Fish as food has played an important role in human nutrition and health. It has been an important part of the diet of human beings in almost all countries in the world. Animal proteins are generally superior to plant proteins and fish is one of the cheapest sources of animal proteins. Besides, the availability and affordability is greater, with regard to fish, in comparison to other animal protein sources. Fish is a rich source of high quality, balanced, easily digestible protein, polyunsaturated fatty acids, minerals and vitamins. The superior nutritional quality of fish lipids (oils) is well established. Fish lipids differ greatly from mammalian lipids in that they include up to 40% of long-chain fatty acids (C14 - C22) that are highly unsaturated and contain 5 or 6 double bonds (Eicosapentanoic acid, Docosahexanoic acid) which have therapeutic value; on the other hand, mammalian fats contain not more than 2 double bonds per fatty acids molecule. Fish is generally a good source of vitamin B complex and the species with a good amount of liver oils are a good
source of fat soluble vitamins A and D. In particular, it is a good source of minerals like calcium, phosphorous, iron, copper and trace elements like selenium and zinc. Nutrient profiling of fishes shows that fishes contain superior nutrients and an umpteen number of health benefits are believed to be associated with regular fish consumption.

Indeed, a key factor limiting fish utilization is its extreme perishability due especially to bacterial and autolytic spoilage which usually occurs at the same time, after the death, during processing and sometimes during storage, and both contribute to normal spoilage processes of fish. Fish flesh offers to microorganisms conditions of good nutrient availability coupled with a moderate pH and high water activity (Adams et al., 1987). Various undesirable changes take place in the fish the moment it is taken out of water, leading to its spoilage and ultimately making it inedible. Spoilage is brought about by the action of bacteria, enzymes and also due to auto-oxidation of fat (Balachandran, 2001). During spoilage, several biochemical, microbiological and organoleptic changes take place in the muscle, producing odoriferous compounds resulting the loss in the nutritional quality of fish. Processing aims at controlling the process of spoilage and make the fish available in a variety of forms acceptable to consumers.

The most common method of utilization of fish in India is in fresh and cured forms (dried, salted, smoked and fermented) (Prasad and Panduranga, 1994). Though traditional, curing preservation methods are still widely practiced in developed and developing countries, in hilly areas, where the availability of fresh fish is comparatively limited, namely interior markets, cured fish is widely consumed. In India, 20% of the fish catch is preserved by curing (Bindu, 2004).

From time immemorial, fish has been associated with the socio economic life of the people of northeast India. More than 98% of the people of northeast consume fish as the main source of animal protein, either in its fresh condition or in preserved and cured forms along with their staple food, rice (Karthikeyan et al., 2007). Geographically, northeast India is located within the eastern Himalayas and Purvanchal Himalayas. The Eastern Himalaya
region lies between the latitudes 26° 40' - 29° 30' North and longitudes 88° 5' - 97° 5' East and covers a total area of 93,988 km² comprising two northeast states viz Sikkim and Arunachal Pradesh, besides eastern Nepal, Darjeeling hills in India, Bhutan and Tibetan autonomous region in China (Tamang, 2010). The Purvanchal Himalayas lie between the latitudes 21° 5' - 28° 23' North and longitudes 91° 13' - 97° 25' East, covering a total area of 1,08,229 km² comprising the hills of Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. The population of the north eastern region of India is 4.56 crores (Population census, 2011).

The north eastern part of India has vast and varied fisheries resources in the form of rivers (21,180 km), flood plain wetlands (beels) and lakes (1,44,555 ha), reservoirs (17,435 ha), ponds and mini-barrages (52,619 ha) as well as low lying paddy fields (32,904 ha) (Bhattacharya, 2004). The eastern Himalayan region encompassing the northeast region of India has been recognized as one of the global hotspots of fresh water fish biodiversity. So far 274 species belonging to 114 genera under 38 families and 10 orders have been reported from this region. This is approximately 33% of the total Indian fresh water fishes (Bhattacharya, 2004). Among the fish species reported, as many as 31 species occurring in the region are reported to be endemic to the north eastern region. In spite of having vast fisheries resources, the region is still reeling under a deficit fish production (2.43 lakh metric tons, 2012) as the per capita availability of fish is far below the recommended quantity i.e. 11 kg per person per year. From the nutritional point of view, attention needs to be directed to increase productivity through proper management and using appropriate location specific aquaculture technology. But, the quality of fish and processed fish products available for consumers is a matter of concern, as fishes are highly perishable in nature and start spoiling just after being taken out from the water. Besides, the quality of cured fish products never receives much attention at any stage of processing, storage and marketing, in the region.

Preservation of fish forms an important component in extending the keeping quality and to make it available throughout the season, reducing the protein loss as waste. As there are no sophisticated methods for fish
preservation in the north eastern region, such as chilling, freezing, canning etc, or facilities of cold storage for fish, the people have been using various traditional indigenous methods such as drying, smoking, salting, roasting, fermentation or combination of these treatments for the preservation of fish, particularly during the monsoon season when the catch is abundant from natural water bodies like rivers, wetlands etc. The choice of a particular processing method is greatly influenced by the area's geographical location, socio-economic factors and the food habits of the local people. Among all the traditional methods, fermentation is one of the popular and most economical methods for producing and preserving food in the region. Fermented foods are encountered worldwide and their origin is due to their prolonged shelf life, reduced volume, shorter cooking times and superior nutritive value as compared to the non-fermented ingredients (Das and Deka, 2012). In the Indian subcontinent, fermented food and beverages, prepared using local food crops and other biological resources have been going on since time immemorial and is a common practice even today (Roy et al., 2004). Few have realized that the northeast India is the centre of the diverse food culture comprising fermented and non fermented ethnic foods and alcoholic beverages. More than 250 different types of familiar and less-familiar ethnic fermented and alcoholic beverages are prepared and consumed by the different ethnic people of northeast India, including fish as raw materials.

1.1 Fermentation

The term fermentation is derived from the Latin word *fervere* meaning to boil. It basically describes the appearance of the action of yeast on extracts of fruit or malted grain during the production of alcoholic beverages. Indigenous food fermentation is one of the oldest food biotechnological processes in human history. It is dependent on the biological activity of microorganisms (Stanbury, 1999; Ross et al., 2002), from which the development of fermented foods is achieved (Geisen and Holzapfel, 1996). During the process of fermentation, locally available ingredient(s), of either plant or animal origin are converted biochemically and organoleptically into upgraded edible products, either naturally or by adding starter culture(s) containing functional microorganisms, called fermented foods (Campbell-
Platt, 1994; Steinkraus, 1996). Microorganisms convert the chemical constituents of raw the substrates of plant or animal origin during food fermentation and to enhance the nutritional value of products, improve flavor and texture, increase digestibility and pharmacological values, preserve the perishable foods and extend shelf life and fortify the product with health promoting bioactive compounds, vitamins and minerals. They also degrade undesirable compounds and anti nutritive factors, produce antioxidant component and anti microbial compounds and stimulate the probiotic function (Beddows, 1985; Tamang, 1998; Asiedu et al., 1991; Cho, 2000; Farhad et al., 2010; Singh et al., 2010). Fermentation is generally carried out to bring diversity into the kind of foods and beverage available; make otherwise inedible foods products edible; decrease toxicity; decrease cooking time and energy requirements (Jeyaram et al., 2009).

1.2 Role of microorganisms in fermentation

Indigenous people have been using microbes unknowingly for various purposes (Sekar and Mariappan, 2007). Functional microorganisms play a significant role in food preservation, such as biopreservation of foods, bioenrichment of nutritional value. The traditional way of carrying out fermentation at the household-scale is still followed using relatively simple processing facilities. These products often contain mixed microbial populations because of the lack of sterility and the use of natural fermentation (Nout and Sarkar, 1999). Microorganisms, capable of surviving in the fermentation media containing salt are able to supply both proteolytic and lipolytic enzymes which can aid in the enzymatic fermentation. It is also known that microorganisms capable of growing in the medium contribute to the development of the characteristics aroma and flavour (Balachandran, 2001). Fermented foods, an important part of the food ecosystem, harness a microbial diversity and converse the functional micro biota in the environment (Tamang, 2001). Filamentous moulds, yeast and bacteria constitute the micro biota in indigenous fermented foods, which are present in or on the ingredients, utensils or environment and are selected through adaptation to the substrate (Tamang, 1998). The major functional microorganisms isolated from the variety of indigenous fermented foods and beverages of the Himalayas are
listed below (Tamang and Sarkar, 1993; Tamang and Sarkar, 1996; Tamang and Nikkuni, 1996; Tamang, 2000; Thapa, 2001; Thapa, 2002; Dewan, 2002).

**Lactic acid bacteria (LAB):** Lactobacillus (Lb.) plantarum, Lb. brevis, Lb. fermentum, Lb. bifermantans, Lb. curvatus, Lb. lactis sub spp. cremoris, Lb. casei sub spp. pseudoplantarum, Lb. casei sub spp. casei, Lb. Coryniformis sub spp. torquens, Lb. alimentarius, Lb. farciminis, Lb. salivarius, Lb. hilgardii, Lb. kefir, Lb. confuses, Lb. fructosus, Lb. amylophilus, Leuconostoc mesenteroides, Pediococcus pentosaceus, Lactococcus lactis sub spp. lactis, Lactococcus plantarum, Enterococcus faecium; Enterococcus faecalis.

**Endospore-forming rods:** Bacillus subtilis, Bacillus pumilus. **Aerobic coccus:** Micrococcus spp.

**Yeast:** Saccharomycopsis fibuligera, Saccharomycopsis crataegensis, Saccharomycopsis capsularis, Pichia anomala, Pichia burtonii, Saccharomyces cerevisiae, Saccharomyces bayanus, Geotrichum candidum, Candida glabrata, Candida parapsilopsis, Candida bombicola, Candida chiropterorum, Candida castellii.

**Filamentous moulds:** Mucor circinelloides, Mucor hiemalis, Rhizopus chinensis, Rhizopus oryzae, Rhizopus stolonifer variety lyococcus.

In east and south-east Asia, filamentous moulds are the predominant microorganisms in the fermentation processes, whereas in Africa, Europe and America, fermented products are prepared exclusively using bacteria or bacteria-yeasts mixed cultures; moulds seem to be little or never used. However, in the Himalayas, all three major groups of microorganisms (moulds-yeasts-bacteria) are associated with indigenous fermented foods and beverages (Tamang, 1998).
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<td>Ayatba</td>
<td>Smoked fish, pickle, curry</td>
<td>Unknown</td>
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<td>Karoti</td>
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<td>Bordia</td>
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1.3 Fish fermentation

Fish fermentation is generally described as a process in which the complex protein molecules in the fish are broken down either by the action of microorganisms or by the action of organic catalysts, enzymes or ferments into simpler molecules (Balachandran, 2001; Beddow, 1985), which are themselves stable at the normal temperature of storage. At the same time, the fish odour of the starting materials is changed to the flavour and aromas of certain foods (Bukholder et al., 1968). The dominant flavour-giving components of fermented fish products are proteins and their hydrolytic cleavage products such as peptides, peptones, amino-acids, higher fatty acids and their esters, glycerides and their derivatives, monosodium glutamate (MSG), nucleotides and inosine mono phosphate (IMP).

When the fermentation process is controlled by adding salt, only a partial breakdown of the protein takes place. Such process are so controlled that a product with the desired type of flavor is produced, simultaneously ensuring preservation of the product. Sometimes various cereals and plants are added in many cases, so that the digestive enzymes from these sources also aid in fermentation process. The degree of fermentation will depend on the proportion of salt used, fat content of the fish, dressing of the fish like complete or partial removal of the gut, the nature of the additives and the temperature at which the salted fish is maintained.

Fermentation alone, as a curing process does not preserve fish because it results in the breakdown of fish muscle. For this reason, fermentation is often combined with salting, smoking and drying in order to reduce water activity and retard or eliminate the growth of proteolytic and putrefying bacteria. These processes may either be used alone or combined in order to achieve the desired product. For instance, smoking is often accompanied by drying. Similarly, salting and sun-drying are often combined with fermentation to get a well preserved product. Invariably, the final product is distinguished by peculiar qualities such as aroma, flavour and colour, according to the consumer's preference.
1.4 Types of fermented fish products

Different processes employed in the fermentation of fish which yield three distinct types of products as follows:

1. **Products in which the fish retain substantially their original form or preserved as large chunks.** Examples: *Pedah siam* (Thailand), *Makassar* (Indonesia), *Buro* (Philippines), Colombo cured mackerel (India)

2. **Products in which fish are reduced to a paste.** Examples: *Ngapi* (Burma), *Prahoc* (Kampuchea), *Belachan* (Malaysia), *Trassi* (Indonesia), *Bagoong* (Philippines).

3. **Products in which fish are reduced to a liquid.** Examples: *Budu* (Malaysia), *Patis* (Philippines), *Nuoc-mam* (Vietnam), *Nam-pla* (Thailand).

Traditional fermented fish products are basically salt fermented products. Depending on the proportion of salt used, the products can also be classified into high salt (more than 20% of total weight), low salt (6 to 8% of total weight) and no salt products.

Another classification of fermented products is based on the technique employed in the process. Two major groups are:

1. **Products primarily involving hydrolysis by enzymes.**

2. **Products preserved by microbial fermentation.**

Fermented fish products are consumed almost everywhere in Southeast Asia, generally as a condiment for rice dishes (Borgstrom, 1962). It has also become very popular in the developed countries due to its high nutritional value and organoleptic characteristics (Sanjeev et al., 1990). Many traditionally processed fermented fish products form an intrinsic part of the diet of the people of northeast India, because of its unique flavor and taste (Tamang, 1998). Ethnic people of the region catch fishes from the rivers, lakes, reservoirs and wetlands (*beels*), some of these catches are traditionally
fermented (Tamang, 2001). *Ngari* and *Hentak* in Manipur, *Gnuchi, Sidra* and *Sukuti* in Darjeeling and Sikkim, *Tungtap* in Meghalaya, *Bordia, Sepaa/Shidol/Hidol* and *Namsing/Hukoti* in Assam are some of the popular fermented fish products in the north eastern part of India.

Among all these products, *Shidol* have been most widely used by the peoples of the region, particularly in the tribal belt and among Bengali communities. *Shidol* is a solid, salt free fish product with a pasty surface and one of the essential ingredients of every household in the area accounting to its taste, strong appetizing nature and its therapeutic properties.

### 1.5 Quality of fermented fish product

Formal quality control systems are entirely lacking in the artisanal fish processing industry. Though the different preservative steps are involved in curing process, the cured fish products undergo a gradual deterioration. The spoilage of the product is mainly due to bacterial, fungal or yeast action, rancidity, autolysis and other reaction all of which are temperature and water activity dependant (Doe, 1982). The medicinal properties (Sarojnalini and Singh, 1988), biochemical, microbiological and sensory quality of different fermented fish products were studied and documented (Achinewhu and Oboh, 2002; Majumdar et al., 2005; Anihouvi et al., 2006, Kopermsub and Yunchalard, 2008, Nayeem et al., 2010, Majumdar and Basu, 2010, Koffi-Nevry et al., 2011, Tamang et al., 2012). There are few reports on the quality of traditional fish products available in the markets of India. But, the quality of *Shidol*, available in the markets of the region has not yet been studied. *Shidol* is produced by natural and uncontrolled fermentation. In addition, the environment in which the fish is processed is generally unhygienic, paving the way for possible microbial contamination. The uncontrolled fermentation process of during *Adjeuvan* preparation could lead some times to a product with variable qualities with occasional public health hazards as indicated by Anihouvi et al., (2006), from their work on *Lanhouin*, a fermented fish product of Benin. The packaging and storage condition of *Shidol* during marketing is also not up to the mark. So far, nutritional and microbiological quality defects are often associated to fermented fish and linked to process
technology (Sanni et al., 2002). Therefore, it is very important to evaluate the nutritional quality, microbial safety and the shelf life of Shidol available in the markets.

1.6 Microbial quality of fermented fish product

The quality of the fermented fish product is judged by its microbiological characteristics. Microbial contamination in processed food is not only a cause of concern to the health of the consumers but also an economic loss to the producer (Rao and Valsan, 1962). Determination of standard plate count, the faecal coliform count and *Staphylococcus* count are the widely accepted parameters in inspection of fish food (Anon, 1964). The growth of *Staphylococcus* in food, presents a potential health hazard, since many strains produce enterotoxins, which cause food poisoning, if ingested. Barber and Deibel (1972) reported the incidence of *staphylococcus* food poisoning associated with fermented food, thus causing gastroenteritis in humans. Lien (2002) reported an outbreak of *Staphylococcus aureus* food poisoning in Nesby in 12 to 22 people who consumed Rakeorret (a fermented fish product). Rieman and Bryan (1979) reported that certain strains of *E. coli* cause enteric disease in man. $10^6$–$10^8$ cells of *E. coli* in the human system show symptoms of food poisoning, as reported in infantile diarrhea.

The fermented food products, including fish products, are an integral part of the diet of the people of northeast India and are widely consumed in the daily diet. There is a great market demand of the products, but these are still prepared by traditional methods. Hence, there is a great scope for scientific intervention in the production of traditional fish product hygienically, which will help in providing a quality product.

The north eastern region of India is a treasure of indigenous knowledge systems pertaining to agriculture, food, medicine, and natural resources management (Jeyaram et al., 2009). Approximately 225 tribes out of the 450 tribes of India reside in this region (Chatterjee et al., 2006). Each tribe having their unique ethnic foods developed through the ages, to adapt to the harsh conditions and environment for centuries. The people of the region have a very rich reserve of traditional knowledge owing to their livelihood in the hilly
terrains. This area is inhabited largely by tribal people who make up 75% of the population of the region (Agrahar-Murungkar and Subbulakshmi, 2006). The major ethnic groups living in eight states of northeast India are Assam (Ahom, Bodo, Karbi, Mising, Sonowal, Kirat, Gorkha, Miri, Rajbongshi, Kachari, Chutia, Lalong, Deori, Dimasa, Hrangkhol, Rabha, Bengali); Arunachal Pradesh (Monpa, Apatani, Nishi, Adi, Hill-miri, Aka, Mishmi, Memba, Khamti, Nocte, Wancho, Khonsa, Kamba, Singpho, Mije); Manipur (Meitei, Naga, Kuki, Meitei pangal, Gorkha); Meghalaya (Khasi, Garo, Jaintia, Gorkha); Mizoram (Mizo is the generic name includes three main sub groups Lushai, Pawi, Lakher, besides Gorkha); Nagaland (Angami, Ao, Sema, Rengma, Lotha, Chakhesang, Chang, Konyak, Sangtam, Phom, Mao, Maram, Tangkhul, Maring, Anal, Mayao-Monsang, Lamkang, Nokte, Haimi, Htangun, Ranpan, Kolyo, Kenyu, Kacha, Yachimi, Kabui, Makaoro, Jeru, Somra, Gorkha, Uchongpok); Sikkim (ethnic Nepali/Gorkha which includes Tamang, Rai, Limboo, Gurung, Bahun, Chettri, Giri, Magar, Pradhan/Newar, Bhujel, Dewan, Suwar, Khagatay, Maji, Sherpa, Kami, Damai, sarki), Lepcha, Bhutia, Tibetan; Tripura: (Reang, Jamati, Noatia, Kuki, Halam, Chakma, Mogh, Lushai, Bengali) (Tamang et al., 2012).

In recent years, a number of ethnic foods and food products traditionally prepared by the different tribes/communities of the region has been reported (Dutta and Dutta, 2005; Mao and Odyuo, 2007; Singh et al., 2007; Jeyaram et al., 2009; Choudhary et al., 2011; Tamang et al., 2012) including some of the traditionally processed fish products such as Ngari, Shidol, Hentak, Tungtap etc. (Muzaddadi and Basu, 2003; Thapa et al., 2004; Muzaddadi and Basu, 2012). The rich indigenous knowledge systems of the region may be threatened by urbanization and thus, the oral tradition of passing traditional ways of food processing from one generation to another, is lost.