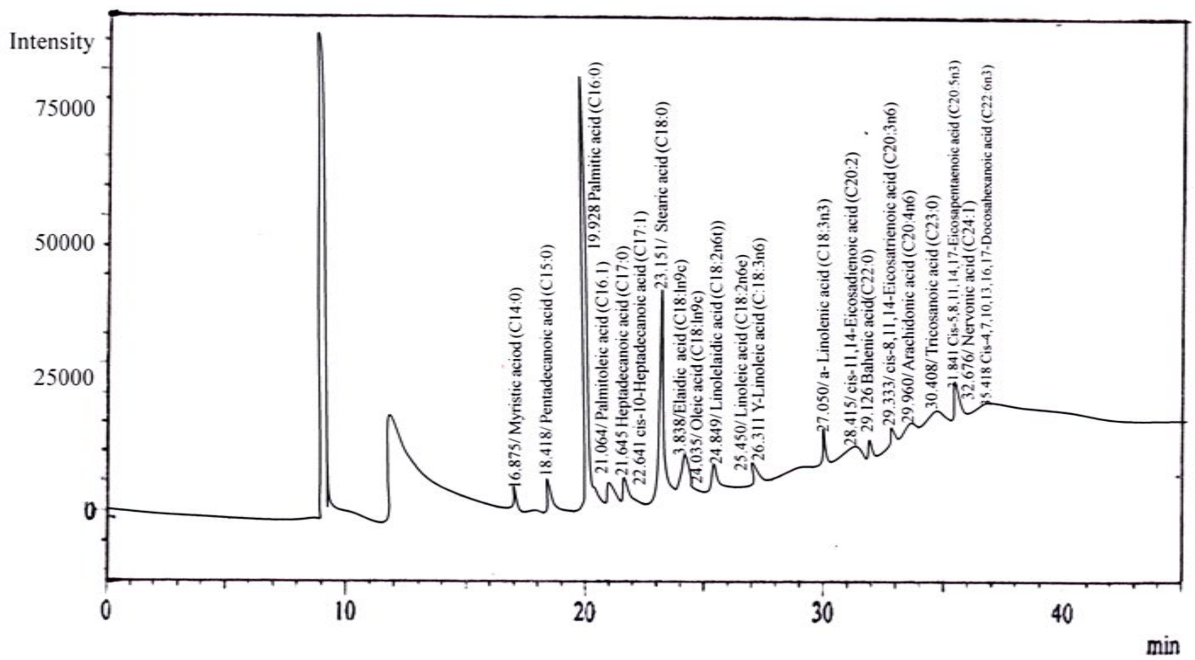


Fig.: 2.4.8 GC-MS Chromatogram of Fatty acids in *Xenentodon cancila*

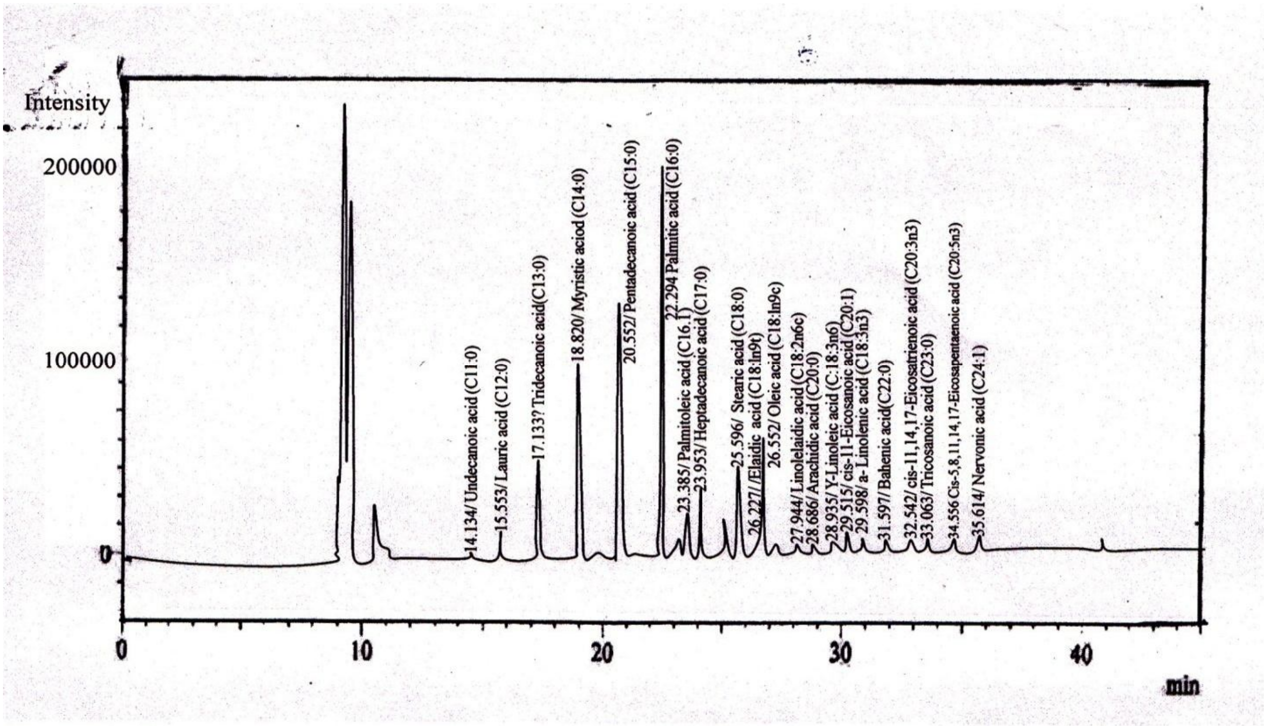


Fig.: 2.4.9 GC-MS Chromatogram of Fatty acids in *Amblypharyngodon mola*

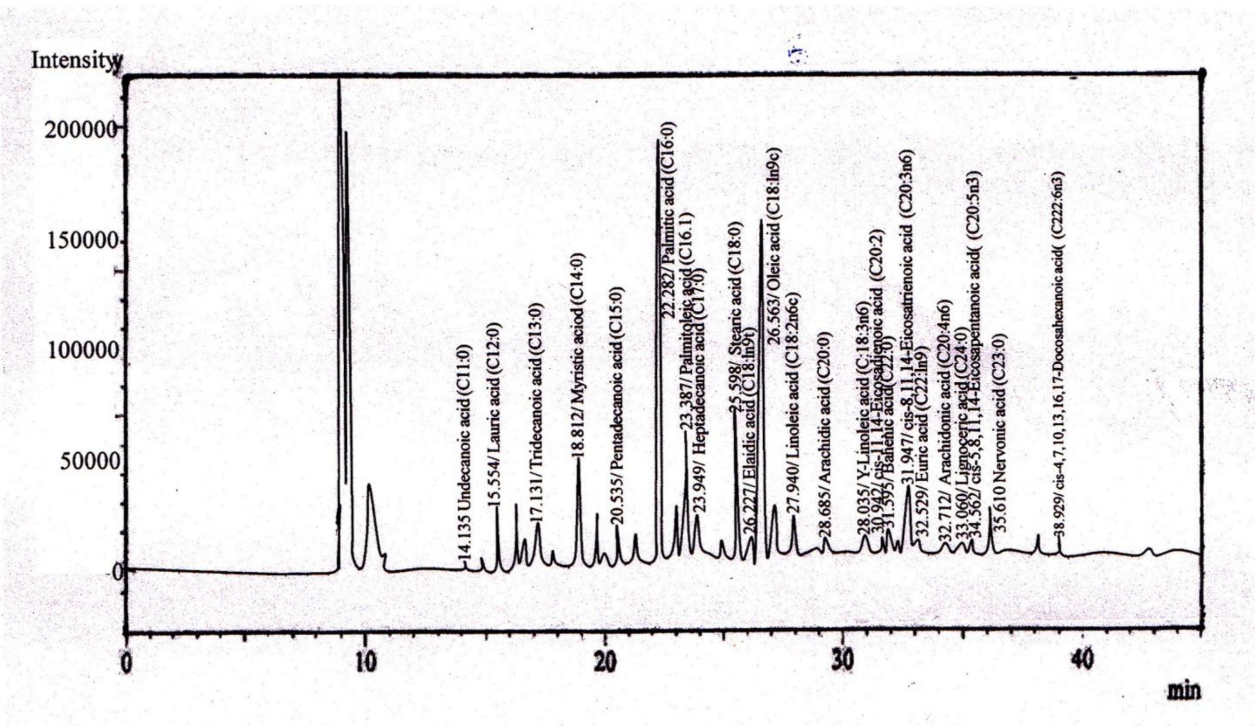


Fig.: 2.4.10 GC-MS Chromatogram of Fatty acids in *Macrognathus pancalus*

The data obtained from the GC-MS chromatogram of fatty acid profile of the different fish samples are shown in the following tables.

Table:2.1.1 Peak Table for Fatty acids in *Barilius vagra*

Peak#	Name	Ret.Time	Area	Height	Area%
1	Myristic Acid(C14:0)	16.732	499216	69300	5.9788
2	Pentadecanoic acid(C15:0)	18.632	101566	10872	1.2522
3	Palmitic acid(C16:0)	19.918	2888329	480160	31.5915
4	Palmitoleic acid(C16:1)	20.925	1525163	275485	18.2658
5	Heptadecanoic acid(C17:0)	21.641	82088	7040	0.9831
6	Cis-10-Heptadecanoic acid(C17:1)	22.576	178438	23546	2.1370
7	Stearic acid (C18:0)	23.102	503541	92319	6.0306
8	Elaidic acid(C18:1n9t)	23.762	43953	8685	0.5264
9	Oleic acid(C18:1n96)	23.972	713903	95060	8.5499
10	Linoleic acid(C18:2n6c)	25.331	217218	29027	2.6015
11	Arachidic acid(C20:0)	26.213	17648	3237	0.2114
12	Y-Linolenic acid(C18:3n6)	26.377	58973	6319	0.7063
13	Cis-11-Eicosenoic acid(C20:1)	26.750	28418	7377	0.3403
14	a-Linoleic acid(C18:3n3)	26.867	357499	18417	4.2815
15	Behenic acid(C22:0)	29.052	14799	2853	0.1772
16	Cis-8,11,14-Eicosatrienoic acid(C20:3n6)	29.224	59707	5878	0.7151
17	Cis-11,14,17-Eicosatrienoic acid(C20:3n3)	29.849	246559	43537	2.9529
18	Cis-5,8,11,14,17-Eicosapentaenoic acid(C20:5n3)	31.396	575218	98695	6.8890
19	Cis-4,7,10,13,16,17-Docosahexanoica acid(C22:6n3)	35.305	234600	37837	2.8096
Total			8349833	1345614	100.0000

Table: 2.2.2 .Peak Table Fatty acids of *Neoeucirrhichthys maydelli*

Peak#	Name	Ret.Time	Area	Height	Area%
1	Undecanoic acid(C11:0)	12.953	18833	2687	0.9604
2	Lauric acid(C12:0)	14.013	90372	12434	4.6086
3	Myristic acid(C14:0)	16.816	97433	30890	4.9687
4	Myristoleic acid(C14:1)	18.035	14470	1157	0.2379
5	Pentadecanoic acid(C15:0)	18.117	19192	1802	2.5239
6	Palmitic acid(C16:0)	19.908	617612	99752	31.4957
7	Palmitoleic acid(C16:1)	21.006	50963	7348	2.5989
8	Heptadecanoic acid(C17:0)	21.590	99340	10716	5.0660
9	Cis-10-Heptadecanoic acid(C17:1)	22.613	24089	2312	1.2285
10	Stearic acid(C18:0)	23.131	277120	41882	14.1320
11	Elaidic acid(C18:9nt)	23.800	24131	4826	1.2306
12	Oleic acid(C18:1n9c)	24.008	379892	40517	19.3720
13	Linolelaidic acid(C18:2n6t)	24.828	11427	1760	0.5827
14	Linoleic acid(C18:2n6c)	25.422	50091	5966	2.5544
15	Arachidic acid(C20:0)	26.292	9158	1276	0.4676
16	Cis-11,14-Eicosadienoic acid(C20:1)	26.912	37539	6963	1.9143
17	a-Linolenic acid(C18:3n3)	27.023	33815	4036	1.7244
18	Cis-11,14-Eicosadienoic acid(C20:2)	28.368	8515	1252	0.4343
19	Behenic acid(C22:0)	29.099	13268	2041	0.6766
20	Cis-8,11,14-Eicosatrienoic acid(C20:3n6)	29.320	7793	978	0.3974

21	Erucic acid(C22:1n9)	29.792	3801	652	0.1938
22	Arachidonic acid(C20:4n6)	29.959	25259	3458	1.2881
23	Tricosanoic acid(C23:0)	30.468	4139	772	0.2111
24	Cis-5,8,13,16,17-Eicosapentaenoic acid(C20:5n3)	31.832	9485	1493	0.4837
25	Cis-4,7,10,13,16,17-Docosahexanoica acid(C22:6n3)	35.447	2921	431	0.1490
Total			1960938	270401	100.0000

Table: 2.2.3.Peak Table of Fatty acids of *Chanda nama*

Peak#	Name	Ret.Time	Area	Height	Area%
1	Undecanoic acid(C11:0)	14.141	7633	2281	0.3794
2	Lauric acid(C12:0)	15.560	16225	4666	0.8064
3	Tridecanoic acid(C13:0)	17.136	22471	6521	1.1168
4	Myristic acid(C14:0)	18.815	142297	41400	7.0722
5	Pentadecanoic acid(C15:0)	20.537	94133	27371	4.6785
6	Palmitic acid(C16:0)	22.290	813944	218854	40.4534
7	Palmitoleic acid(C16:1)	23.387	121281	35525	6.0277
8	Heptadecanoic acid(C17:0)	23.950	78950	23362	3.9239
9	Stearic acid(C18:0)	25.601	259948	76815	12.9195
10	Elaidic acid(C18:9nt)	26.224	23917	4223	1.1887
11	Oleic acid(C18:1n9c)	26.554	351279	82297	17.4588
12	Linoleic acid(C18:2n6c)	27.940	17138	4816	0.8518
13	Arachidic acid(C20:0)	28.685	14408	4264	0.7161
14	Y-Linolenic acid(C18:3n3)	28.934	4292	1167	0.2133
15	Cis-11-Eicosenoic acid(C20:1)	29.465	5922	1284	0.2943
16	a-Linolenic acid(C18:3n3)	29.598	5558	1655	0.2762
17	Henicosanoic acid(C21:0)	30.145	1841	612	0.0915
18	Behenic acid(C22:0)	31.596	9648	2776	0.4795
19	Cis-11 ,14,17-Eicosatrienoic acid(C20:3n3)	32.536	2523	664	0.1254
20	Arachidonic acid(C20:4n6)	32.702	1548	395	0.0770
21	Tricosanoic acid(C23:0)	33.061	2614	773	0.1299
22	Cis-5,8,11,14,17-Eicosapentaenoic acid(C20:5n3)	34.562	9010	2062	0.4478
23	Nervonic acid(C24:1)	35.592	5472	1611	0.2719
Total			2012052	545394	100.0000

Table: 2.2.4 Peak Table of Fatty acids of *Channa gachua*

Peak#	**Name**	**Ret.time**	**Area**	**Height**	**Area%**
1	Lauric acid(C12:0)	14.094	27351	3383	0.5718
2	Tridecanoic acid(C13:0)	15.482	1253	611	0.0889
3	Myristic acid(C14:0)	16.882	79115	8984	1.6541
4	Pentadecanoic acid(C15:0)	18.182	45883	1816	0.9593
5	Palmitic acid(C16:0)	19.939	1660477	306317	34.7171
6	Palmitoleic acid(C16:1)	20.989	165480	24574	3.4598
7	Heptadecanoic acid(C17:0)	21.620	97360	9589	2.0356
8	Cis-10-Heptadecanoic acid(C17:1)	22.615	31102	3272	0.7130
9	Stearic acid(C18:0)	23.153	508383	87111	10.6292
10	Elaidic acid(C18:9nt)	23.816	23983	4936	0.5011

11	Oleic acid(C18:1n9c)	24.022	1110275	188316	23.8107
12	Linolelaidic acid(C18:2n6t)	24.812	33186	58960	0.6938
13	Linoleic acid(C18:2n6e)	25.306	115371	61775	8.6843
14	Arachidic acid(C20:0)	26.260	26318	4844	0.5509
15	Cis-11-Eicosenoic acid(C20:1)	26.938	201737	37302	4.2179
16	a-Linolenic acid(C18:3n3)	27.017	78036	16351	1.6316
17	Cis-11,14-Eicosadienoic acid(C20:2)	28.365	37101	4052	0.7757
18	Behenic acid(C22:0)	29.101	23536	4173	0.4921
19	Cis-8,11 ,14-Eicosatrienoic acid(C20:3n6)	29.298	26336	3422	0.5506
20	Erneic acid(C22:1n9)	29.790	21030	3988	0.4397
21	Arachidonic acid(C20:4n6)	29.940	91050	14177	1.9037
22	Tricosanoic acid(C23:0)	30.482	5287	1116	0.1105
23	Cis-5,8,11,14,17-Eicosapentaenoic acid(C20:5n3)	31.840	19857	3399	0.4152
24	Nervonic acid(C24:1)	32.685	4207	831	0.0880
25	Cis-4,7,10,13,16,17-Docosahexanoica acid(C22:6n3)	35.437	13141	1997	0.2748
Total			4782885	805502	100.0000

Table: 2.2.5 .Peak Table of Fatty acids of *Rasbora daniconius*

Peak #	**Name**	**Ret.time**	**Area**	**Height**	**Area%**
1	Lauric acid(C12:0)	14.145	7166	820	0.3946
2	Tridecanoic acid(C13:0)	15.463	16821	1409	0.9262
3	Myristic acid(C14:0)	16.833	76951	8490	4.2371
4	Pentadecanoic acid(C15:0)	18.399	71080	7718	3.9138
5	Palmitic acid(C16:0)	19.924	792896	136809	43.6589
6	Palmitoleic acid(C16:1)	21.022	105860	10671	5.8289
7	Heptadecanoic acid(C17:0)	21.640	54401	5054	2.9955
8	Cis-10-Heptadecanoic acid(C17:1)	22.633	15485	1587	0.8527
9	Stearic acid(C18:0)	23.146	266109	40385	14.6526
10	Oleic acid(C18:1n9e)	24.022	301631	38062	16.6086
11	Linolelaidic acid(C18:2n6t)	24.851	7858	927	0.4327
12	Linoleic acid(C18:2n6e)	25.452	35562	3874	1.9581
13	Y-Linolenic acid(C18:3n6)	26.310	7961	1139	0.4383
14	a-Linolenic acid(C18:3n3)	27.057	20555	1375	1.1318
15	Behenic acid(C22:0)	29.117	12720	1720	0.7001
16	Arachidonic acid(C20:4n6)	30.012	4094	582	0.2251
17	Tricosanoic acid(C23:0)	30.486	4139	784	0.2279
18	Cis-5,8,11,14,17-Eicosapentaenoic acid(C20:5n3)	31.840	14827	2627	0.8161
Total			1816116	264033	100.0000

Table: 2.2.6 Peak Table of Fatty acids of *Channa punctatus*

Peak#	Name	Ret.Time	Area	Height	Area%
1	Lauric acid(C12:0)	15.556	4108	1236	0.6273
2	Tridecanoic acid(C13:0)	17.132	6059	1739	0.9253

3	Myristic acid(C14:0)	18.810	24051	6771	3.6730
4	Pentadecanoic acid(C15:0)	20.533	28166	8231	4.3013
5	Palmitic acid(C16:0)	22.263	235553	68936	35.9723
6	Palmitoleic acid(C16:1)	23.380	38317	9591	5.8515
7	Heptadecanoic acid(C17:0)	23.945	21435	6296	3.2734
8	Stearic acid(C18:0)	25.586	76169	22614	11.6321
9	Elaidic acid(C18:1n9t)	26.218	11773	1949	1.7979
10	Oleic acid(C18:1n9e)	26.541	126297	29779	19.2873
11	Linoleic acid(C18:2n6e)	27.937	24285	6639	3.7087
12	Arachidic acid(C20:0)	28.683	6228	1699	0.9511
13	Y-Linolenic acid(C18:3n6)	28.936	1627	453	0.2484
14	Cis-11-Eicosenoic acid(C20:0)	29.515	17029	3502	2.605
15	a-Linolenic acid(C18:3n3)	29.594	30082	974	0.4706
16	Cis-11,14-Eicosadienoic acid(C20:2)	30.943	4943	933	0.7549
17	Behenic acid(C22:0)	31.595	3894	1169	0.5947
18	Cis-8,11,14-Eicosatrienoic acid(C20:3n6)	31.948	1000	298	0.1527
19	Cis-11,14,17-Eicosatrienoic acid(C20:3n3)	32.532	3355	842	0.5123
20	Arachidonic acid(C20:4n6)	32.709	7484	1941	1.1429
21	Tricosanoic acid(C23:0)	33.058	1499	410	0.2290
22	Cis-5,8,11,14,17-Eicosapentaenoic acid(C20:5n3)	34.561	4103	1060	0.6266
23	Nervonic acid(C24:1)	35.608	1590	397	0.2428
24	Cis-4,7,10,13,16,17-Docosahexanoica acid(C22:6n3)	38.930	2771	608	0.4232
Total			654818	178067	100.0000

Table: 2.2.7 Peak Table of Fatty acids of *Trichogaster fasciata*

Peak#	**Name**	**Ret.Time**	**Area**	**Height**	**Area%**
1	Undecanoic acid(C11:0)	14.133	17070	5120	0.2973
2	Lauric acid(C12:0)	15.553	35604	10424	0.6200
3	Tridecanoic acid(C13:0)	17.131	33378	22357	1.3475
4	Myristic acid(C14:0)	18.818	369510	105093	6.4350
5	Pentadecanoic acid(C15:0)	20.546	375278	107206	6.5355
6	Palmitic acid(C16:0)	22.328	2079891	446638	36.2214
7	Palmitoleic acid(C16:1)	23.410	675275	172078	11.7596
8	Heptadecanoic acid(C17:0)	23.960	211568	63088	3.6845
9	Stearic acid(C18:0)	25.615	436375	122506	7.5995
10	Elaidic acid(C18:1n9t)	26.233	21929	5287	0.3819
11	Oleic acid(C18:1n9c)	26.586	1267658	254866	22.0763
12	Linoleic acid(C18:2n6c)	27.950	32460	7667	0.5653
13	Arachidic acid(C20:0)	28.689	35532	10561	0.6188
14	Y-Linolenic acid(C18:3n6)	28.935	9024	2574	0.1572
15	a-Linolenic acid(C18:3n3)	29.599	27726	8111	0.4828
16	Henicosanoic acid(C21:0)	30.149	11518	3560	0.206

17	Behenic acid(C22:0)	31.597	20810	6094	0.3624
18	Cis-11,14,17-Eicosatrienoic acid(C20:3n3)	32.539	3085	931	0.0537
19	Arachidonic acid(C20:4n6)	32.687	4562	1099	0.0795
20	Tricosanoic acid(C23:0)	33.059	10913	3129	0.1900
21	Cis-5,8,11,14,17-Eicosapentaenoic acid(C20:5n3)	34.562	15005	4081	0.2613
22	Nervonic acid(C24:1)	33.610	409	1034	0.0698
Total			5742162	1363504	100.0000

Table: 2.2.8 Peak Table of Fatty acids of *Xenentodon cancila*

Peak#	**Name**	**Ret.Time**	**Area**	**Height**	**Area%**
1	Myristic acid(C14:0)	16.875	35628	3509	2.9034
2	Pentadecanoic acid(C15:0)	18.418	48700	4913	3.9686
3	Palmitic acid(C16:0)	19.928	440958	69626	35.9341
4	Palmitoleic acid(C16:1)	21.064	21476	2993	1.7501
5	Heptadecanoic acid(C17:0)	21.645	42314	4316	3.4482
6	Cis-10-Heptadecanoic acid(C17:1)	22.641	14158	1215	1.1537
7	Stearic acid(C18:0)	23.151	213511	31696	17.3992
8	Elaidic acid(C18:1n9t)	23.838	5222	1178	0.4255
9	Oleic acid(C18:1n9c)	24.035	228338	24628	18.6075
10	Linolelaidic acid(C18:2n6t)	24.849	6298	961	0.5132
11	Linoleic acid(C18:2n6c)	25.450	34329	4210	2.7975
12	Y-Linolenic acid(C18:3n6)	26.331	3556	580	0.2898
13	a-Linolenic acid(C18:3n3)	27.050	22254	1736	1.8135
14	Cis-11,14-Eicosadienoic acid(C20:2)	28.415	4320	639	0.3521
15	Behenic acid(C22:0)	29.126	5889	1147	0.4799
16	Cis-8,11,14-Eicosatrienoic acid(C20:3n6)	29.333	6478	833	0.5279
17	Arachidonic acid(C20:4n6)	29.960	38892	5982	3.1694
18	Tricosanoic acid(C23:0)	30.498	2674	547	0.2179
19	Cis-5,8,11,14,17-Eicosapentaenoic acid(C20:5n3)	31.841	13648	2485	1.1122
20	Nervonic acid(C24:1)	32.676	5256	1099	0.4283
21	Cis-4,7,10,13,16,17-Docosahexanoica acid(C22:6n3)	35.418	33232	4691	2.7081
Total			1227131	168984	100.0000

Table: 2.2.9 Peak Table of Fatty acids of *Amblypharyngodon mola*

Peak#	**Name**	**Ret.Time**	**Area**	**Height**	**Area%**
1	Undecanoic acid(C11:0)	14.134	7912	2383	0.2719
2	Lauric acid(C12:0)	15.553	55249	16271	1.8991
3	Tridecanoic acid(C13:0)	17.133	192716	56572	6.6243
4	Myristic acid(C14:0)	18.820	415162	120181	14.2705
5	Pentadecanoic acid(C15:0)	20.552	556562	157224	19.1309
6	Palmitic acid(C16:0)	22.294	929120	241700	31.9370
7	Palmitoleic acid(C16:1)	23.385	72276	21629	2.4844
8	Heptadecanoic acid(C17:0)	23.953	144043	42808	4.9512

9	Stearic acid(C18:0)	25.596	179489	52770	6.1696
10	Elaidic acid(C18:1n9t)	26.227	4294	1154	0.1476
11	Oleic acid(C18:1n9c)	26.552	280295	71739	9.6347
12	Linoleic acid(C18:2n6c)	27.944	12538	3262	0.4310
13	Arachidic acid(C20:0)	28.686	11168	3173	0.3839
14	Y-Linolenic acid(C18:3n6)	28.935	4091	1137	0.1406
15	Cis-11-Eicosenoic acid(C20:1)	29.515	14285	3229	0.4910
16	a-Linolenic acid(C18:3n3)	29.598	10173	2886	0.3497
17	Behenic acid(C22:0)	31.597	6304	1680	0.2167
18	Cis-11,14,17-Eicosatrienoic acid(C20:3n3)	32.542	2669	712	0.0918
19	Tricosanoic acid(C23:0)	33.063	3031	720	0.1042
20	Cis-5,8,11,14,17-Eicosapentaenoic acid(C20:5n3)	34.566	6078	1502	0.2089
21	Nervonic acid(C24:1)	35.614	1773	467	0.0609
Total			2909228	100.0000	100.0000

Table: 2.2.10 Peak Table of Fatty acids of *Macrognathus pancalus*

Peak#	Name	Ret.Time	Area	Height	Area%
1	Undecanoic acid(C11:0)	14.141	7633	2281	0.3794
2	Lauric acid(C12:0)	15.560	16225	4666	0.8064
3	Tridecanoic acid(C13:0)	17.136	22471	6521	1.1168
4	Myristic acid(C14:0)	18.815	142297	41400	7.0722
5	Pentadecanoic acid(C15:0)	20.537	94133	27371	4.6785
6	Palmitic acid(C16:0)	22.290	813944	218854	40.4534
7	Palmitoleic acid(C16:1)	23.387	121281	35525	6.0277
8	Heptadecanoic acid(C17:0)	23.950	78950	23362	3.9239
9	Stearic acid(C18:0)	25.601	259948	76815	12.9195
10	Elaidic acid(C18:1n9t)	26.224	23917	4223	1.1887
11	Oleic acid(C18:1n9c)	26.554	351279	82297	17.4588
12	Linoleic acid(C18:2n6c)	27.940	17138	4816	0.8518
13	Arachidic acid(C20:0)	28.685	14408	4264	0.7161
14	Y-Linolenic acid(C18:3n6)	28.934	4292	1167	0.2133
15	Cis-11-Eicosenoic acid(C20:1)	29.465	5922	1284	0.2943
16	a-Linolenic acid(C18:3n3)	29.598	5558	1655	0.2762
17	Henicosanoic acid(C21:0)	30.145	1841	612	0.0915
18	Behenic acid(C22:0)	31.596	9648	2776	0.4795
19	Cis-11,14,17-Eicosatrienoic acid(C20:3n3)	32.536	2523	664	0.1254
20	Arachidonic acid(C20:4n6)	32.702	1548	395	0.0770
21	Tricosanoic acid(C23:0)	33.061	2614	773	0.1299
22	Cis-5,8,11,14,17-Eicosapentaenoic acid(C20:5n3)	34.562	9010	2062	0.4478
23	Nervonic acid(C24:1)	35.592	5472	1611	0.2719
Total			2012052	545394	100.0000

Table: 2.3a Fatty acid profile of the selected fish species. (UOM=g/100g)

Sl. No.	Fish species	Undecan-oic acid	Lauric acid	Tridecan-oic acid	Myristic acid	Myristoleic acid	Pentadecanoic acid	Palmitic acid	Palmitoleic acid	Heptadecan-oic acid	Heptadecen-oic acid
1	*Barilius vagra*	BDL	BDL	BDL	0.31	BDL	0.06	1.80	0.95	0.05	0.11
2	*N. maydelli*	0.03	0.16	BDL	0.17	0.03	0.09	1.08	0.09	0.17	0.04
3	*Chanda nama*	BDL	BDL	0.12	0.78	BDL	0.52	4.49	0.69	0.44	BDL
4	*Channa gachua*	BDL	0.02	0.003	0.06	BDL	0.03	1.23	0.12	0.17	0.03
5	*Rasbora daniconius*	BDL	0.01	0.03	0.12	BDL	0.11	1.23	0.16	0.08	0.02
6	*Channa punctatus*	BDL	BDL	BDL	0.18	BDL	BDL	BDL	0.29	BDL	BDL
7	*Trichogatser fasciata*	BDL	BDL	0.12	0.38	BDL	0.38	4.49	0.69	0.22	BDL
8	*Xenentodon cancila*	BDL	BDL	BDL	0.05	BDL	0.06	0.57	0.03	0.05	0.02
9	*Amblypharyngodon mola*	BDL	BDL	0.19	0.42	BDL	0.56	0.94	BDL	0.15	BDL
10	*Macrognathus pancalus*	BDL	0.18	0.13	0.13	0.31	0.12	1.35	0.44	0.14	BDL

Table: 2.3b Fatty acid profile of the selected fish species

Sl. No	Fish species	Stearic acid	Oleic acid	Elaidic acid	Linoleic acid	Linolelaidic acid	ɤ-linolenic acid	α-linolenic acid	Arachidic acid	Cis -11-eicosenoic acid	Cis-11,14-eicosadienoic acid
1	*Barilius vagra*	0.31	0.44	0.03	0.14	BDL	0.04	0.22	0.11	0.02	BDL
2	*N. maydelli*	0.48	0.66	0.04	0.09	0.02	BDL	0.06	0.02	0.07	0.01
3	*Chanda nama*	1.43	1.94	0.13	BDL	BDL	BDL	BDL	BDL	BDL	BDL
4	*Channa gachua*	0.38	0.84	0.02	0.31	0.02	BDL	0.06	0.02	0.15	0.03
5	*Rasbora daniconius*	0.41	0.47	BDL	0.06	0.01	0.01	0.03	BDL	BDL	BDL
6	*Channa punctatus*	0.57	0.95	BDL	0.18	BDL	BDL	BDL	BDL	0.13	BDL
7	*Trichogatser fasciata*	0.44	1.29	0.13	BDL	BDL	BDL	BDL	BDL	BDL	BDL
8	*Xenentodon cancila*	0.27	0.29	0.007	0.04	0.008	0.005	0.03	BDL	BDL	0.006
9	*Amblypharyngodon mola*	0.18	0.28	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
10	*Macrognathus pancalus*	0.44	1.26	BDL	0.13	BDL	BDL	BDL	BDL	BDL	BDL

BDL=Below Detectable Limit

Table: 2.3c Fatty acid profile of the selected fish species. (UOM=g/100g)

Sl. No	Fish species	Cis-8,11,14-eicosatrienoic acid	Cis-11,14,17-eicosatrienoic acid	Arachid-onic acid	Cis-5,8,11,14,17-eicosapentaenoic acid	Behenic acid	Erucic acid	Cis-13,16-docosahexaenoic acid	Cis-4,7,10,13,16,19-docosahexaenoic acid	Tricosan-oic acid	Nervonic acid
1	*Barilius vagra*	0.04	0.03	BDL	0.36	0.009	BDL	BDL	0.15	BDL	BDL
2	*N. maydelli*	0.01	BDL	0.04	0.02	0.02	0.007	BDL	0.005	0.007	BDL
3	*Chanda nama*	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
4	*Channa gachua*	0.02	BDL	0.07	0.01	BDL	0.02	BDL	0.01	0.004	0.003
5	*Rasbora daniconius*	BDL	BDL	0.006	BDL	BDL	BDL	BDL	BDL	BDL	BDL
6	*Channa punctatus*	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
7	*Trichogatser fasciata*	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
8	*Xenentodon cancila*	0.008	BDL	0.05	0.02	0.008	BDL	BDL	0.04	0.003	0.007
9	*Amblypharyngodon mola*	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
10	*Macrognathus pancalus*	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

BDL=Below Detectable Limit

The fatty acid contents of the selected fish species are shown in table 1.6 (a), .6(b) and 1.6(c) The present investigation recorded the fatty acid compositions of all the fish species. The fatty acids were not present in higher contents in the studied fishes. Although in lower amounts palmitic acid was detected in fair values and present in all the fish species oleic acid & stearic acid, were present in all of the studied fishes but in lower contents. A total numbers of 39 individual fatty acids had been analysed for the selected small fish species. Amongest them palmitic acid was predominantly detected in all the fish species. It was followed by oleic acid, stearic acid and palmitoleic acid. The present study indicated that the small fish species cannot be regarded as highly fatty fishes.

Palmitic acid was recorded as the significant saturated fatty acid in all the studied species. Ackman, 1980 investigated that palmitic acid was a vital substance in fish and its level was not affected by diet. The present work confirms that the selected fish species contained lower amount of Omega-6 & Omega-3 fatty acids. Harper et al., 2001 studied that a lower proportion of Omega-6 to Omega-3 fatty acids is appreciated in reducing the risk of Chronic disease in the developing countries. In this context, it is attributed that all the small fish species could be recommended safely for human consumption. Simopoulos, 2008 further studied that a balanced n-6:n-3 PUFA ratio is widely accepted in the prevention of cardiovascular disease. This fact agreed to higher risk of life alarming problems with low intake of n-3, rather that high n-6 intake (FAO, 2010). The presence of free fatty acids above 1.5% throws an indication of unsuitability of the lipid for the sake of edible purpose (Molla et al., 2007). The record of lower percentage of free fatty acids in the lipids of studied species might be a conclusion that the fishes are suitable for edible purpose.

The experimental data of the fatty acid profile of the fish species Clarias batrachus by Rafikul Islam et al., 2013, studied that the species contained palmitic acid (37.41%) lauric acid (2.60%), Arachielic acid (3.04%), Behenic acid (4.21%). In the present report also, palmilic acid was in higher content than the other in all the studied species. Amongest them species *Chanda nama* and *Xenentodon cancila* was found to contain same amount (4.49%) of palmitic acid which was followed by oleic acid (1.94%), stearic acid (1.43%). Fishes are not able to synthesize any fatty acids of the Omega-6 and Omega-3 series without the presence of a precursor with this structure in their diet. All the fish species are not having the same abilty to elongate and desaturate fatty acids (Stancheva et al., 2010). The ratio of Omega-3:Omega-6 fatty acids between (0.2-1.6gm) would make a nutritionous human diet. (Stanchava et al., 2010). The present research work found a lower range of the fatty acids. The feeding habits of the fish species may determine the significance of the lower contents of fatty acids among the fish species.

4.7 Mineral profile

Table 2.4: Measurement of absorbance of standard Iron (Fe) solutions:

Solution	**Cal Zero**	**Std 1**	**Std 2**	**Std 3**	**Std 4**	**Std 5**
SET-I						
Concentration (mg/L)	0.000	0.200	0.500	1.000	2.000	3.000
Mean Absorbance	0.0009	0.0212	0.0407	0.0763	0.1410	0.2025
SET-II						
Concentration (mg/L)	0.000	0.200	0.500	1.000	2.000	3.000
Mean Absorbance	0.0022	0.016	0.0344	0.0625	0.122	0.1791

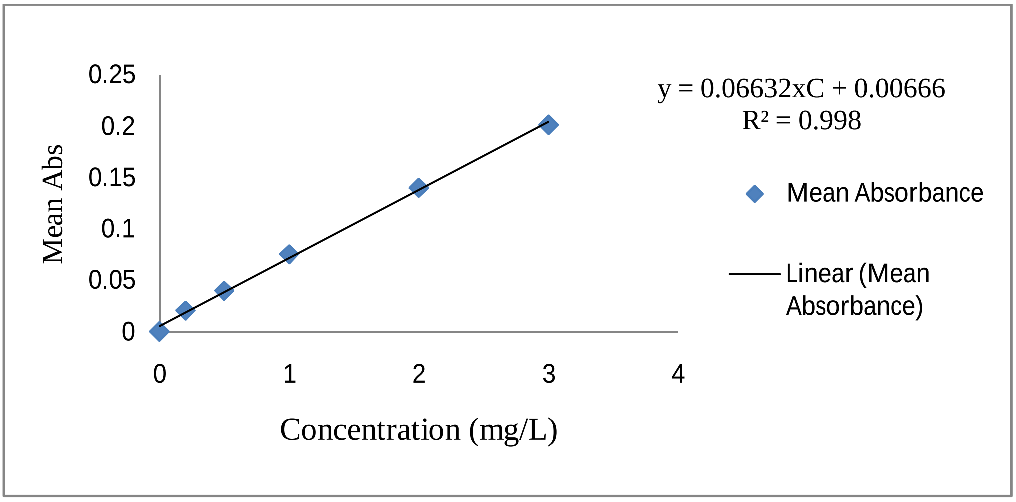


Fig.: 2.5.1a Calibration curve-I for standard Iron Solutions

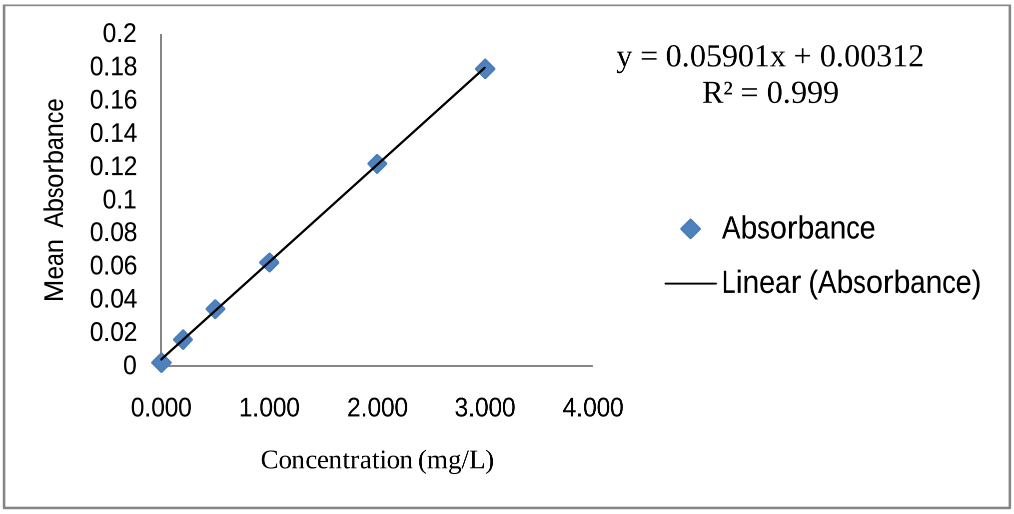


Fig.: 2.5.1b Calibration curve-II for standard Iron Solutions

Table: 2.5 Iron content in different fish species

Sample. No.	Species	Absorbance	Concentration (mg/L)	Iron Content (mg/100g)
Calculated from calibration curve-I				
1	*Barili vagra*	0.1312	1.883	9.15
2	*Neoeucirrhichthys maydelli*	0.0854	1.192	5.95
4	*Channa gachua*	0.0713	0.979	4.84
5	*Rasbora daniconius*	0.0240	0.266	12.84
8	*Xenentodon cancila*	0.0578	0.775	3.83
Calculated from calibration curve-II				
3	*Chanda nama*	0.525	0.0341	3.9
6	*Channa punctatus*	0.501	0.0327	3.67
7	*Trichogatser fasciata*	1.975	0.1197	18.23
9	*Amblypharyngodon mola*	0.565	0.0365	4.31
10	*Macrognathus pancalus*	0.510	0.0332	3.75

Table 2.6: Measurement of absorbance of standard Zinc (Zn) solutions:

Standard solutions	Cal Zero	Std 1	Std 2	Std 3	Std 4	Std 5	Std 6
SET-I							
Concentration	0.0000	0.050 0	0.200 0	0.500 0	0.800 0	1.000 0	1.500 0
Mean Absorbance	0.0019	0.026 5	0.087 9	0.201 2	0.296 8	0.353 6	0.470 1
SET-II							
Concentration (mg/L)	0.0000	0.050 0	0.200 0	0.500 0	0.800 0	1.000 0	1.500 0
Mean Absorbance	0.0006	0.019 8	0.078 6	0.162	0.260 8	0.315 8	0.420 7

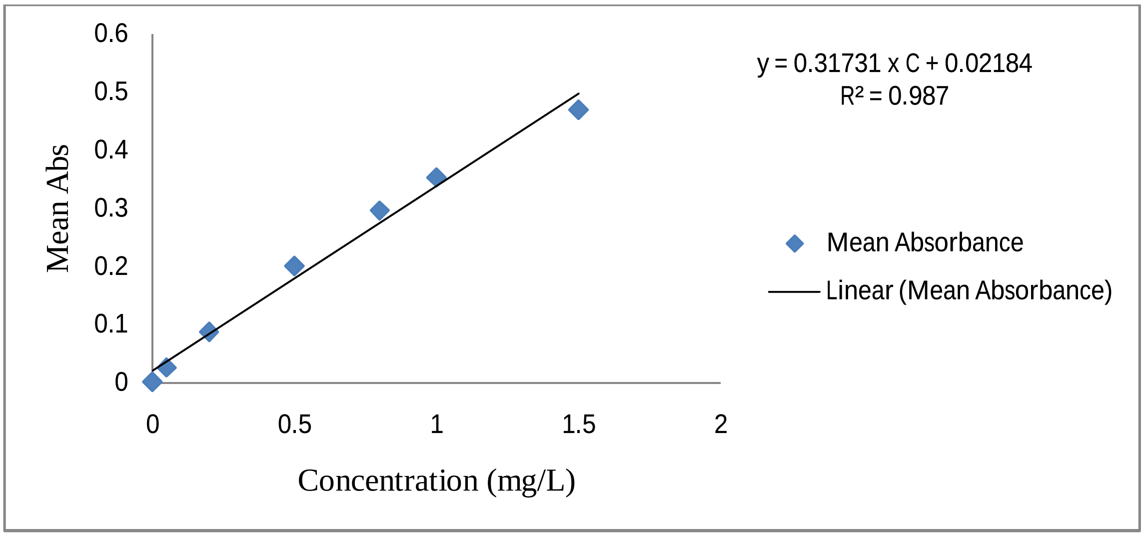


Fig.: 2.5.2a Calibration curve-I for standard Zinc solutions

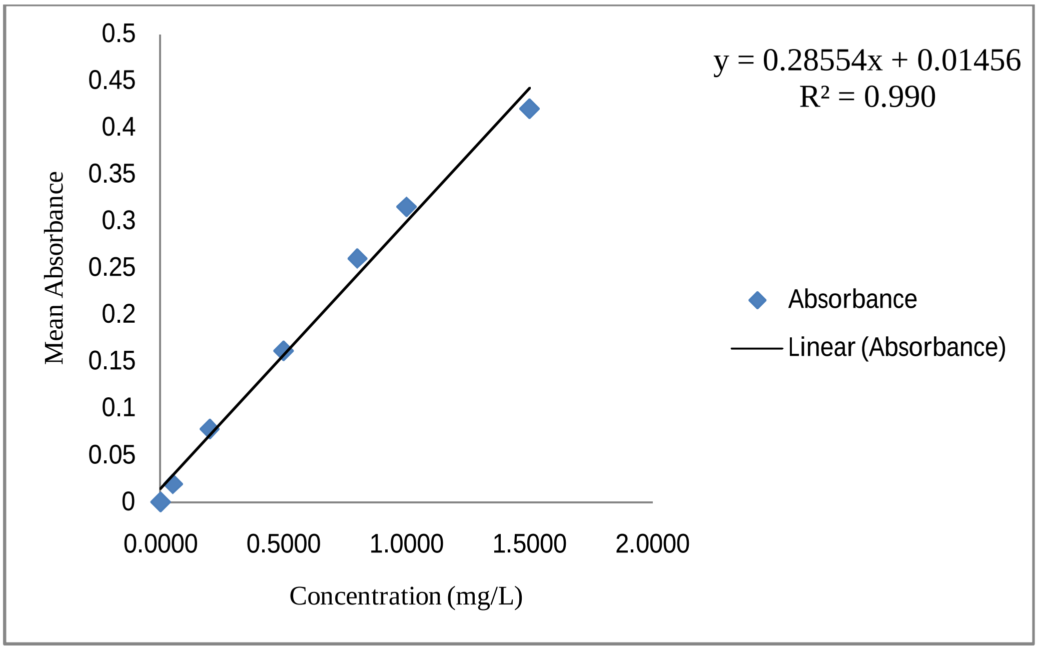


Fig.: 2.5.2bCalibration curve-II for standard Zinc Solutions

Table: 2.6 Zinc content in different species

Sample. No.	Species	Absorbance	Concentration (mg/L)	Zinc Content (mg/100g)
Calculated from calibration curve-I				
1	*Barili vagra*	0.1760	0.4858	2.36
2	*Neoeucirrhichthys maydelli*	0.2025	0.5695	2.84
4	*Channa gachua*	0.5374	0.1924	2.66
5	*Rasbora daniconius*	0.3272	0.9623	4.64
8	*Xenentodon cancila*	0.2051	0.5774	2.86
Calculated from calibration curve-II				
3	*Chanda nama*	0.3193	0.1057	3.18
6	*Channa punctatus*	0.1580	0.0597	1.57
7	*Trichogatser fasciata*	0.3010	0.1005	2.98
9	*Amblypharyngodon mola*	0.4738	0.1498	4.73
10	*Macrognathus pancalus*	0.1444	0.0558	1.44

Table 2.7: Measurement of absorbance of phosphorous (P) solutions:

Standard solutions	Blank	Std 1	Std 2	Std 3	Std 4	Std 5
Concentration (mg/L)	0.0	5.0	10.0	20.0	40.0	50.0
Absorbance	0.00	0.0549	0.1242	0.2216	0.4412	0.5572

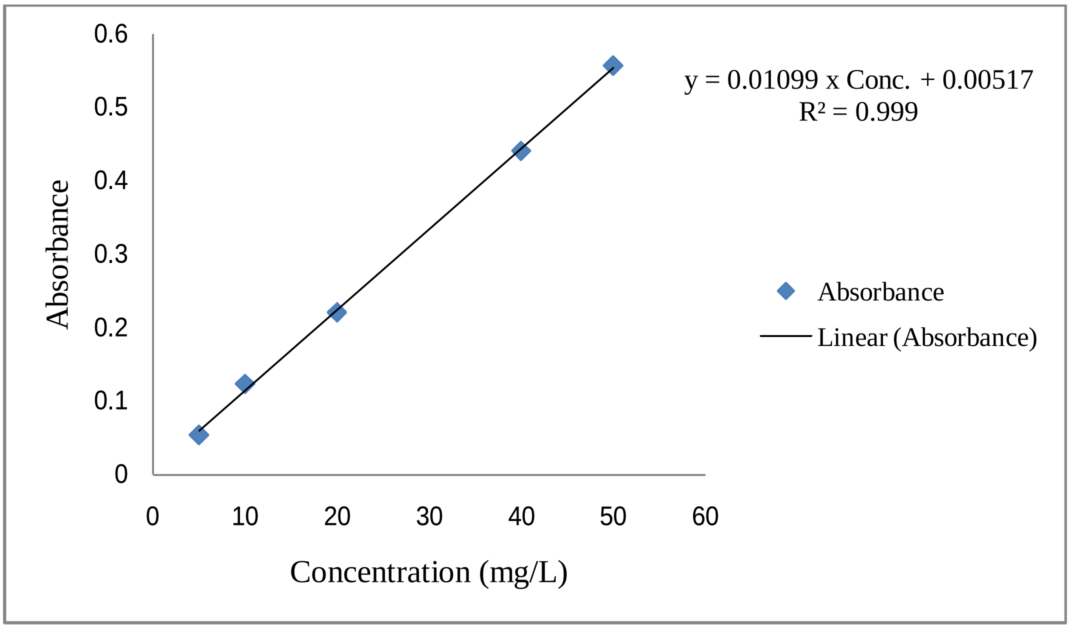


Fig.: 2.5.3 Calibration curve for standard Phosphorous solutions

Table 2.8: Phosphorous content in different fish species

Sample No.	Species	Absorbance	Concentration (mg/L)	Phosphorous Content (mg/100g)
1	*Barili vagra*	0.0685	5.8	891.81
2	*Neoeucirrhichthys maydelli*	0.0620	5.2	825.64
3	*Chanda nama*	0.1745	15.4	2470.00
4	*Channa gachua*	0.0476	3.9	616.79
5	*Rasbora daniconius*	0.0957	8.2	1246.55
6	*Channa punctatus*	0.2228	19.8	3170.00
7	*Trichogaster fasciata*	0.2469	22	3520.00
8	*Xenentodon cancila*	0.0638	5.3	858.78
9	*Amblypharyngodon mola*	0.1414	12.4	1990.00
10	*Macrognathus pancalus*	0.1161	10.1	1620.00

Table 2.9 Measurement of absorbance of Calcium (Ca) solutions

Standard solutions	Cal Zero	Std 1	Std 2	Std 3	Std 4	Std 5
SET-I						
Concentration	0.000	0.050	0.200	0.500	0.800	1.000
Mean Absorbance	0.0018	0.0117	0.0332	0.0733	0.1238	0.159
SET-II						
Concentration (mg/L)	0.000	0.500	1.000	1.500	2.000	-
Absorbance	0.0011	0.0653	0.1169	0.1823	0.2459	-

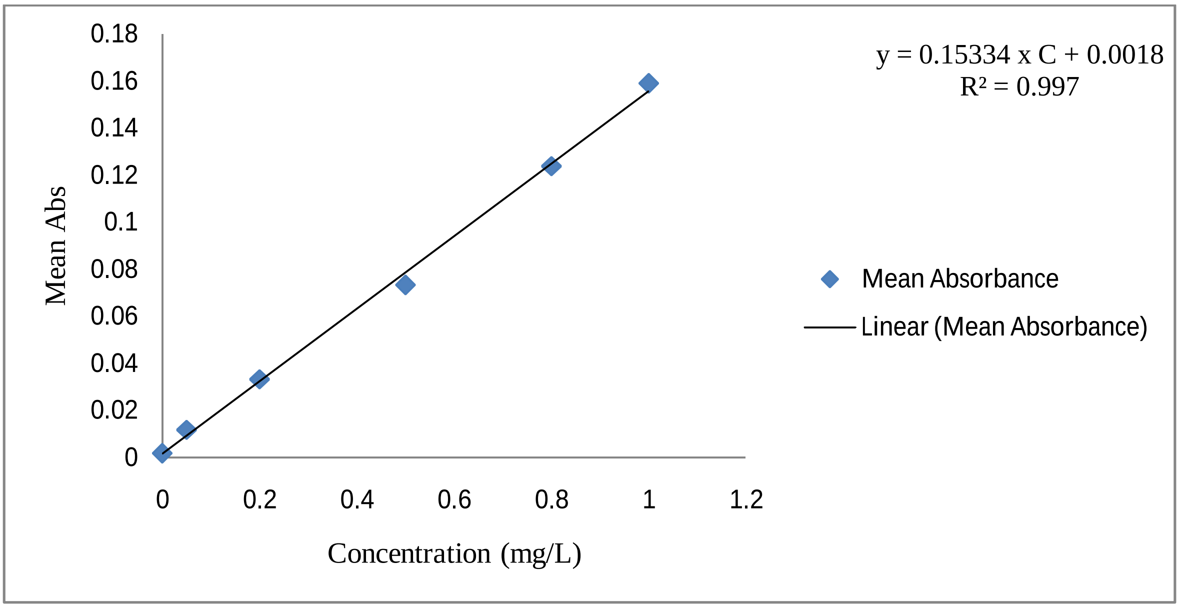


Table: 2.5.4a Calibration curve-I for standard Calcium solutions

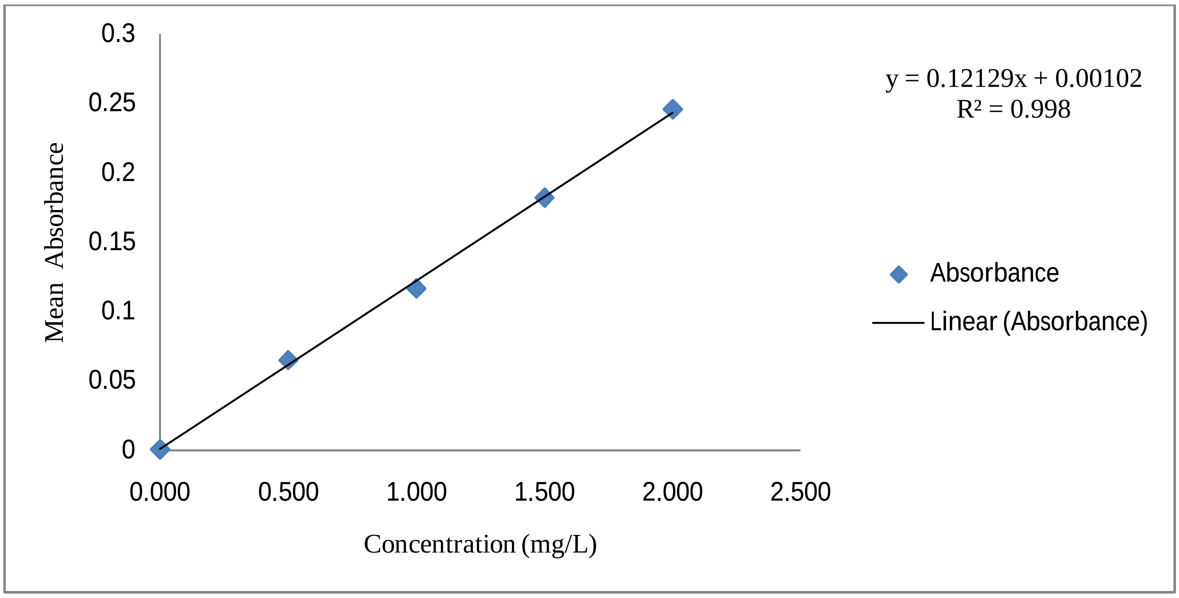


Fig.: 2.5.4b Calibration curve-II for standard Calcium Solutions

Table 2.10: Calcium content in different fish species

Sample No.	Species	Absorbance	Concentration (mg/L)	Calcium Content (mg/100g)
Calculated from calibration curve-I				
1	*Barili vagra*	0.0446	0.279	636.91
2	*Neoeucirrhichthys maydelli*	0.0408	0.254	591.20
4	*Channa gachua*	0.378	0.235	539.39
5	*Rasbora daniconius*	0.0487	0.306	697.39
8	*Xenentodon cancila*	0.0447	0.279	647.75
Calculated from calibration curve-II				
3	*Chanda nama*	0.811	0.0994	807.93
6	*Channa punctatus*	0.675	0.0829	672.98
7	*Trichogaster fasciata*	1.661	0.2025	1640.00
9	*Amblypharyngodon mola*	1.466	0.1788	731.10
10	*Macrognathus pancalus*	0.783	0.0960	389.32

Table 2.11 Mineral (Fe, Zn, P & Ca) contents in different fish species

Sl No	**Scientific name of species**	**Iron (mg/100 g)**	**Zinc (mg/100 g)**	**Phosphorous (mg/100g)**	**Calcium (mg/100g)**
1	*Barilius vagra*	9.15	2.36	891.81	636.91
2	*N. maydelli*	5.95	2.84	825.64	591.20
3	*Chanda nama*	3.90	3.18	2470.00	807.93
4	*Channa gachua*	4.84	2.66	616.79	539.39
5	*Rasbora daniconius*	12.84	4.64	1246.55	697.39
6	*Channa punctatus*	3.67	1.57	3170.00	672.98
7	*Trichogaster fasciata*	18.23	2.98	3520.00	1640.00
8	*Xenentodon cancila*	3.83	2.86	858.78	647.75
9	*Amblypharyngodon mola*	4.31	4.73	1990.00	731.10
10	*Macrognathus pancalus*	3.75	1.44	1620.00	389.32

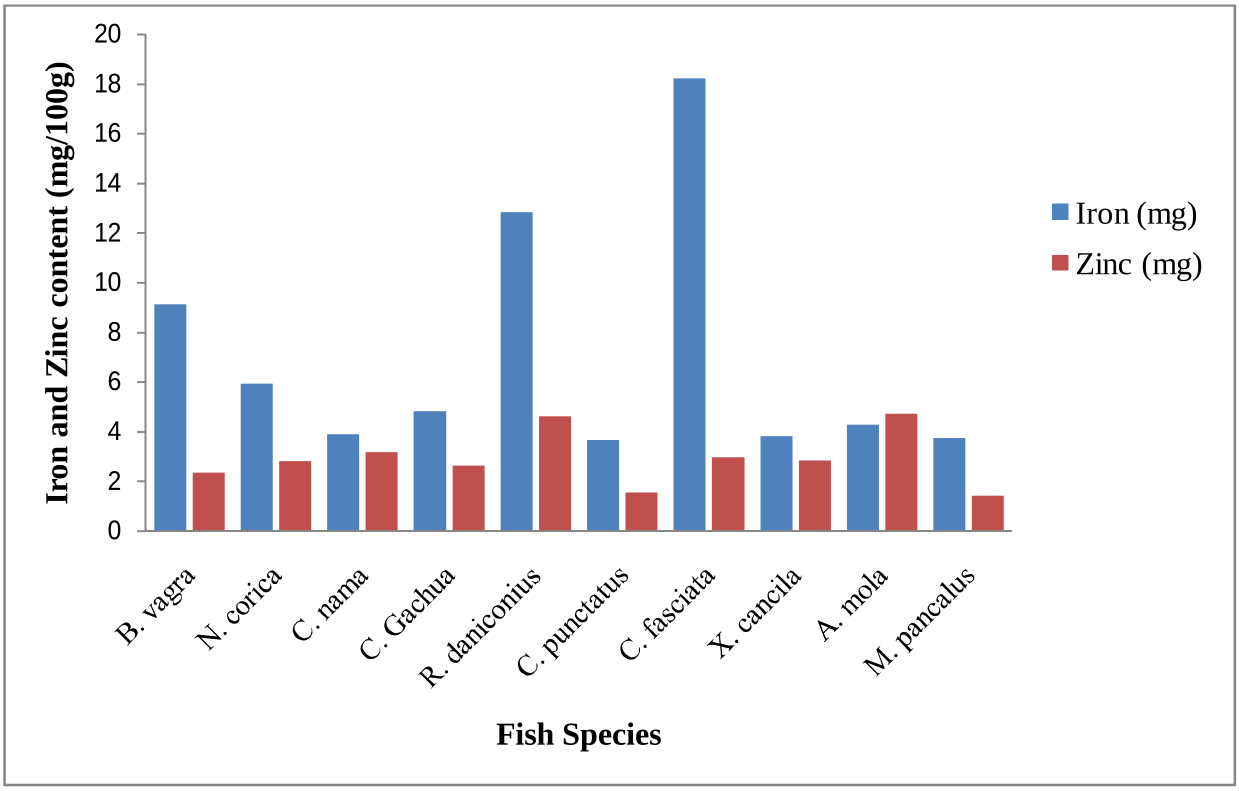


Fig.: 2.5.5a Comparision of Iron (Fe) and Zinc (Zn) content in different fish specie

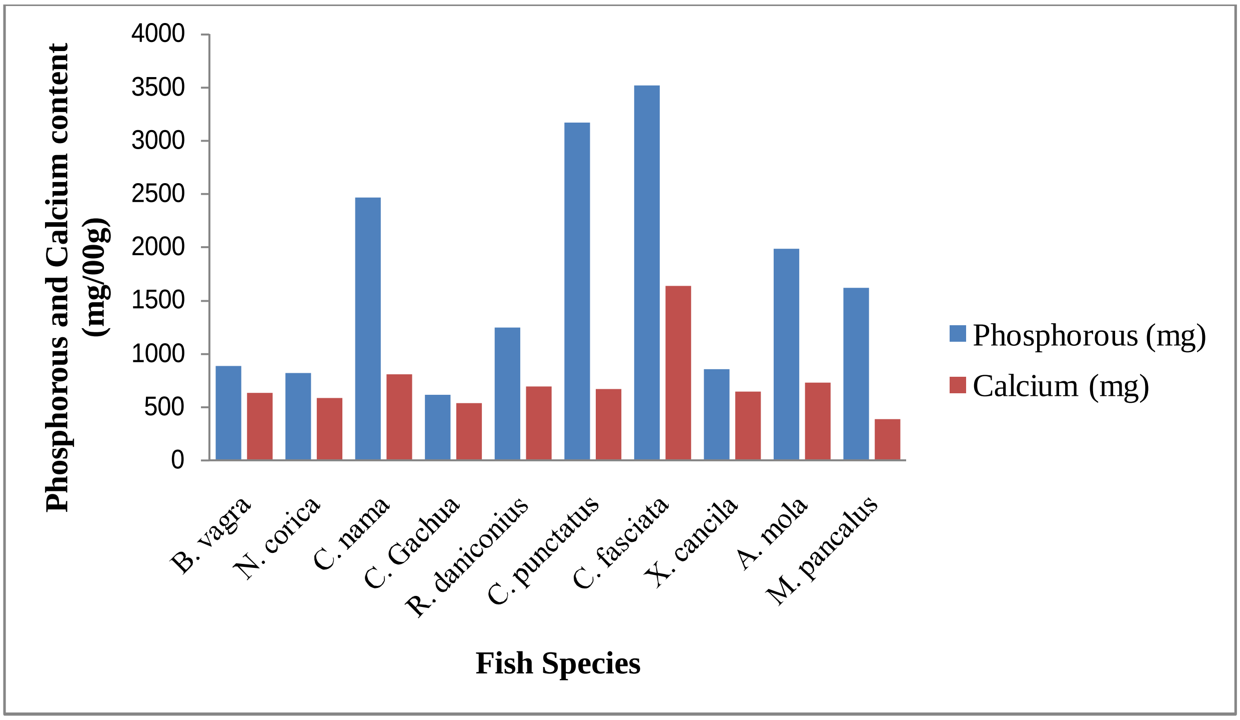


Fig.: 2.5.5b Comparision of Phosphorous (P) and Calcium (Ca) content in different fish species

Fish is an important source of mineral like Potassium, phosphorous, iron, sodium, magnesium, iodine, zinc, calcium etc. Mineral components find their vital importance for human nutrition (Love, 1957). Some of the trace elements such as iron, manganese and iodine are adequately present in fish species (Borgstrom, 1962). The present study had been done on quantification of some selected minerals like iron, zinc, phosphorus and calcium which are very essential minerals for human (Burch, R.E. et al., 1975). Many keys functions in human body are performed by Iron. It is highly demanded in several stages of human being such as growing period, menstrual loss and pregnancy. Iron deficiency may cause major problem when the intake is insufficient (Belitz, et al., 2001).

In the present investigation the iron contents were sufficiently higher in all the fish species. Highest content of iron (18.23 mg) was recorded in *Trichogatser fasciata*. It was followed by *Rasbora daniconius* (12.84 mg), *Barilius vagra* (9.15 mg), *N. maydelli* (5.95 mg), *Channa gachua* (4.84 mg). The content of zinc were also in a good amount in all the studied small fishes. The highest content of zinc was found in *Amblypharyngodon mola* (4.73mg) which was followed by *Rasbora daniconius* (4.64mg), *Xenentodon cancila* (2.86mg), *Noemacheilus corica* (2.84mg), *Channa gachua* (2.66mg), *Barilius vagra* (2.36mg).

The contents of phosphorus was highest in *Trichogatser fasciata* (3520 mg/100g) which was followed by *Channa punctatus* (3170 mg/100g) and *Chanda nama* (2470 mg/100g). Further more, the calcium contents was highest in *Trichogatser fasciata* (1640 mg/100g) followed by *Chanda nama* (807.93mg/100g) and *Amblypharyngdon mola* (731.10 mg/100g)

The amount of mineral as well as metal contained in a fish species are changed with the change of environmental condition (Ambedkar et al., 2011). The minerals paly vital role in skelatal formarion, maintenance of colloidal systems, regulation of acid – base equilibrium. Major components of some biologically important compounds like as hormones and enzymes etc. are made of the minerals (Lal, 1995, Netal, 2007). Different types of biochemical structural and functional pathologies are caused by mineral deficiencies (Sankar et al., 2013). As per the project report of (Tasbozan et al., 2013), the calcium contents of spiny eel was found to be 254 mg Kg^{-1}. According to Martinez-Valverde et al., blue whitling was found to contain 5.3 mg Kg^{-1} of Zn and 4 mg Kg^{-1} of Fe. Celik M. et al., reported that rainbow trout contained 5.45 mg Kg^{-1} of Zn and 4.15 mg Kg^{-1} of Fe.

Being a trace element Fe is to be present in lower quantities in fish flesh. The daily intake of Fe for the human body is 8-15 mg Kg^{-1} 0f body weight (Oksuz et al., 2009). Iron is having tremendous importance in the formation of hemoglobin which is essential for the formation of red blood cells (Mller et al., 2013 & Oksuz et al., 2009). Hossain et al., 2015 documented that *Batasio tengana* (Tengra) possessed 2.02 mg Kg^{-1} of Fe and marked as a good supplemental source of Fe. In the present investigation the macro elements P & Ca of the studied fishes were in higher quantities. But the micro elements viz., Iron & zinc were of minimum contents. The abundance in the values of macro elements than the micro elements might be attributed to the fact that the body needs more amounts of marco elements for the sake of structure and function. Phosphorus is not only the main constituent of the fish skeleton. It is included in adenosine polyphosphates which is the vital component for the release of energy and also in phospholipids (Nair et a.,, 2001).

The mineral contents of individual species are dependent on the abundance of the elements in their local enviorment, capacity of diet absorption and their accumulation as preferred (Hei et al., 2012).

The micro elements like Fe and Zn are vitally important for the formation of skeleton structure, transfer of electrons, regulation of acid-base equilibrium as well as osmoregulation. Minerals are also important components of harmones, enzymes and vitamins. Many a biochemical mechanisms are activated by the minerals. By the presence of different minerals in the fish body help in excretion of several inorganic elements allowing the fish to live in a dynamic equilibrium with the aquatic medium (Committee on animal nutrition, 1993). Lacking in the contents of these elements lead to different diseases in the body. Fe is the vital element for the metabolism of almost entire living organisms. A lot of procedures of cellular metabolism are dependent on zinc (Hei et al., 2012).

In human body calcium is the most abundant mineral as at least 20% of the weight of the body. It plays the versatile role in human body as like as for the growth, bone formation, coagulation of blood, formation of milk, absorption of vitamin D etc. It is mainly associated with bones and formation of tooth.

Calcium deficiency lead to rickets, osteomalacia and osteoporosis (Anderson, 1982). As per the research report of Islam et al., 2013, the calcium contents of *C. batrachus* was 210.10 mg/Kg. The present work documented the highest calcium contents were recorded in kholisa (1640 mg). Phosphorous is one of the major constituents of all the animal cells. All the natural foods contain phosphorus. People consuming large quantities of aluminum hydroxide antacids suffer from secondary phosphate depletion. This can lead to weakening of muscles and body pain. The diseases which affect kidneys and bones may disturb phosphate metabolism in the body (Rosenquist et al., 1996). In the present work, highest contents of phosphorous was found in kholisa fish (3520 mg), Iron is an essential life supporting elements for one and the all living beings. Iron plays the vital role in cellular metabolism. The primary function of iron includes the transportation of oxygen to the tissues (heamoglobin). One of the life threatening problem, anemia is caused by the deficiency of iron. Mostly nursing mothers, children, adolescent girls are attacked by anemia. In the present study all the selected fish species are rich in iron contents. The highest iron contents were found in kholisa fish (18.23 gm). Another micronutrient zinc was also highly contained by all the selected ten fishes, The small fish *Amblypharyngodon mola* contained the highest amount of zinc (4.73 mg) amongst all other fishes. It is the vital part of 110 metalloenzymes as well as other cellular components. It has its enormous importance for the synthesis of protein, RNA, DNA and also for the transportation of vitamin A. Zn has its vital role in the protection of heart damage after a heart attack (Islam et al 2013). The most alarming symptoms of zinc deficiency include growth retardation, anaemia and impaired sexual development, skin changes, loss of appetite, white opaque spots on finger nails (A.H. Molla, Biochemical and nutritional studies of the Bangladeshi fishes).

4.8 Vitamin Profie

Several literatures justified that fish is a good source of vitamins like A, D, E and K. The contents of Vitamin A originated from fish food is easily demonstrated to the human body than the same from plant source (Liu , 2003). As far as the human health is concened, Vitamin A is mainly required for normal vision and growth of the bones.

The HPLC Chromatogram analysis of the fish samples selected were shown in next set of figures

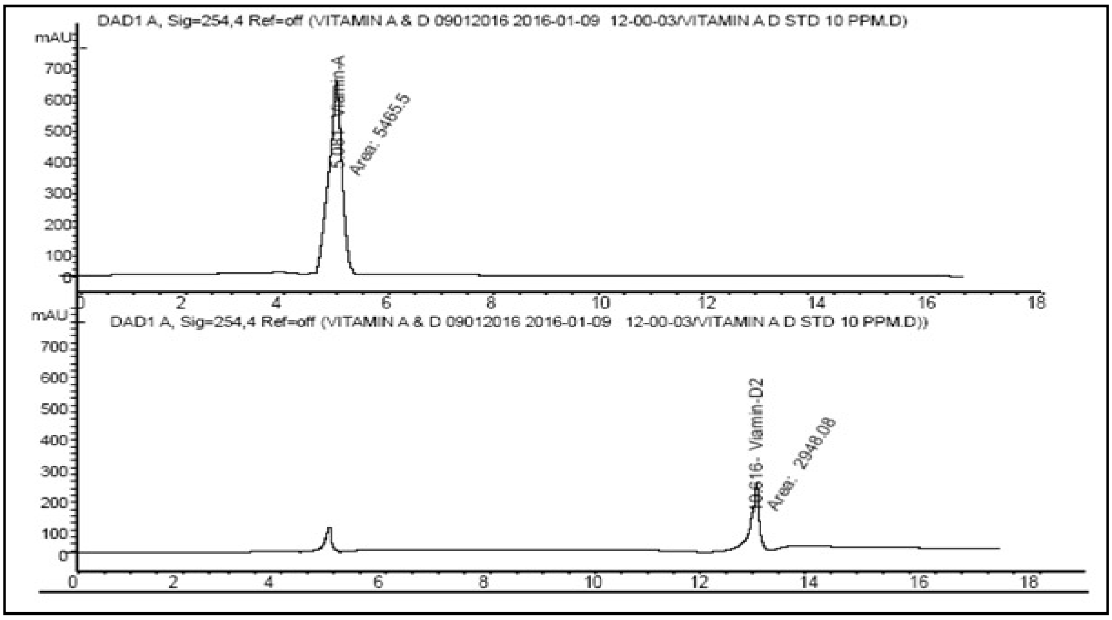


Fig.: 2.7.1 HPLC Chromatogram of Standard Vitamin Aand Vitamin D solutions

AREA PERCENT REPORT

Peak	RetTime Type (Min)	Width (Min)	Area (mAU*S)	Area	Name
1	5.081 MM	0.1627	5465.49854	100.0000	Vitamin-A
2	10.616 MM	0.2648	29848.07886	100.0000	Vitamin-D2

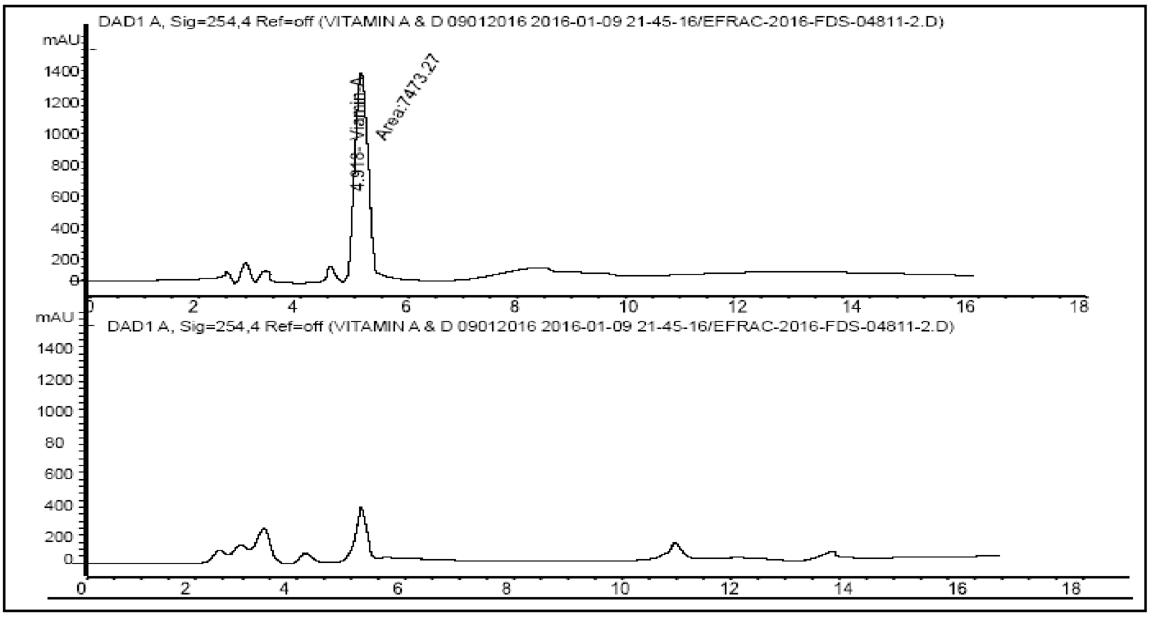


Fig.: 2.7.2a HPLC Chromatogram of *Barilius Vagra*

AREA PERCENT REPORT

Peak	RetTime Type (Min)	Width (Min)	Area (mAU*S)	Area	Name
1	4.918 MM	0.2022	7473.26563	100.0000	Vitamin-A
Totals :			7473.26563		

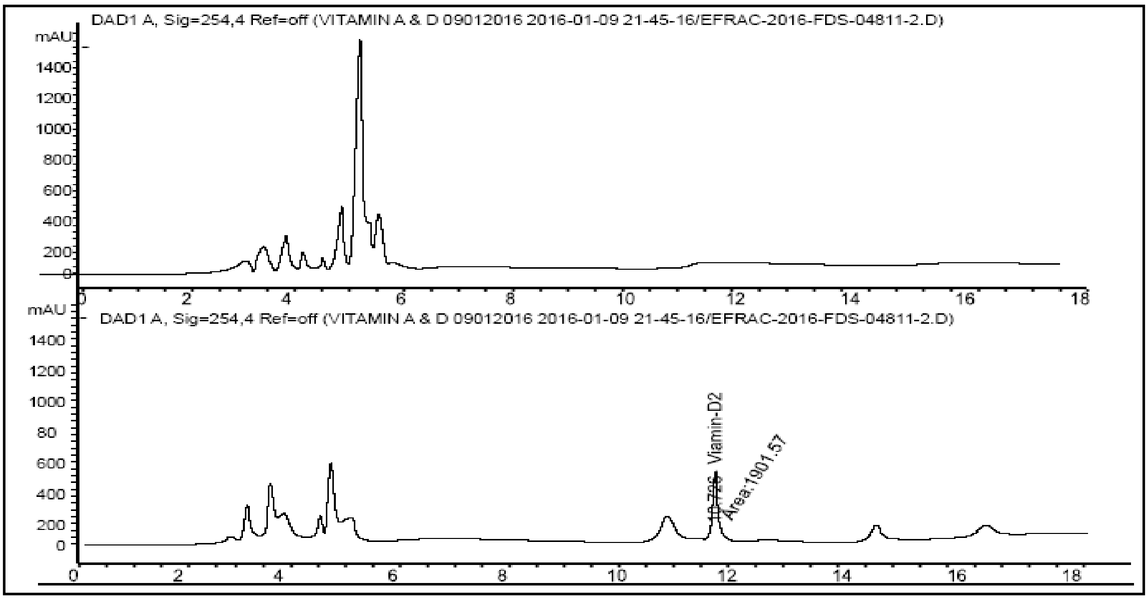


Fig.: 2.7.2b HPLC Chromatogram of *Barilius Vagra*

AREA PERCENT REPORT

Peak	RetTime Type (Min)	Width (Min)	Area (mAU*S)	Area	Name
	1 10.726 MM	0.2022	1901.15740	100.0000	Vitamin-D2
Totals :			1901.15740		

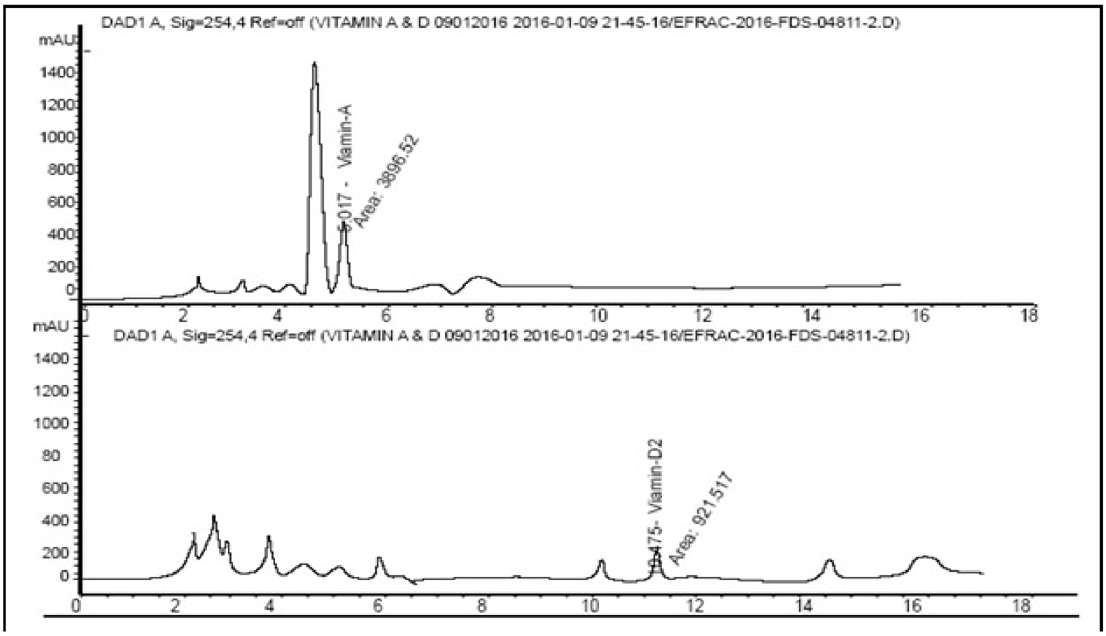


Fig.: 2.7.3 HPLC Chromatogram of *Neoeucirrhichthys maydelli*

AREA PERCENT REPORT

Peak	RetTime Type (Min)	Width (Min)	Area (mAU*S)	Area	Name
1	5.017 MM	0.2233	3896.52173	100.0000	Vitamin-A
2	10.475 MM	0.3239	921.51709	100.0000	Vitamin D

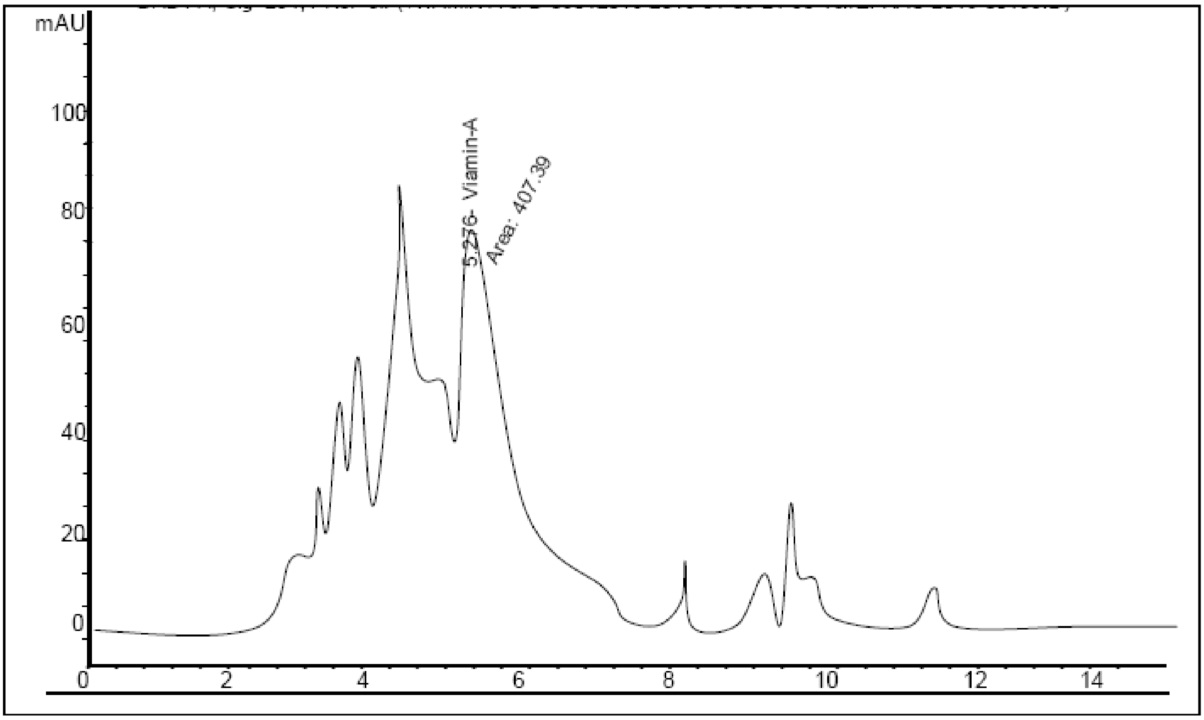


Figure 2.7.4 HPLC Chromatogram of *Chanda nama*

AREA PERCENT REPORT

Peak	RetTime Type (Min)	Width (Min)	Area (mAU*S)	Area	Name
1	5.276 MM	0.1875	407.39180	100.0000	Vitamin-A
2	2.332 MM	0.0000	0.0000	0.0000	Vitamin-D
Totals :			407.39180		

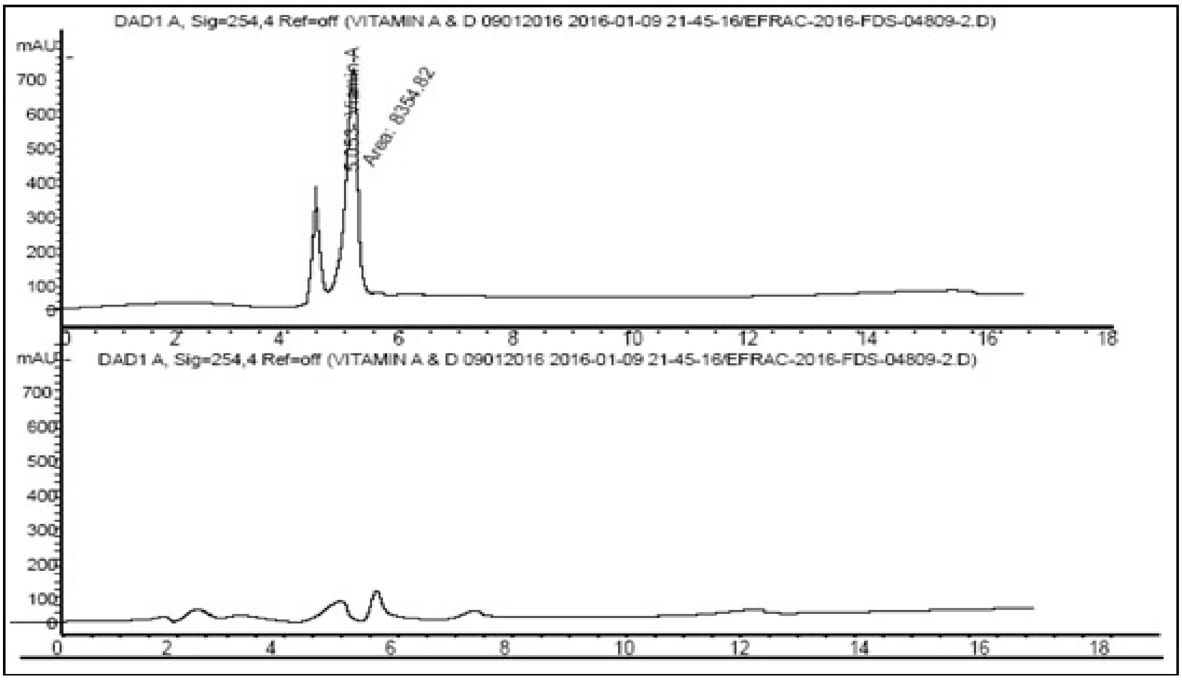


Fig.: 2.7.5a HPLC Chromatogram of *Channa gachua*

AREA PERCENT REPORT

Peak	RetTime (Min)	Type	Width (Min)	Area (mAU*S)	Area	Name
1.	5.053	MM	0.1850	8354.81836	100.0000	Vitamin-A
Totals :				8354.81836		

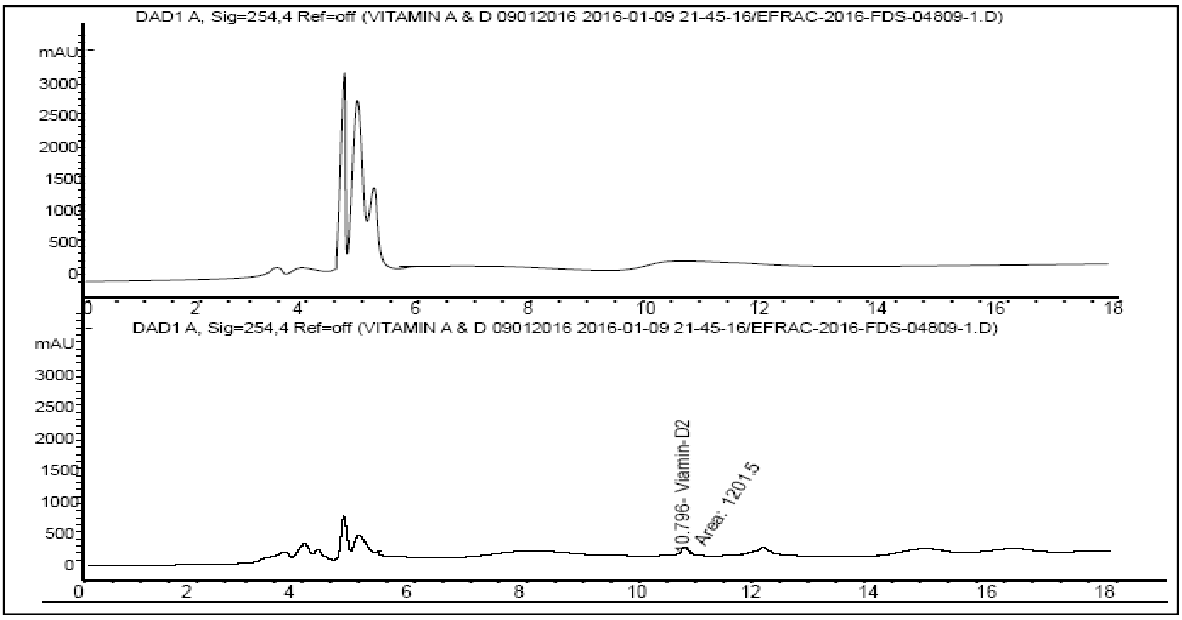


Fig.: 2.7.5b HPLC Chromatogram of *Channa gachua*

AREA PERCENT REPORT

Peak	RetTime (Min)	Type	Width (Min)	Area (mAU*S)	Area	Name
1	10.796	MM	0.3671	1201.49902	100.0000	Vitamin-D2
Totals :				1201.49902		

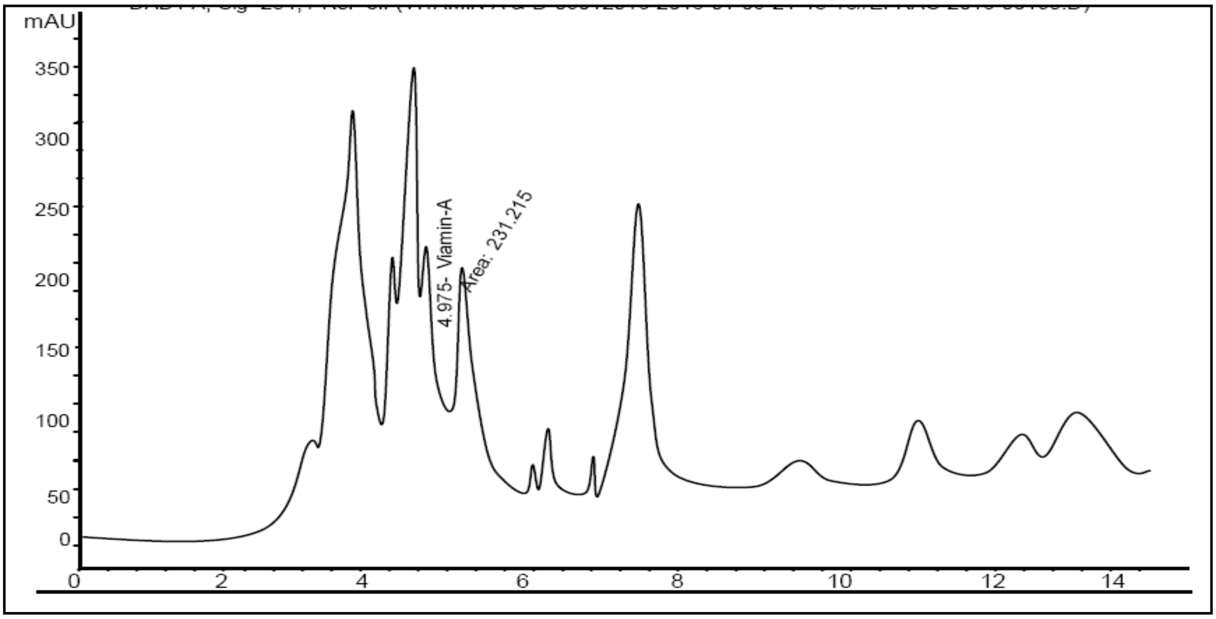


Fig.: 2.7.6 HPLC Chromatogram of *Channa punctatus*

AREA PERCENT REPORT

Peak	RetTime (Min)	Type	Width (Min)	Area (mAU*S)	Area	Name
1	4.975	MM	0.1335	231.21461	100.0000	Vitamin-A
2	9.542	MM	0.0000	0.0000	0.0000	Vitamin-D
Totals :				231.21461		

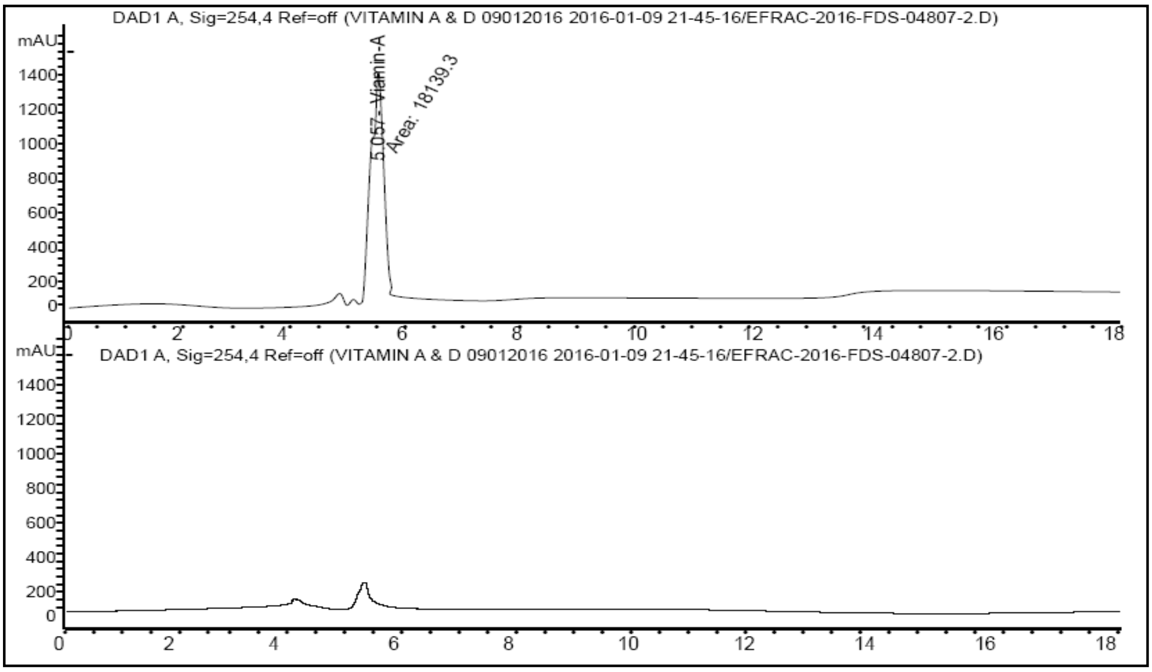


Fig.: 2.7.7a HPLC Chromatogram of *Rasbora daniconius*

AREA PERCENT REPORT

Peak	RetTime Type (Min)	Width (Min)	Area (mAU*S)	Area	Name
1	5.057 MM	0.1825	1.81393e4	100.0000	Vitamin-A
Totals :			1.81393e4		

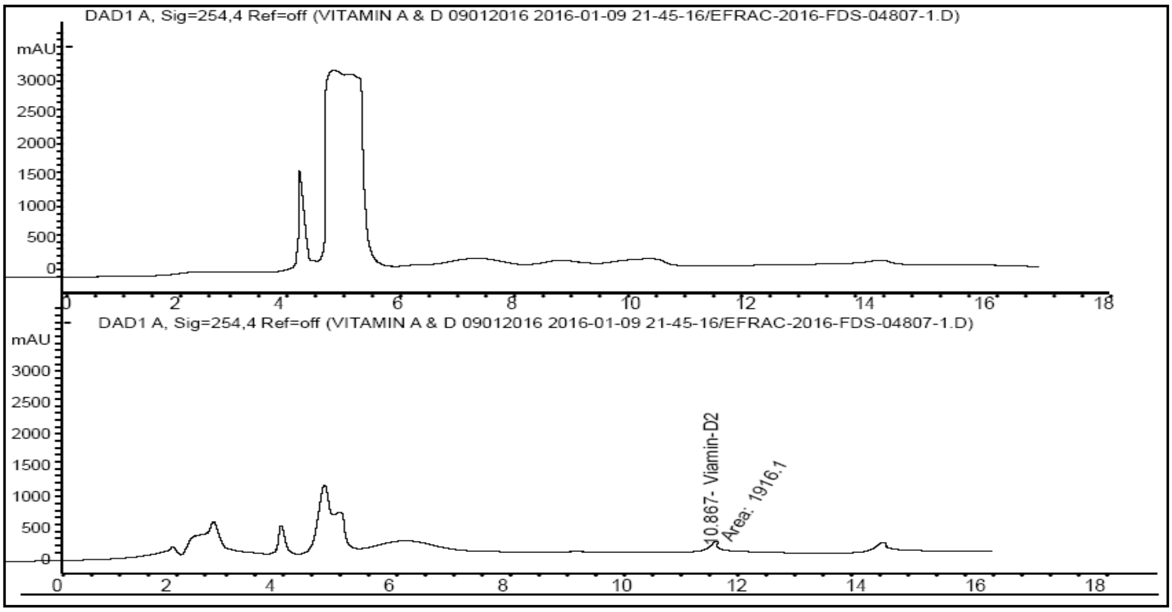


Fig.: 2.7.7b HPLC Chromatogram of *Rasbora daniconius*

AREA PERCENT REPORT

Peak (Min)	RetTime Type	Width (Min)	Area (mAU*S)	Area	Name
1	10.867 MM	0.3014	1916.09998	100.0000	Vitamin-D2
Totals :			1916.09998		

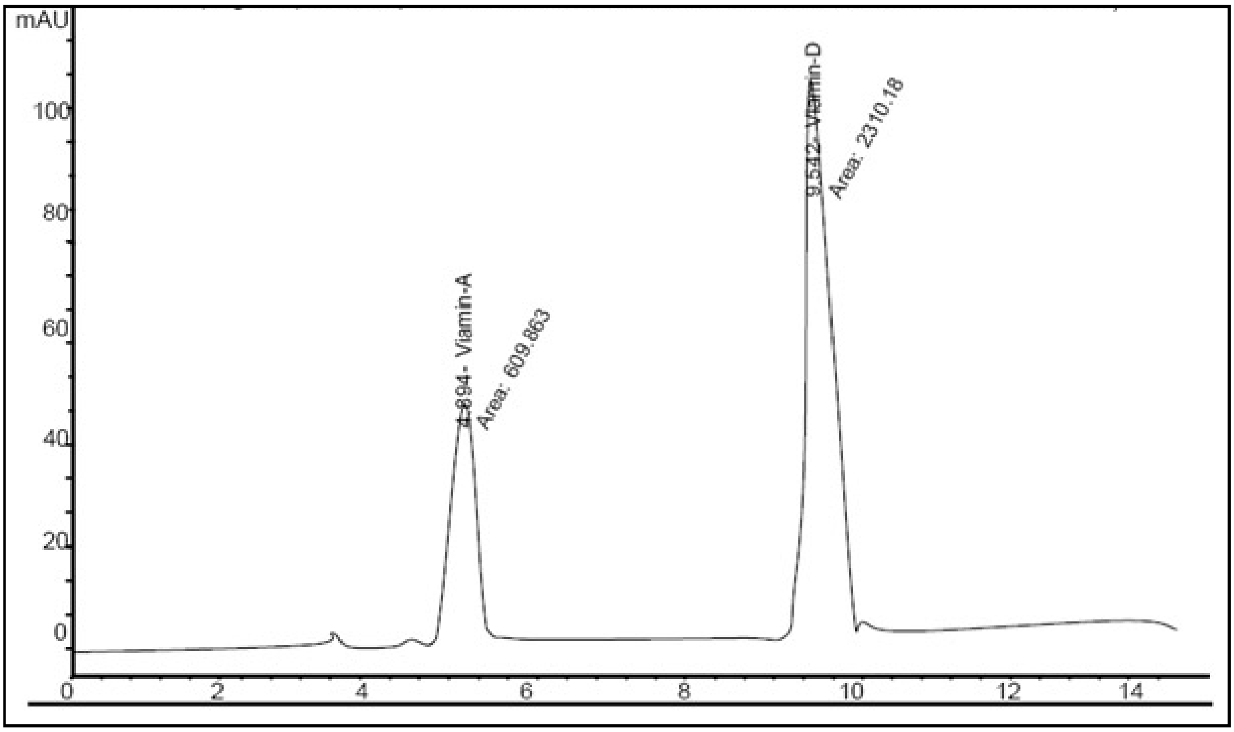


Fig.: 2.7.8 HPLC Chromatogram of *Trichogaster fasciata*

AREA PERCENT REPORT

Peak	RetTime (Min)	Type	Width (Min)	Area (mAU*S)	Area	Name
1	4.894	MM	0.2161	609.86255	20.8854	Vitamin-A
2	9.542	MM	0.3526	2310.17896	79.1146	Vitamin-D
Totals :				2920.04150		

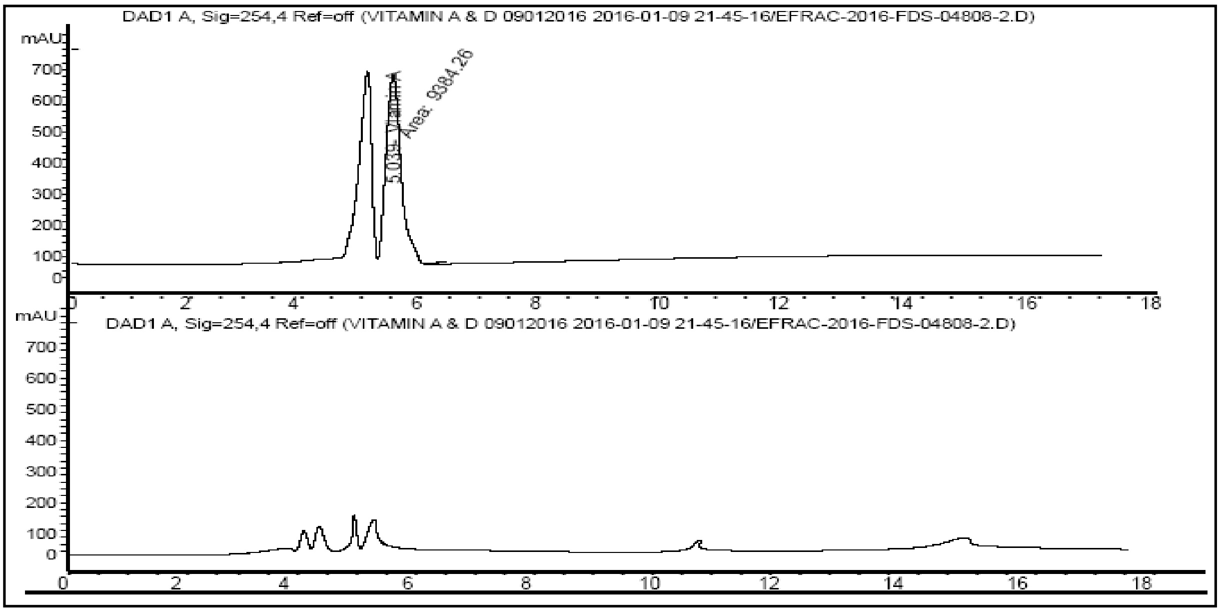


Fig.:: 2.7.9a HPLC Chromatogram of *Xenentodon cancila*

AREA PERCENT REPORT

Peak	RetTime Type (Min)	Width (Min)	Area (mAU*S)	Area	Name
1	5.039 MM	0.2086	9384.26465	100.0000	Vitamin-A
Totals :			9384.26465		

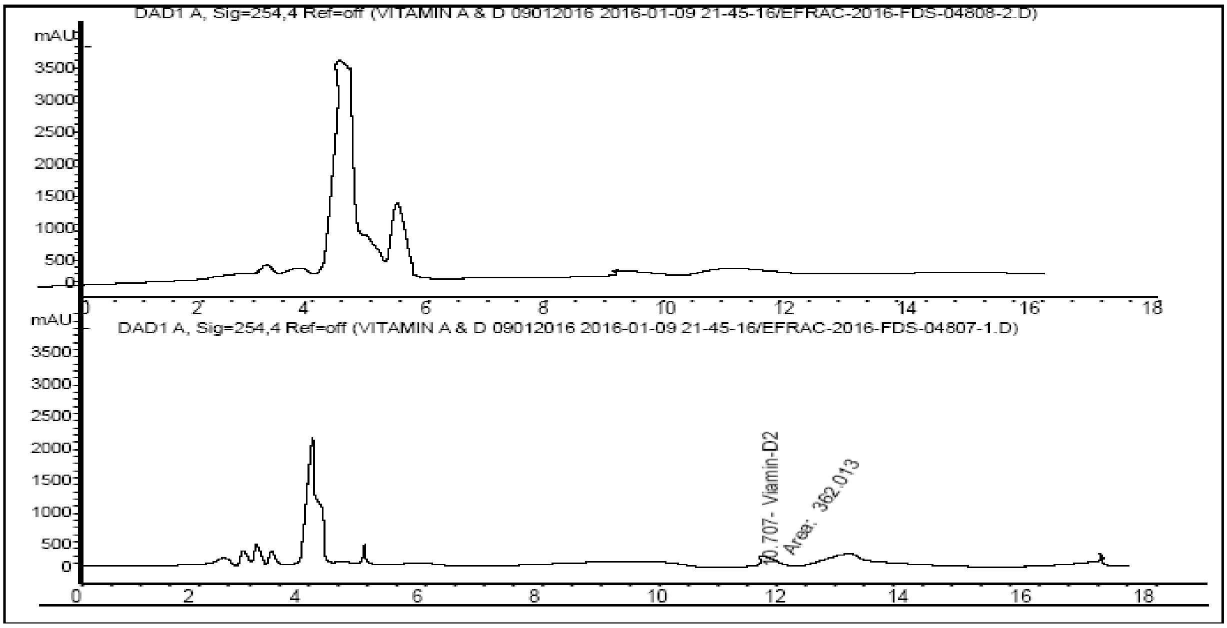


Fig.: 2.7.9b HPLC Chromatogram of *Xenentodon cancila*

AREA PERCENT REPORT

Peak	RetTime Type (Min)	Width (Min)	Area (mAU*S)	Area	Name
1	10.707 MM	0.4039	362.01273	100.0000	Vitamin-D2
Totals :			362.01273		

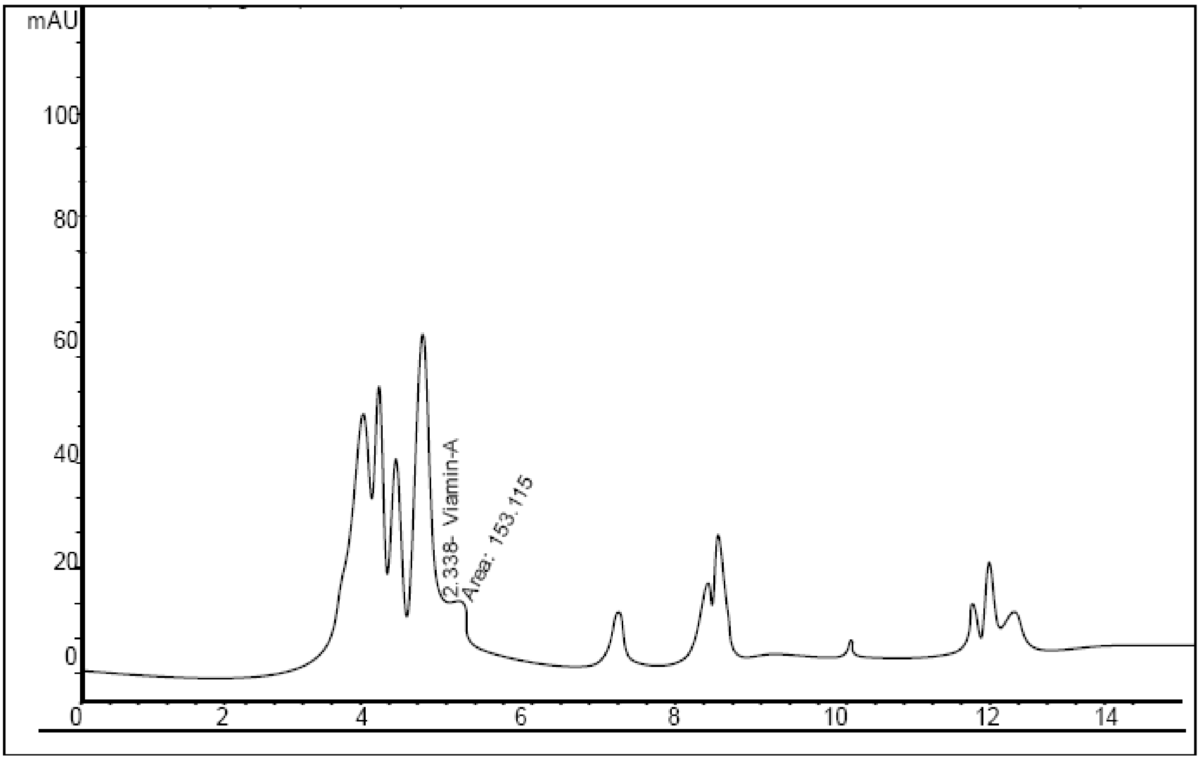


Fig.: 2.7.10 HPLC Chromatogram of *Amblypharyngodon mola*

AREA PERCENT REPORT

Peak	RetTime Type (Min)	Width (Min)	Area (mAU*S)	Area	Name
1	2.338 MM	0.1894	0.0000	0.0000	Vitamin-A
2	1.232 MM 0.1243		0.0000	0.0000	Vitamin-D
Totals :			0.0000		

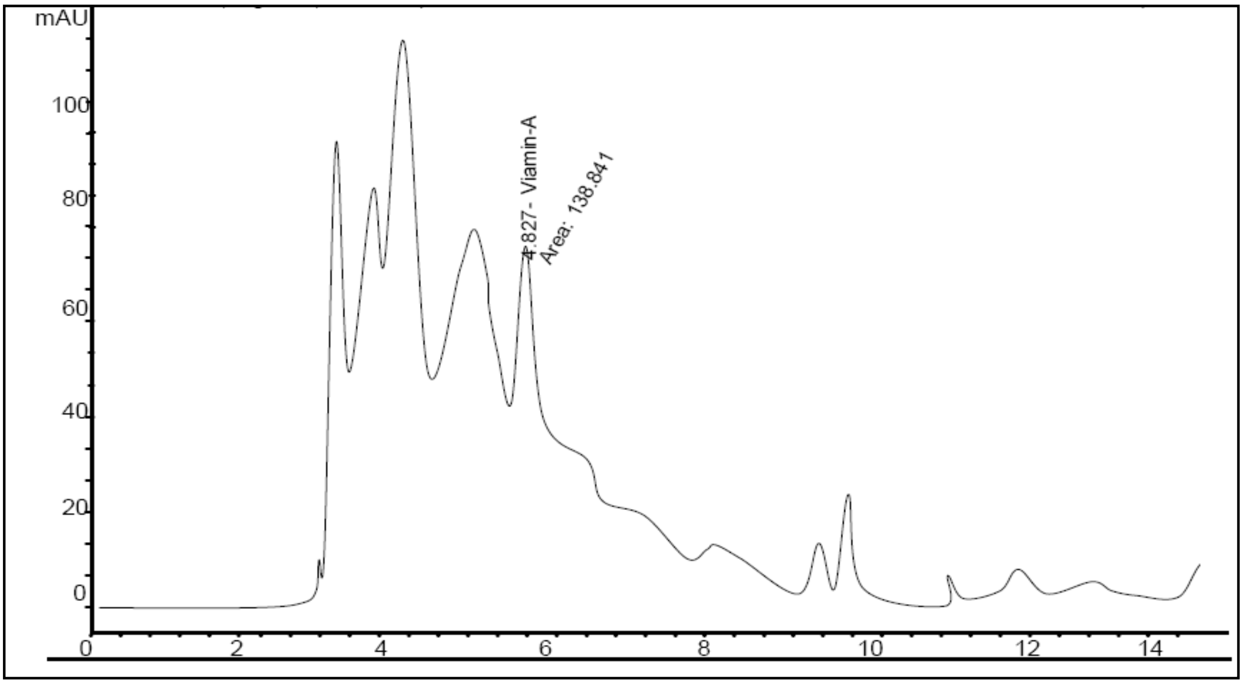


Fig.: 2.7.11 HPLC Chromatogram of *Macrognathus pancalus*

AREA PERCENT REPORT

Peak	RetTime (Min)	Type	Width (Min)	Area (mAU*S)	Area	Name
1	4.827	MM	0.2114	138.84105	100.0000	Vitamin-A
2	9.542	MM	0.0000	0.0000	0.0000	Vitamin-D
Totals :				138.84105		

Vitamin A and Vitamin D content in the selected fish species in this study is shown in table: 1.9

Table: 3.1 Vitamin A and Vitamin D content in different fish species

Sl No	Scientific name of species	Vitamin A (µg/100g)	Vitamin D (µg/100g)
1	*Barilius vagra*	672.57	31.73
2	*Neoeucirrhichthys maydelli*	34.97	15.33
3	*Chanda nama*	378.96	BDL
4	*Channa gachua*	756.04	20.16
5	*Rasbora daniconius*	1644.38	32.20
6	*Channa punctatus*	248.76	BDL
7	*T. Colisa fasciata*	18.88	BDL
8	*Xenentodon cancila*	849.51	6.08
9	*Amblypharyngodon mola*	BDL	BDL
10	*Macrognathus pancalus*	111.85	BDL

BDL= Below Detectable Limit

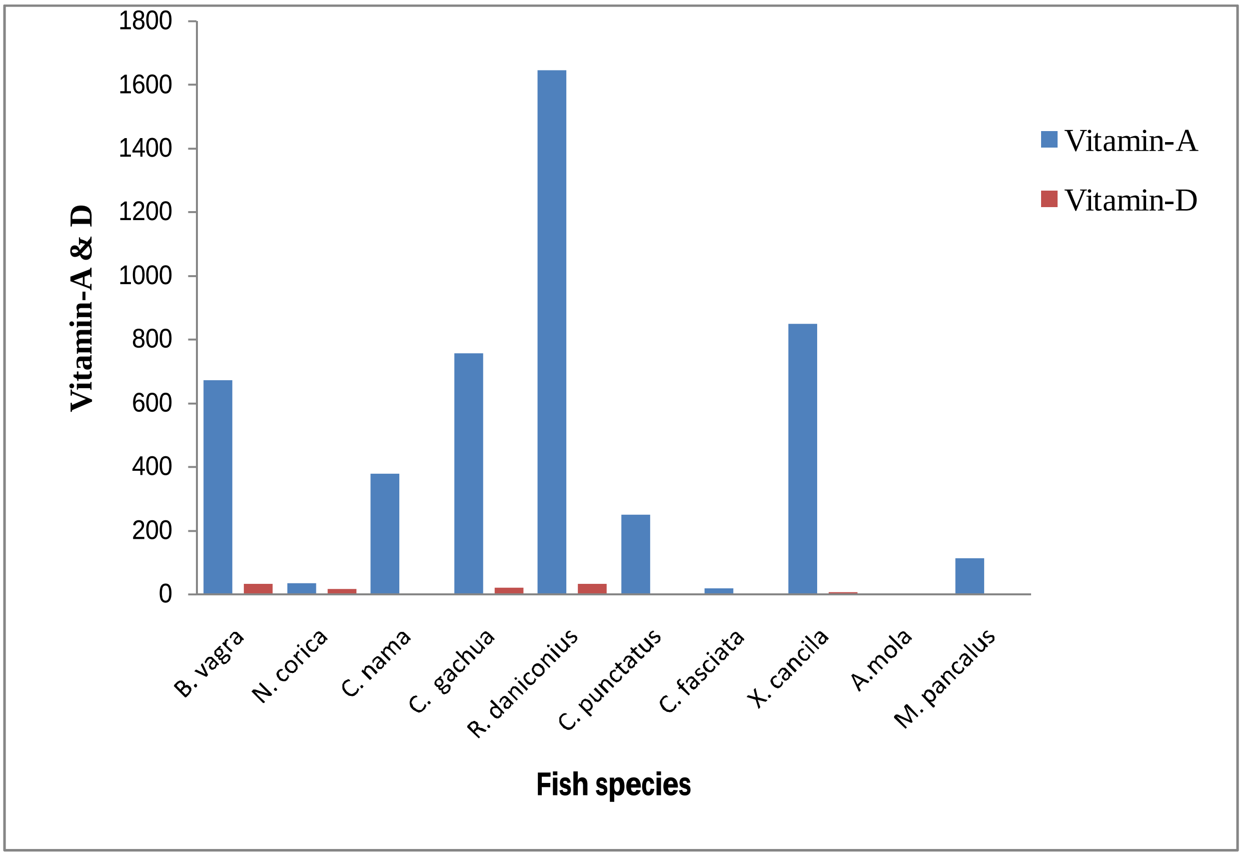


Fig.: 2.7 Comparision of Vitamin-A & D content in different fish species

Vitamin A derivative Retinolic acid is the regulator of gene expression which is needed in the development of epithelial tissue (Roos et al., 2003). The present study revealed that all the ten studied small fishes were rich source of vitamin A. The highest contents of Vitamin A (1644.38 µg/100g) was found in the small fish *Rasbora daniconius* and the lowest of the same value (111.85 µg/100g) was shown by *Trichogatser fasciata*.

Vitamin D has its crucial role in regulating calcium phosphate balance in such way that stimulates calcium absorption by the small intestine and hence promoting bone metabolism The fat soluble vitamins are documented to be the vital nutrients which control many biologically important processes in human body. The vitamin D contents of the selected fishes ranged from 6.08 µg/100g to 32.20 µg/100g. The maximum value of Vitamin D (32.20 µg/100g) was found in *Barilius vagra*.

In the present study the fat soluble vitamins A & D were studied in the selected small fishes. Deficiency of Vitamin A is a mojor health problem in most of the developing countries. The specific diseases caused by the deficiency of Vitamin A include Night blindness and keratomalacia significantly in children and reproducible women (West, 2002). Previous researches established that the life risks of children below five years are mostly reduced with a status of good vitamin A. Many commonly consumed freshwater fish species were found to contain an excellent amounts of Vitamin A in the form of retinal and 3, 4 dehydroretinal isomers with the relative amounts changing with the species (Roos et al., 2002). Vitamin A (Retinol) palys a key role as the visual pigment of the vertebrate eyes (Mahanty et al., 2013). The small indigenous fish *Amblypharyngodon mola* was found to contain very high contents of Vitamin A (Kongstak et al., 2008). A mole was investigated to conclude that the contents of Vitamin A were stored mainly in the eyes and viscera (Roos et al., 2002).

In the present study the small fish *Rasbora daniconius* contained the highest amount of Vitamin A (1644.38 µg/100g) which was followed by (849.51µg/100g) in *Xenentodon cancila* . As per the present work, the small fish *Rasbora daniconius* contained the highest amount of Vitamin D (32.20 µg/100g) also.

4.9 Physicochemical analysis of water bodies

The physicochemical analysis of some water bodies of the study area area shown in Table: 1.10

Table: 3.2 Physicochemical parameters of the water samples

Sl No	Test Parameters	Gaurang River	Gour Beel	Diplai Beel	Haloidal Beel
1	pH value	7.1	6.8	7.0	7.3
2	Temperature (^oC)	24	23	24	23
3	Total Dissolved Solid (TDS) (mg/L)	48	346	16.0	50.0
4	Dissolve Oxygen (DO) (mg/L)	7.65	6.21	7.46	7.65
5	Biochemical Oxygen Demand (BOD) (mg/L)	1.6	2.4	1.2	1.5
6	Chemical Oxygen Demand (COD) (mg/L)	5.76	9.60	4.80	5.76
7	Alkalinity (mg/L)	12	14.0	4.0	6.0
8	Turbidity (Nephelometric Turbiditu Unit, NTU)	7.7	130.0	5.0	24.0
9	Salinity (Practical Salinity Unit, PSU)	0.05	0.32	0.02	0.05
10	Viscosity (mm^2/S)	0.9118	0.9359	0.9125	0.9328

(1NTU= 1/3 mg/L & 1 PSU= 1g/Kg)

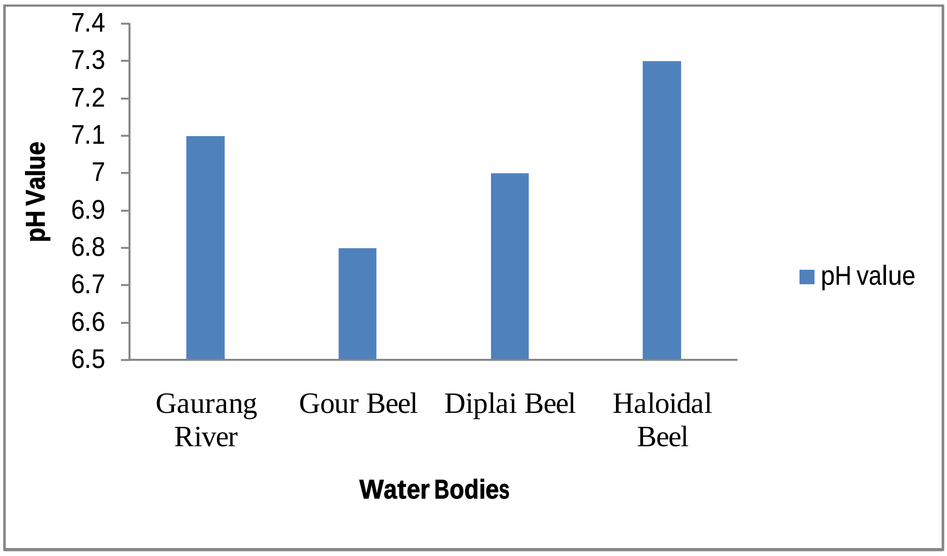


Fig.: 2.8.1 Variations of pH in different water bodies

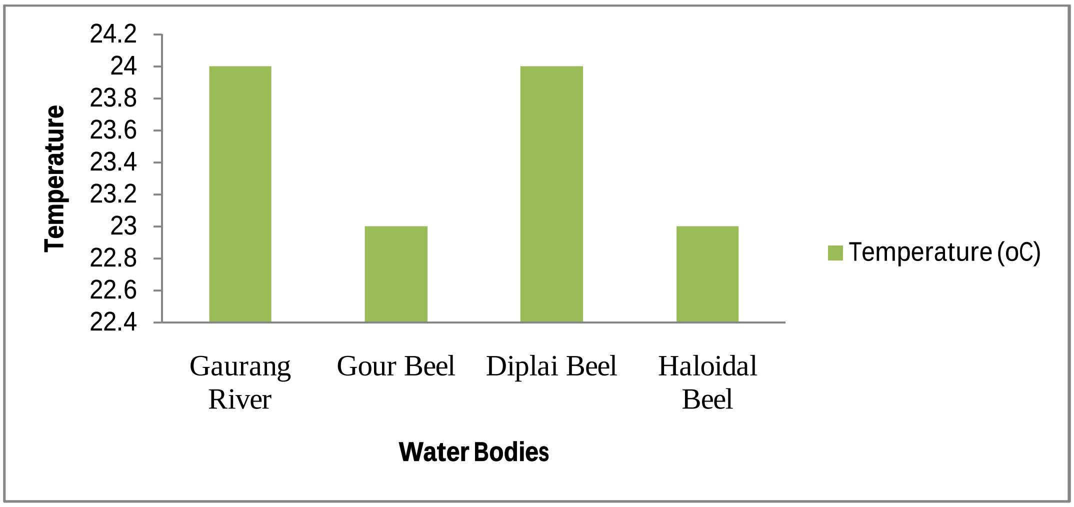


Fig.:2.8.2 Variations of temperature in different water bodies

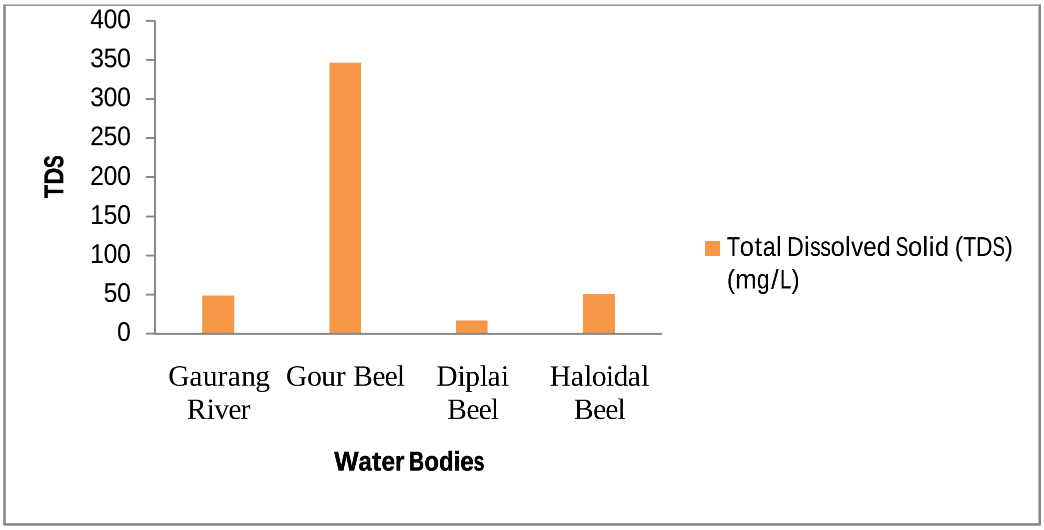


Fig.: 2.8.3 Variations of TDS in different water bodies

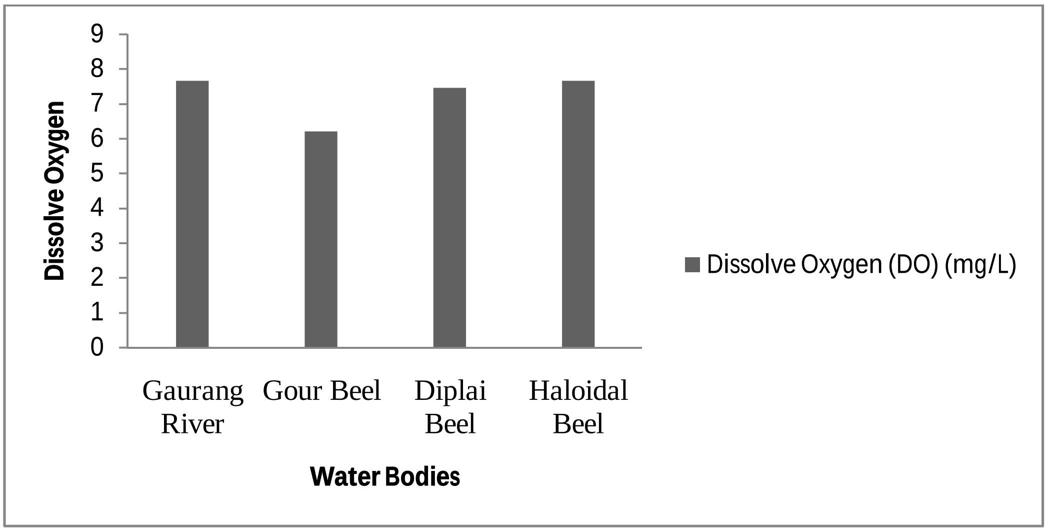


Fig.:2.8.4 Variations of dissolve oxygen in different water bodies

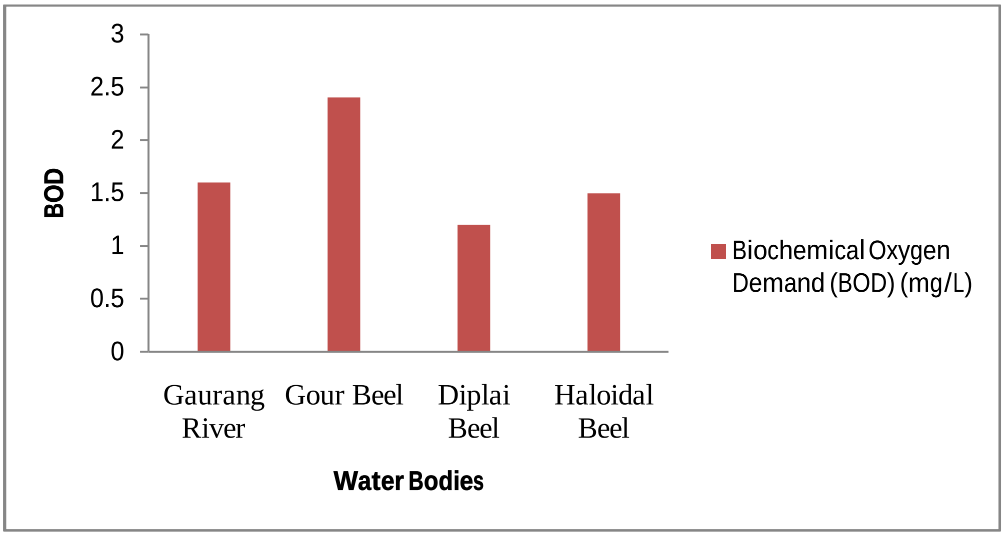


Fig.: 2.8.5 Variations of BOD in different water bodies

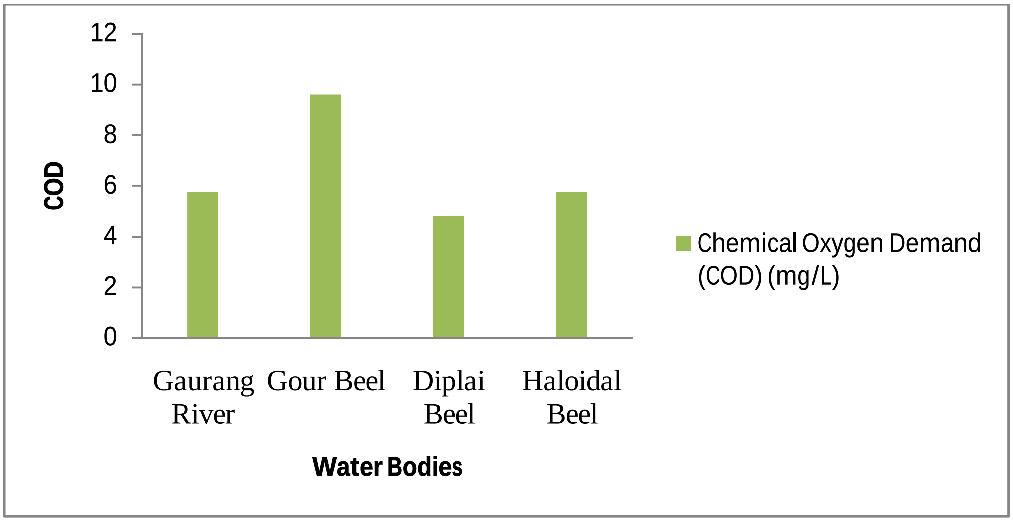


Fig.: 2.8.6 Variations of COD in different water bodies

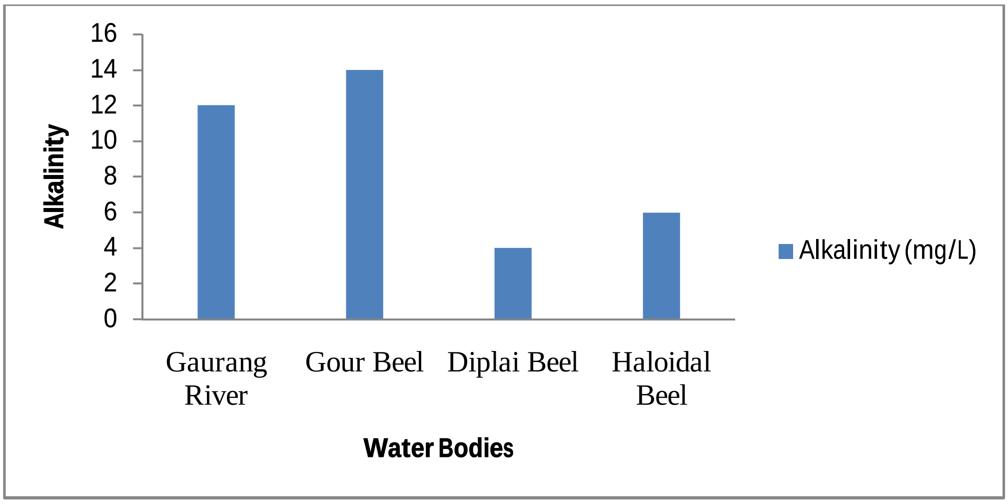


Fig.: 2.8.7 Variations of alkalinity in different water bodies

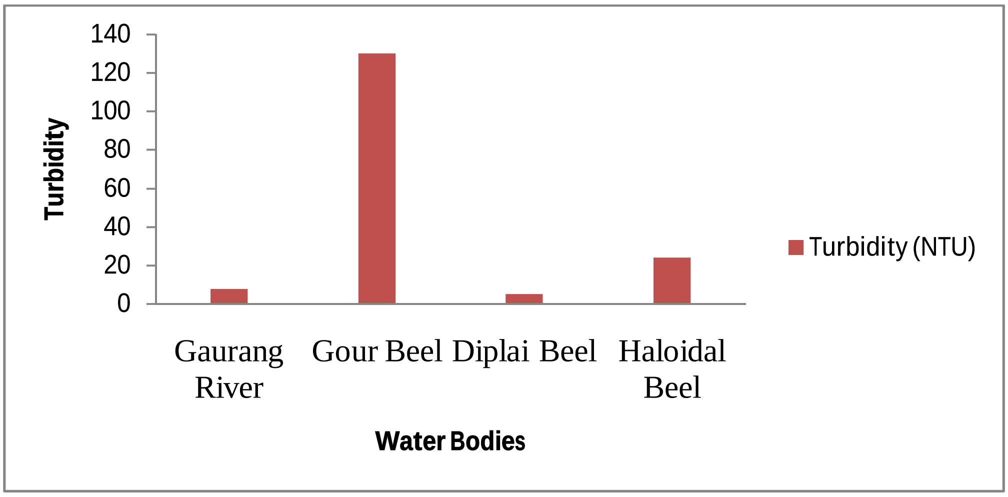


Fig.: 2.8.8 Variations of Turbidity in different water bodies

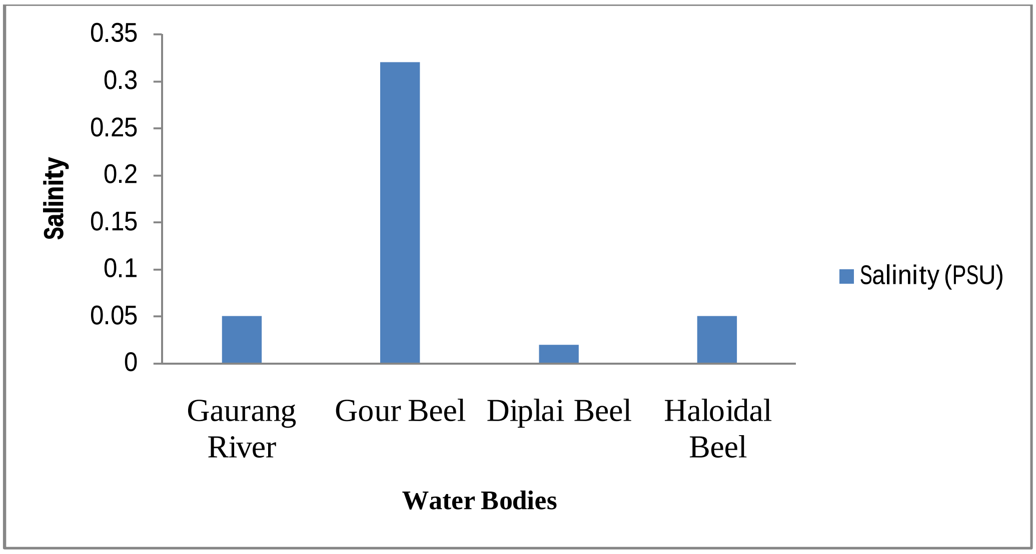


Fig.: 2.8.9 Variations of Salinity in different water bodies

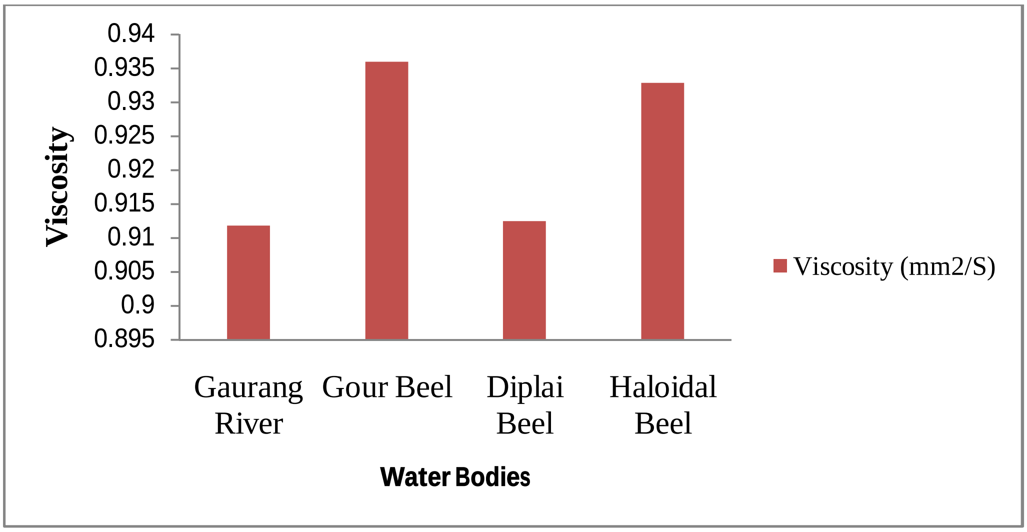


Fig.: 2.8.10 Variations of Viscosity in different water bodies

4.9.1 Measurement of pH

The pH value ranged from 6.8 to 7.3 as shown in Fig.:2.8.1. Maximum pH was recorded in Haloidol beel whereas the minimum was found in Gour Beel. The study of Choudhury *et al*, 2013 revealed a pH range of 7.0 - 8.3. Shrivastava *et al.*, 2013 also reported a similar range of pH of 6.93 - 7.55. They studied the physico-chemical status of different surface waters of pond water of Surguja District Chattisgarh, India. Sharma *et al*., 2013 reported that in India, many small confined water pockets are particularly alkaline in nature. This type of alkaline nature was justified in this present study. The pH values of all the water samples were in the alkaline range. Islam *et al.*, 2014 reported that this pH has been noted to be productive and thus up to snuff for pisciculture.

4.9.2 Measurement of temperature

Temperature is the measure of hotness of any substance. It insigate the physical and chemical characteristics of water and also impinge the aquatic lives in it. Good knowledge about temperature prior to study an water habitat is very much important for fish culture. According to Hemlata *et al*., 2014, the Guidelines for water Quality Management for fish culture in Tripura the optimum temperature is 24˚C - 30˚C. So far the current work is concerned the least variation of temperature from 23˚C-24˚C was recorded which is well within the guidelines limit (Fig.:2.8.2). Maximum temperature was recorded in Gaurang river and Diplai beel.

4.9.3 Measurement of total dissolved solid (TDS)

In the current study the TDS values were in the range from 16 mg/L to 346 mg/L (Fig.:2.8.3). Maximum value of TDS was found in Gour beel and the minimum was in Diplai beel. High value of TDS insinuate the increased nutriment status of water body which leads to eutrophication of aquatic bodies as repoted by Swarnalatha et *al*., 1998 & Singh *et al*.,2015. Yadav *et al*., 2012 reported that the water having more than 500mg/L of TDS values are not acclaimed for drinking purpose. The present work manifested that the selected water samples may be used for drinking by the local communities.

4.9.4 Determination of Dissolved Oxygen (DO)

Dissolved oxygen is an essential component to delineate man-made pollutants. According to Dixit et *al*., 2005, the presence of DO is awfully necessitous to maintain the aquatic lives and balancing different pollutions which make the aquatic bodies healthy. Quantification of DO values stands for the key test for any kind of pollution in water. In the present study dissolved oxygen ranged from 6.21 to 7.65 mg/L (Fig.:2.8.4). Maximum DO was traced in Gaurang river and Haloidal beel i.e. 7.65 mg/L. Similar observations were also made by Bhavimani and Puttaiah, 2014. According to Adakole, 2000, the concentration of DO not less than 5.0 mg/L is suitable for aquatic lives. Thus all the sites are good for aquatic life in general and fishes in particular.

4.9.5 Determination of Biological Oxygen Demand (BOD)

BOD is dissolved oxygen required by micro organism for aerobic decomposition of organic matter present in water. Jain et al.,2000, have considered BOD as an important parameter in aquatic system to analyze the level of water pollution. Fig.:2.8.5 shows the values of BOD were in the range from 1.2 to 2.4 mg/L. The maximum value of BOD was found in Gour beel. The least value was recorded in Diplai beel. If the BOD value of water is less than 1.0 mg/L then water is considered as pollution free, if it is between 2.0 to 9.0 mg/L then water is considered as polluted but in moderate level and if it is higher than 10.0 mg/L then water is considered as highly polluted (Adakole, 2000). The present study revealed the water samples being moderately polluted.

4.9.6 Determination of Chemical Oxygen Demand (COD)

Fig.:2.8.6 shows the variation in COD of different water bodies. The value of COD were in the range from 4.8 to 9.6 mg/L. COD determines the oxygen required for chemical oxidation of all organic matters viz. biodegradable and non-biodegradable by a strong chemical oxidant as repoted by Mahananda et al., 2010. The maximum COD level for fish culture is below 50 mg/L as per the Guidelines for water Quality Management for fish culture in Tripura (Hemlata et al, 2014). In the present study the COD values of all the four aquatic system were well within the permissible range and was found to be suitable for pisciculture.

4.9.7 Determination of total alkalinity

Total alkalinity of the water samples ranged from 4-14 mg/L (Fig.:2.8.7). Highest alkalinity was recorded in Gour Beel and the lowest in Diplai beel. According to Yadav *et al.*, 2013, alkalinity in most natural water estimates the amount of carbonates and bicarbonates whose salts get hydrolysed in solution and produced hydroxyl ions. It is used as a measure of productivity (Hulayal *et al,* 2011).

4.9.8 Determination of turbidity

Turbidity values of the water samples in the present study ranged from 5 NTU -130 NTU (Fig.:2.8.8). Turbid water is generally unpalatable for aesthetic problem. Turbidity is generated flow of muddy water from neighbouring the water sampling habitat or water bottom lodging fish and muskrats. In the current study all water samples have the turbidity level within the legitimate range of World Health Organization. As per Zweigh (Zweigh, 1989), turbidity of 20-30 NTU is pertinent for pisciculture. Thus the turbidity of Halwadol beel (24 NTU) was more suitable for fish culture compared to the other three.

4.9.9 Determination of salinity

Salinity of the studied water samples ranged from 0.02-0.32 PSU (Fig.:2.8.9). Salinity implies the measure of saltiness of a water body. Low salinity implies the sites have more dissolved oxygen which is required for the aquatic life.

4.9.10 Determination of viscosity

Viscosity of the studied water bodies ranged from 0.9118-0.9359 mm^2/S (Fig.:2.8.10). The highest value was recorded in Gour Beel and the lowest in Gaurang river.

The ideal values of various physico-chemical parameters (Boyd, 1998) for freshwater aquaculture are presented in Appendice-I.

4.10 Comparision of small fish species with some popular large fish species

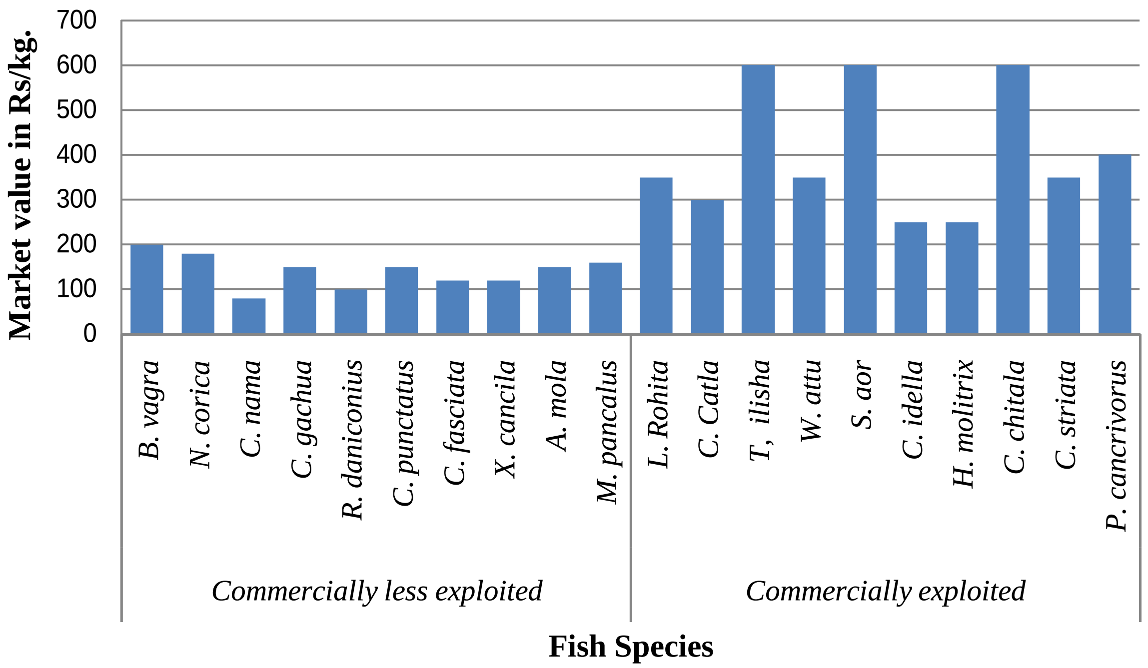
4.10.1 Comparision of market value

After thorough survey in some of the village areas of Kokrajhar district, it wasclearly highlighted that the available small fish species posses lower market value than some of the popular large fishes as shown in table below.

Table: 4.1Market values of different fish species

Fish Species	**Local name**	Market value (Rs./kg)	**Fish Species**	**Local name**	Market value (Rs./kg)
B. vagra	Boroli	200.00	*L. Rohita*	Rahu	350.00
N. maydelli	Bothia	180.00	*C. Catla*	Catla	300.00
C. nama	Chanda	80.00	*T, ilisha*	Hilsha	600.00
C. gachua	Cheng	150.00	*W. attu*	Boal	350.00
R. daniconius	Darikana	100.00	*S. aor*	Eir	600.00
C. punctatus	Goroi	150.00	*C. idella*	G. Carp	250.00
C. fasciata	Kholihona	120.00	*H. molitrix*	S. Carp	250.00
X. cancila	Kokila	120.00	*C. chitala*	Chital	600.00
A. mola	Mola	150.00	C. striata	Shol	350.00
M. pancalus	Turi	160.00	*P. cancrivorus*	Kuchia	400.00

Fig.: 3.1 Comparision of Market values in Rs./kg of different fishes



The poor villagers cannot afford readily to get the popular large fishes. Rather the small species were mostly admired by the below poverty groups.The small fishes had been less exploited commercially

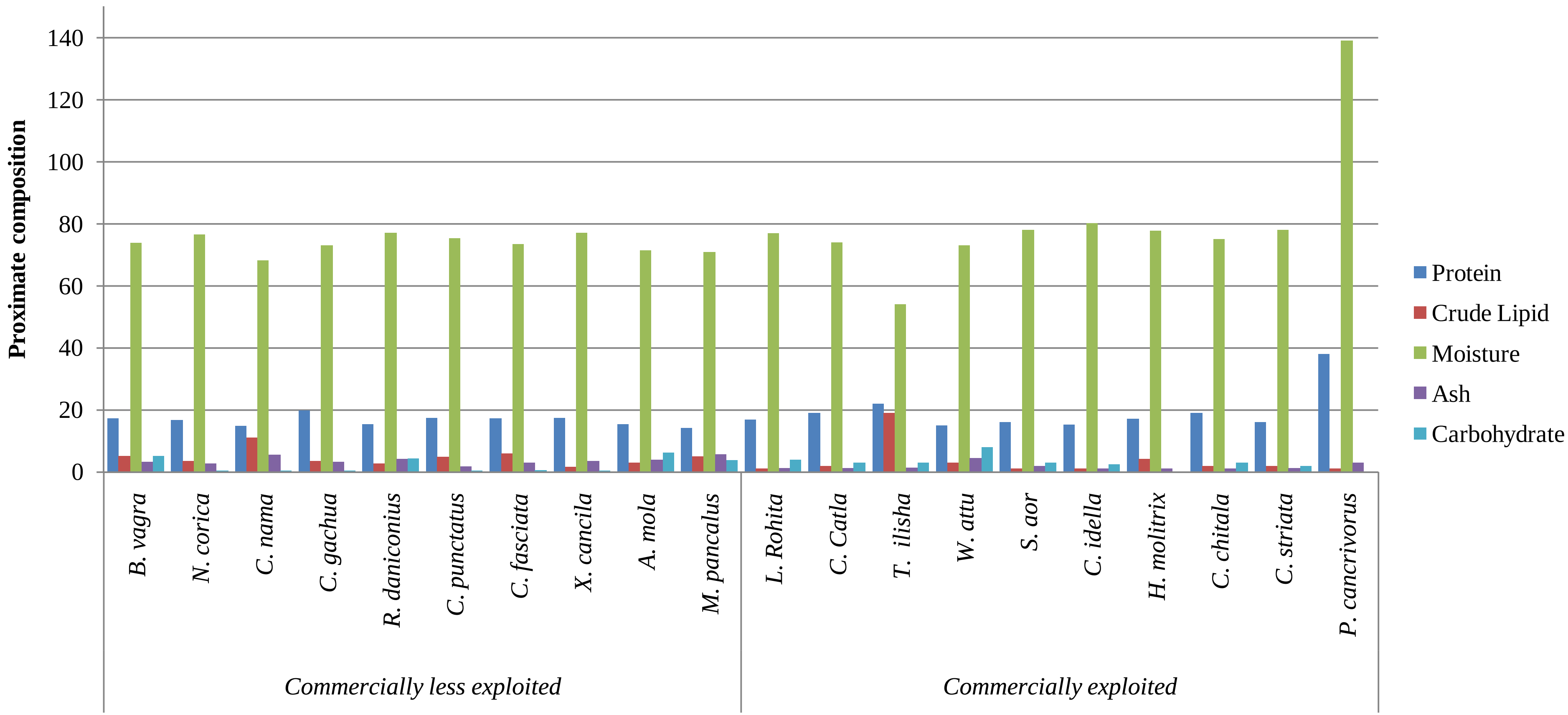
4.10.2 Comparision of Proximate composition

Table: 4.2 Proximate composition of small fish species compared with those of some popular large fish species

Sl no.	Scientific name of species	Protein (g/100g)	Crude Lipid (g/100g)	Moisture (g/100g)	Ash (g/100g)	Carbohydrat e (g/100g)
1	*B. vagra*	17.30	5.19	73.89	3.36	5.20
2	N. *maydelli*	16.72	3.42	76.71	2.85	0.40
3	*C. nama*	14.86	11.09	68.12	5.59	0.33
4	*C. gachua*	19.85	3.53	73.05	3.26	0.35
5	*R. daniconius*	15.35	2.82	77.21	4.22	4.31
6	*C. punctatus*	17.48	4.92	75.50	1.73	0.37
7	*C. fasciata*	17.22	5.84	73.51	2.95	0.48
8	*X. cancila*	17.41	1.58	77.07	3.55	0.30
9	*A. mola*	15.43	2.94	71.50	3.94	6.19
10	*M. pancalus*	14.26	5.08	70.96	5.79	3.91
11	*L. Rohita*	17	1	77	1.23	4
12	*C. Catla*	19	2	74	1.22	3
13	*T. ilisha*	22	19	54	1.4	3
14	*W. attu*	15	3	73	4.46	8
15	*S. aor*	16	1	78	2.0	3
16	*C. idella*	15.2	1.1	80.2	1.1	2.4
17	*H. molitrix*	17.2	4.1	77.8	1.0	0.1
18	*C. chitala*	19	2	75	1.0	3
19	C. striata	16	2	78	1.2	2
20	*P. cancrivorus*	38	1	139	2.9	

Going through the literature on the nutritional aspects of some commonly available popular large fishes, it was pointed out that the nutritional values of those popular large fishes do not vary remarkably with the nutritional contents of the small fishes which are easily available here, there and everywhere of the local areas.

Fig.: 3.2 Comparision of proximate composition of the selected fish species with that of other commercially important fishes



4.10.3 Comparision of mineral content

Table: 4.3 Mineral content (Fe, Zn, P & Ca) of small fish species compared with those of some popular large fish species

Sl No	Scientific name of species	Iron (mg/100g)	Zinc (mg/100g)	Phosphorous (mg/100g)	Calcium (mg/100g)
1	*B. vagra*	9.15	2.36	891.81	636.91
2	*N. maydelli*	5.95	2.84	825.64	591.20
3	*C. nama*	3.90	3.18	2470.00	807.93
4	*C. gachua*	4.84	2.66	616.79	539.39
5	*R. daniconius*	12.84	4.64	1246.55	697.39
6	*C. punctatus*	3.67	1.57	3170.00	672.98
7	*C. fasciata*	18.23	2.98	3520.00	1640.00
8	*X. cancila*	3.83	2.86	858.78	647.75
9	*A. mola*	4.31	4.73	1990.00	731.10
10	*M. pancalus*	3.75	1.44	1620.00	389.32
11	*L. Rohita*	1	1.0	175	650
12	*C. Catla*	1	1.1	255	530
13	*T, ilisha*	2	1.2	280	180
14	*W. attu*	1		490	160
15	*S. aor*	1	2.13	180	380
16	*C. idella*	0.46	0.91	190	54
17	*H. molitrix*	4.4	1.4	-	903
18	*C. chitala*	3		250	180
19	C. striata	0	0.41	95	140
20	*P. cancrivorus*	1	3.3	441	40.8

Fig.: 3.3 Comparision of the Fe & Zn content of the selected fish species with that of other commercially important fishes

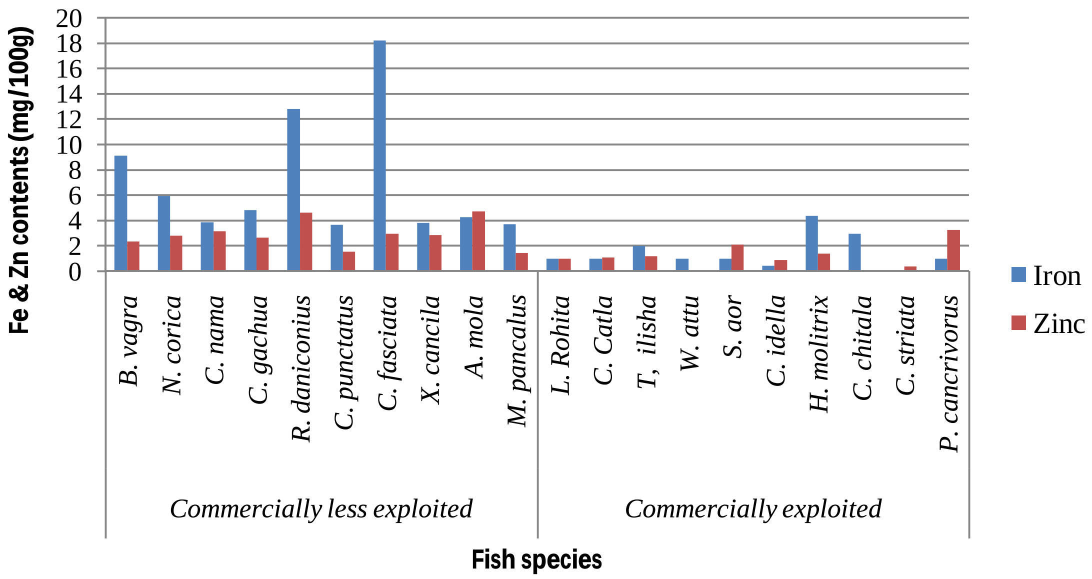
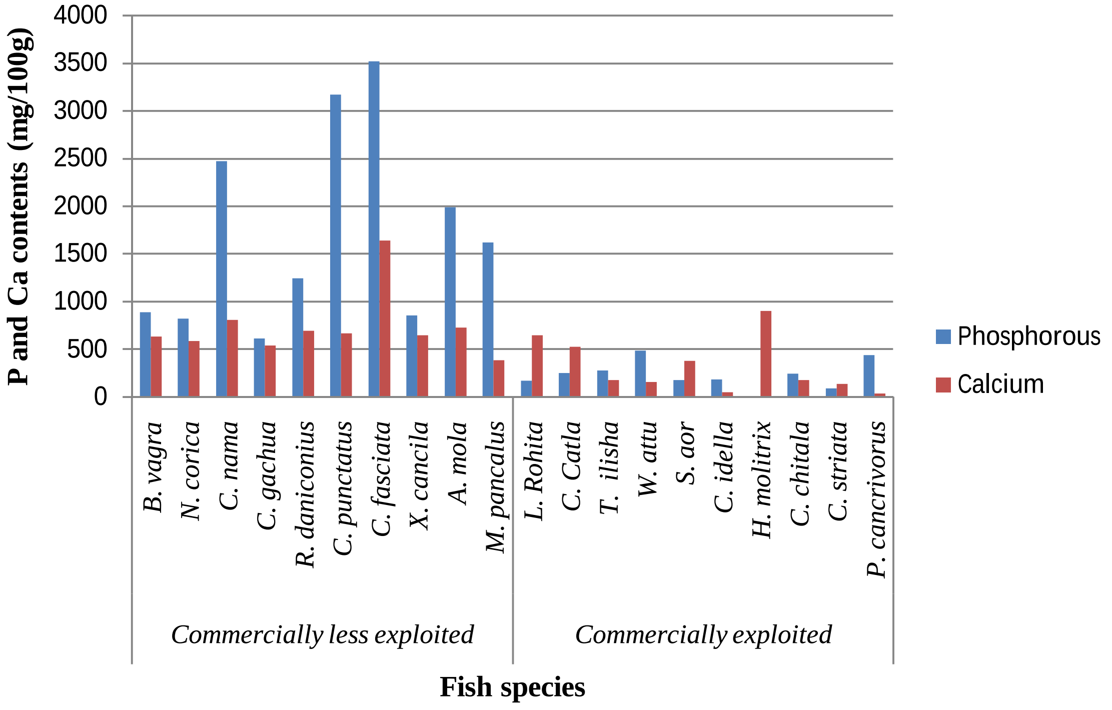


Fig.: 3.4 Comparision of the P & Ca content of the selected fish species with that of other commercially important fishes



The comparision of some of the mineral contents also revealed that those small fishes which the poor villagers incude in their diet have a high mineral contents compared to those of some popular large fishes. The studied small fishes were thus found to be nutritionally competitive with the popular large fish species.

CHAPTER-V
Summary

In the present study quantitative analysis was performed for the nutritional contents of ten selected small food fishes. The studied small fishes are mostly consumed by the local communities of Kokrajhar, BTAD, Assam. These are easily available and of low costs. In rainy seasons these fishes are found in each of the wet lands, ponds, beels, lakes etc. The rural poor people of the local area consume the fish food regularly and also sell them in the nearest market. Most of the small fishes are available throughout the year. Nutritional informations about the fish species make them pronounced for both human consumption as well as commercialization.

The experimental investigations of the nutritional contents of the studied fishes concluded that all of them were rich in protein contents. Amongst them, the highest contents of protein were shown by *channa gachua* (19.85g/100g) and the lowest of the same was reported by *Macrognathus pancalus* (14.26g/100g). Maximum amount of Crude lipid was possessed by *Chanda nama* (11.09g/100g) and the lowest was shown by the species *Xenentodon cancila* (1.58g/100g). The fish species *Rasbora daniconius* was found to contain highest moisture values (77.21g/100g and the lowest moisture contents were recorded by *Chanda nama* (68.12g/100g). Highest contents of ash was possessd by *Macrognathus pancalus* (5.79g/100g) and the lowest value of the same was found in the species *Channa punctatus*. All the studied fishes were of low carbohydrate contents.

All the studied fish species were found to contain fair contents of amino acid. The highest contents (10.0%) of essential amino acid histidine was found in *Trichogaster fasciata* which was followed by (8.36%) in *Chanda nama*. Another essential amino acid methionine was highly recorded (9.42%) in *Channa gachua*. Threonine, the non essential amino acid was also highly contained (8.67%) by the same fish species, *Channa gachua*. The studied fish species can be recommended as ideal dietary supplementation for human health. The fatty acid profiling of the studied fish species revealed that all of the ten fishes contained low amounts of fatty acids. Palmitic acid was predominantly present in all the fish species. The presence of lower percentage of free fatty acids in the lipids of studied species might be a conclusion that the fishes are suitable for edible purposes.

All of the ten fish species were reported to have good contents of selected micro and macro elements like iron, zinc and calcium, phosphorus. The presence of the minerals in the studied fishes highlighted them to have vital potentialities regarding human health functions.

The presence of fat soluble vitamins, Vitamin A and Vitamin D is the selected fish species concluded the major role of the fish species to enrich a balanced human diet for regular consumption

On the basis of the experimental findings of the present study, it can be concluded that the common people may readily include the small fishes in their reular diet at lower expenses. Moreover, the selected small food fishes are enriched in nutritional contents. Due to their low cost and larger abundance the small fish species might be ignored and commercially less exploited. Most of the people are having an idea that popular large and costly fishes are only good for health and consumed deliciously by the communities. The poor people cannot afford so much and prefer to buy the small fishes of low cost. These small fishes are available in ponds, beels, lakes, rivers and also in wet places in the rainy season. Many local villagers opt for carrying on livelihood being a fisherman. A lot of traditional concepts lead the rural people to consume certain foods for the recovery of certain diseases. Lack of proper investigations about the nutritional properties of the small food fishes make them overlooked by the commercial sector. Proper care is not taken by the government side for the sustainable development of the fish species.

Worldwide several works had so far been done on the nutritional analysis of fish flesh and oil. But not any detailed works had been offered on the nutritional contents of small food fishes of Kokrajhar, B.T.A.D., Assam.

For the sake of less market value these small fishes had not been given major importance by the industrialists as well as the researchers. By the passage of time people starts to think seriously about the healthy life. The wind of science and technology touch each and every corners of human life. All the natural resources are given priority to make them more enriched. As the small fishes are mostly available and more appreciated by the poorers for their low cost, scientific investigations must be carried out on their nutritional values for the development of both entire communities as well as commercialization of the lesser known fish species.

From the experiment carried out for water quality it can be concuded that all the water samples from different water bodies of Kokrajhar were suitable for drinking, bathing as well as other household activities. These water bodies can be used as place for several aquatic organisms

including fishes. However, ample care should be taken for the sustanenance of the water quality of the aquatic bodies available in this area.

The scientific informations with respect to the taxonomic position, varnicular name, edible as well as conservation status of the different fishes were gathered by investigating the Ichthyofunal diversity of fish species of the study area. The Ichthyological survey also showed that the study area is diversed in different fish fauna with vital economic potentialities. The government as well as the local people of the area should conserve the diversity by regular monitoring the fish fauna, analyzing the water quality of the different water habitats and controlling the anthropogenic activities.

Due to the lack of proper knowledge, investigation and infra structure fascilities for the research work in fisheries sector, the pisiculturists are not encouraged to contribute much in the healthy fish production of the state of Assam. The present work concludes that the studied small food fishes are nutrient- rich and can be recommended as a vital health suppliments.It can be summerised that the nutritional studies of the lesser known small food fishes carry a key role to develop scientific awareness among the rural poor people and creative attempts to utilize the fishes in the light of commercialization.

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Appendix-I

Questionaries during Survey on small fish species consumed by the Bodo communities

(i) What are the different types of fishes available in the water bodies of your locality?

Answers: ....

....

(ii) How do you catch the fish for your dietary item?

Answers: ....

....

(iii) What fishes you generally prefer in your daily diet?

Answers: ....

....

(iv) Whether the popular large fishes are used in your regular diet?

Answers: ....

....

(v) What are the small fishes you consume regularly?

Answers: ....

....

(vi) Whether the small fishes which you consume have any commercial value?

Answers: ....

....

(vii) Where from you collect the small fishes for regular consumption?

Answers: ....

....

The persons who had been interacted for the field survey are enlisted below:

1. Benudhar Gayari, Sillgari, Kokrajhar
2. Daniram Boro, Deeplai Beel, Kokrajhar
3. Bathuram Narzery, Gaurang, Kokrajhar.
4. Rinkhang Basumatary, Patgaon, Kokrajhar
5. Mihiram Daimary, Dotma, Kokrajhar.
6. Gambari Brahma, Batabari, Kokrajhar.
7. Bhanumati Narzery, Kachugaon, Kokrajhar.
8. Jaymati Basumatary, Santhaibari, Kokrajhar.
9. Binita Khaklary, Hlang Bazar, Kokrajhar.
10. Hungma Wary, Jaleswari, Kokrajhar.
11. Jaykhungur Narzery, Tipkai, Kokrajhar.
12. Ansuma Narzery, Diabari, Kokrajhar.

Appendix-II

Optimum water quality requirement for a fish

Sl. No.	Parameters	Optimum level
1.	Colour (colour unit)	Clear water with greenish hue <100 colour unit
2.	Transparency (cm)	30-40
3.	**Turbidity (mg/l)**	**<30**
4.	**Solids (mg/l)** **a. Total** **b. Suspended**	 **<500** **30-200**
5.	**Temperature (^{0}C)** **a. Tropical climate** **b. Temperate climate**	 **25-32** **10-12**
6.	**pH**	**6.5-8.5**
7.	Hardness (mg/l)	30-180
8.	**Alkalinity (mg/l)**	**50-300**
9.	Chlorides (mg/l)	31-50
10.	**Salinity (ppt)**	**<0.5**
11.	**Dissolved oxygen (mg/l)**	**5-10**
12.	Total dissolved CO_2 free (mg/l)	<3
13.	Ammonia nitrogen (mg/l) a. Unionised b. Ionised	 0-0.1 0-1.0
14.	Nitrite nitrogen (mg/l)	0-0.5
15.	Nitrate nitrogen (mg/l)	0.1-3
16.	Total nitrogen (mg/l)	0.5-4.5
17.	Total phosphorus (mg/l)	0.05-0.4
18.	Potassium (mg/l)	0.5-10
19.	Calcium (mg/l)	75-150
20.	Silica (mg/l)	4-16
21.	Iron (mg/l)	0.01-0.3
22.	**B.O.D. (mg/l)**	**<10**
23.	**C.O.D. (mg/l)**	**<50**
24.	Hydrogen sulphide (mg/l)	<0.002
25.	Residual chlorine (mg/l)	<0.003

Appendix-III

Retention time of fatty acids and methyl ester (FAME)

Fatty acid	Retention time, min	times (to 11:0 int. std.)
4:0 Butyric	10.49	0.46
6:0 Caproic	12.36	0.54
8:0 Caprylic	15.69	0.68
10:0 Capric	20.39	0.89
11:0 Undecanoic	22.99	1.00
12:0 Lauric	25.58	1.11
13:0 Tridecanoic	28.15	1.22
14:0 Myristic	30.65	1.33
14:1 Myristoleic	32.63	1.42
14:1 *trans*-Myristelaidic	32.01	1.39
15:0 Pentadecanoic	33.04	1.44
15:1 Pentadecenoic	34.98	1.52
16:0 Palmitic	35.41	1.54
16:1 *trans*-Palmitelaidic	36.39	1.58
16:1 Palmitoleic	36.88	1.60
17:0 Margaric	37.54	1.63
17:1 Margaroleic	38.92	1.69
18:0 Stearic	39.78	1.73
18:1 *trans* 6-Petroselenic	40.50	1.76
18:1 *trans*-Elaidic	40.61	1.77
18:1 *trans* 11-Vaccenic	40.72	1.77
18:1 Petroselenic	40.90	1.78
18:1 Oleic	40.99	1.78
18:1 Vaccenic	41.18	1.79
18:1 Octadecenoic	41.54	1.81
18:2 *trans*-Linolelaidic	41.69	1.81
18:2 *trans* 9-Linolelaidic	42.11	1.83
18:2 *trans* 12-Linolelaidic	42.53	1.85
18:2 Linoleic	42.87	1.86
20:0 Arachidic	43.75	1.90
18:3 g-Linolenic	44.25	1.92
20:1 Eicosenic *cis* 5	44.42	1.93
20:1 Eicosenic *trans* 11	44.45	1.93
20:1 Eicosenic *cis* 8	44.67	1.94
20:1 Eicosenic *cis* 11	44.82	1.95
20:1 Eicosenic *cis* 13	44.99	1.96
18:3 Linolenic	45.02	1.96
18:2 Linoleic—conjugated	45.35	1.97
18:2 Linoleic—conjugated	45.40	1.97
21:0 Heneicosanoic	45.69	1.99
18:2 Linoleic—conjugated	46.18	2.01
18:4 Octadectetraenoic	46.39	2.02
20:2 Eicosadienoic	46.65	2.03
22:0 Behenic	47.46	2.06
20:3 g-Eicosatrienoic	47.94	2.09
22:1 Cetoleic	48.27	2.10
22:1 Erucic	48.50	2.11
20:3 Eicosatrienoic	48.68	2.12
20:4 Arachidonic	48.94	2.13
23:0 Tricosanoic	49.22	2.14
22:2 Docosadienoic	50.17	2.18
24:0 Lignoceric	50.79	2.21
20:5 Eicosapentaenoic	50.96	2.22
24:1 Nervonic	51.92	2.26
22:3 Docosatrienoic	51.98	2.26
22:4 Docosatetraenoioc	52.28	2.27
22:5 Docosapentaenoic	54.75	2.38
22:6 Docosahexaenoic	55.82	2.43

Factors(f_{TG}) for conversion of FAMEs TG equivalents

4:0 Butyric	0.8627	0.9868
6:0 Caproic	0.8923	0.9897
8:0 Caprylic	0.9114	0.9915
10:0 Capric	0.9247	0.9928
11:0 Undecanoic	0.9300	0.9933
12:0 Lauric	0.9346	0.9937
13:0 Tridecanoic	0.9386	0.9941
14:0 Myristic	0.9421	0.9945
14:1 Tetradecenenoic	0.9417	0.9944
15:0 Pentadecanoic	0.9453	0.9948
15:1 Pentadecenoic	0.9449	0.9947
16:0 Palmitic	0.9481	0.9950
16:1 Hexadecenoic	0.9477	0.9950
17:0 Margaric	0.9507	0.9953
17:1 Margaroleic	0.9503	0.9952
18:0 Stearic	0.9530	0.9955
18:1 Octadecenoic	0.9527	0.9955
18:2 Octadecdieoic	0.9524	0.9954
18:3 Linolenic	0.9520	0.9954
18:4 Octadectetraenoic	0.9517	0.9954
20:0 Arachidic	0.9570	0.9959
20:1 Eicosenic	0.9568	0.9959
20:2 Eicosadienoic	0.9565	0.9958
20:3 Eicosatrienoic	0.9562	0.9958
20:4 Arachidonic	0.9560	0.9958
20:5 Eicosapentaenoic	0.9557	0.9958
21:0 Heneicosanoic	0.9588	0.9961
22:0 Behenic	0.9604	0.9962
22:1 Docosaenoic	0.9602	0.9962
22:2 Docosadienoic	0.9600	0.9962
22:3 Docosatrienoic	0.9598	0.9961
22:4 Docosatetraenoic	0.9595	0.9961
22:5 Docosapentaenoic	0.9593	0.9961
22:6 Docosahexaenoic	0.9590	0.9961
23:0 Tricosanoic	0.9620	0.9964
24:0 Lignoceric	0.9963	0.9965
24:1 Nervonic	0.9632	0.9965

[a] F_{Ai} is the conversion factor for conversion of FAMESs to corresponding fatty acids.

[b] F_{Tgi} is the conversion factor for conversion of FAMEs to triglycerides for individual fatty acids.

List of Publications:

1. **Chakraborty, S.**, Brahma, B.K., and Goyal, A.K. (2015). Proximate Composition of Three Small Indegenous Fish Species Encountered In The Local Fish Market of Kokrajhar, BTAD, Assam. *Indian Journal of Applied Research*, **5**(10): 712-714

2. **Chakraborty, S.**, Brahma, B.K., and Goyal, A.K. (2016). Ichthyofaunal Diversity of Various Water Bodies of Kokrajhar Ditrict, BTAD, Assam. *International Journal of Fundamental and Applied Sciences*. **5**(1): 9-16

3. **Chakraborty, S**., Kausor, M.A., Goyal, A.K., Basumatary, A.K. and Brahma, B.K. (2017) Studies on PhysicoChemical Parameters of Fish Inhabiting Four Water Bodies In the Vicinity of Kokrajhar, BTAD, Assam. International Journal of Applied Chemistry. **13**(3) 409-420