Fermentation is a low cost method of fish preservation using artisanal equipments, which are readily available, easy to fabricate and repair. Therefore, processors do not need a large capital outlay to start operations. Rudimentary equipments such as baskets, old barrels, earthenware pots, old nets, locally-made drying racks, mats, sack jute/ poly sacks and plastic bottles are the major items used in Shidol preparation in the region. Generally, these items are locally available and affordable. Consequently, a large number of people are engaged in Shidol processing by fermentation either at home or at the small scale factory level through indigenous practices. Shidol is widely consumed in the daily diet of the people of the north eastern region of India. Owing to its wide acceptance, there is a ready domestic market and high demand for the product mainly at local and sub-regional levels, and sometimes even at the national level.
As *Shidol* is prepared in a traditional way, there is great scope for scientific invention in the production of a hygienic product, which will help in providing a consumer-friendly product. Endowed with its precious food value and medicinal qualities, this fermented product is becoming more popular day by day. A higher market value for superior quality *Shidol* will improve the economic situation of the processors who adopt improved technologies for *Shidol* processing; in addition the public will consume a healthy product.

Bioenrichment of food substrates by traditional fermentation with protein, essential amino acids and vitamins enhances the nutritive value of raw materials. This has great significance for developing countries, where the majority of the people cannot afford to have commercially available expensive fortified nutritive foods (Tamang, 1998). Therefore, there is ample scope to popularize the product after necessary study like the nutritional quality, medicinal value, the biological and microbiological process through which the actual fermentation occurs, food hygiene and marketing potential with proper packing method. Fermentation of *Shidol* is brought about by micro-organisms and enzymes present on the surface of the raw fish, before and after capture and microorganisms present in the utensils used in the process or through the salt used during post fermentation preservation process of *Shidol*. During the fermentation process and storage for retailing of *Shidol*, many physico-chemical, microbiological changes take place due to the breakdown of protein and fat in the fish muscle. All these reactions result in changes in the texture, odour and taste of the final product. A peculiar characteristic of fermentation is a strong, sometimes offensive smell. Therefore, the quality of *Shidol* prepared form *Puntius sophore* and *Setipinna phasa*, which were available in markets of northeast India, was evaluated, determining the biochemical, microbiological and sensory quality parameters and whether it could be acceptable for consumers. But, there were some pathogenic bacteria present in the market samples, which should not be ignored. This problem can be mitigated by using the improved method and maintaining hygienic conditions during *Shidol* preparation.

Although *Shidol* is prepared form a small freshwater fish species *P. sophore* and an estuarine dried fish product from *Setipinna phasa* and is widely
accepted by the consumers of the north eastern region, a new fresh water fish species i.e. *Amblypharyngodon mola*, which is abundantly available during monsoon period in the region, was identified and successfully used for *Shidol* preparation. The *Shidol* from *A. mola* was prepared following all possible hygienic and improved practices and standardized the process of preparation. Further, the product was evaluated by determining its biochemical, microbiological and sensory quality and found a high acceptability among the consumers in the region. As the quality of the end product of *Shidol* is mainly depend on the quality of the raw materials used, therefore, quality evaluation of raw materials used for the *Shidol* preparation were studied in the present experiment along with some other suitable candidate species available in the region. Six numbers of small freshwater fish species and six numbers of dried fish products available in the markets in the region were selected for the present study to identify the suitable species to replace the raw material for *Shidol*.

High microbial loads, presence of pathogenic microorganisms and a tendency towards the oxidation process are some of the major problems associated with the marketing of *Shidol*, as the product starts to deteriorate as soon as it is taken out form the hermetically sealed earthen pot for retailing. A study has been conducted to determine the effect of salting with different concentrations on keeping quality of *Shidol* during storage in plastic bottles. This achieves a good shelf life during storage and helps the retailers to sell the product successfully.

Despite a lack of official reports on food poisoning caused by the consumption of fermented fish products, there is potential for more than just sporadic amine poisoning, since many food poisoning cases in African or other countries do not reach official channels. In the present experiment, a study was conducted to determine the effect of gamma irradiation on microbial and biochemical quality of vacuum packed *Shidol* in polyethylene bags during storage at ambient temperature.
Much folklore prevails about the medicinal usage of the fish and fish products among different communities in their locality and this has been documented for the further study.

A brief summary of the present investigations is given below:

1. In the present experiment, traditional processes of Shidol preparation by different communities of north eastern part of India were documented to preserve the originality of the fermentation processes of the product in the region. During the study of the fermentation process, major constraints were identified and the method was standardized accordingly to prepare the quality product. The critical steps of the preparation process to maintain the quality of the final products were identified and the improved method was demonstrated in the production site of Shidol.

2. The proximate and the biochemical quality of six small indigenous fresh water fish species that are commonly used for preparation of an indigenous fermented fish product including Shidol, were studied. The fish species had an average length of 6.5 to 12.6 cm and average weight of 2.5 to 27.8 g. The moisture, crude protein, fat and ash content of the fish species ranged from 65.7 – 76.2%, 14.8 - 22.3%, 3.6 - 9.4%, 3.4 - 6.1%, respectively. The SSN, NPN and TVB-N content of samples were within the acceptable limit. The pH was 6.7 - 7.1. Fresh fish samples available in the markets were found to be highly nutritious and were thus found suitable for Shidol preparation.

3. The proximate composition, biochemical and microbiological quality of six dried fish products commonly used for preparation of fermented fish product including Shidol were studied. The moisture content varied from 9.8 to 22.5% and the protein content of the product from 52.24 to 58.32%. The products were of acceptable quality. The products had low microbial load and were found to be free from bacteria like Escherichia coli, faecal Streptococci and Salmonella spp. The products had acceptable sensory quality. Dried products from markets were found to be highly nutritive and of an acceptable quality,
though they differed in overall acceptability and were found to be suitable for Shidol preparation.

4. The proximate composition, biochemical, microbiological and sensory quality of two types of Shidol prepared from Puntius sophore (Puthi Shidol) and Setipinna phasa (Phassya Shidol) available in markets were studied. The results of the analysis showed that the market samples of Shidol were a good source of protein ranging from 27.2 - 38.35%. The pH and moisture content are from 6.1 - 6.2 and from 33.44 - 37.52%, respectively. The physicochemical analysis revealed that the products are of acceptable quality.

5. Both Puthi Shidol and Phassya Shidol and raw fish used were rich in lysine, leucine, valine, aspartic acid, alanine and glutamic acid. Lysine was the most abundant among essential amino acids, whereas glutamic acid was found to be higher in the non essential amino acids group. Each amino acid content was increased during fermentation in the case of both the Shidols, except in proline in Phassya Shidol. Shidols in the markets of northeast region could serve as a significant source of essential amino acids and the sulphur-containing essential amino acids and lysine and could supplement the corresponding deficiency in plant proteins.

6. An increase in the content of the fatty acids composition was observed in both the Shidols during fermentation, but the fermentation effect on the composition of fatty acids of both the samples was almost negligible. The major SFA were C16:0 (Palmitic acid) and C18:0 (Stearic acid). The C18:1 (Oleic acid) was the prominent MUFA. The dominant PUFA are of the n-6 series in fresh Puntius sophore and Puthi Shidol, whereas n-3 series was found in major quantity in fresh Setipinna phasa and Phassya Shidol. The major PUFA was found chiefly in C18:2 (Linoleic acid) fatty acids in all samples. The essential fatty acids composition showed prominence in C18:3n-3 (Linolenic acid) and C18:2n-6 (Linoleic acid). Both the Shidols studied are good sources of n-6 and n-3 essential fatty acids.

7. The bacterial flora of both the Shidols comprised Staphylococcus aureus, Streptococcus spp. and Escherichia coli indicating unhygienic
handling practices during preparation and storage. There were no visible fungal colonies on the products. The products had acceptable sensory quality. Strict hygienic measures should be adopted right from the preparation of raw materials, use of utensils, handling practices, processing methods and during storage of Shidol in order to safeguard the health of the consumers.

8. Investigation was carried out to evaluate the effect of salting as the preservation method of Puthi Shidol outside the earthen pot, using different concentrations of salt in plastic bottles. Puthi Shidol was packed in plastic bottles after sprinkling with salt @ 3% and 5% of the product weight and stored at ambient temperature (28-32° C) for 180 days.

9. The effect of salt on the pH value of salted Puthi Shidol is relatively small. Moisture, protein, fat and ash content of all the samples vary significantly ($P<0.05$) during the storage period, indicating significant effects by the treatments on proximate composition.

10. Quality parameters like NPN and TVB-N of control and salt treated Puthi Shidol were increased significantly ($P<0.05$) during storage, indicating hydrolysis and degradation of protein. But, the treated samples had slower rate of increments in the NPN and TVB-N compared to the control. In the case of SSN content also, treated samples showed significant effects ($P<0.05$) and decreased throughout the storage period. Similarly, the PV and FFA showed slower rate of increments and significant changes in the treated samples than the control. TPC did not change significantly ($P>0.05$) and remained near 7 log cfu g$^{-1}$. Yeast and mould count were low in all control and treated samples.

11. The sensory scores of the Puthi Shidol showed an acceptable quality up to 60 days and 120 days for control and both the treated sample (3% and 5% salt treated) packed in plastic bottles, respectively. Hence, post-fermentation preservation of Puthi Shidol may be achieved by using 3% salt in view of health concerns and for the retention of characteristic Shidol odour and texture. Therefore, treatment with 3% salt may be recommended as a cheap and easy method to preserve
*Puthi Shidol* after it is taken out of the sealed earthen pot or during retailing.

12. The effect of gamma radiation (3 and 5 kGy) on the keeping quality of *Shidol* prepared from *Puntius sophore* (*Puthi Shidol*) and *Setipinna phasa* (*Phassya Shidol*), which were vacuum packed in polyethylene bags and stored under an ambient temperature (28-32°C) was studied by measuring microbiological and biochemical changes in 6 months.

13. Gamma irradiation had significant effects (*P*<0.05) on the reduction of microbial populations. The initial total bacterial counts of the control samples were 4.60-4.90 log cfu/g, whereas the counts in irradiated samples at 3 and 5 kGy were not detectable at day 0 of storage. Microbial load of irradiated samples at 3 kGy until the end of the first month and in the case of 5 kGy, until the end of the second month were below the detection level in the case of both the *Shidol* samples. The lowest microbial load at the end of the sixth months of storage was related to irradiated samples at 3 kGy in both the samples. The total bacterial counts of *Puthi Shidol* and *Phassya Shidol* after six months of storage were 2.36 log cfu/g and 2.35 log cfu/g, respectively.

14. Yeasts and moulds were not detected in irradiated samples at 3 kGy until the end of 5th month and at 5 kGy until the end of the 4th month of storage. But the count was comparatively less in *Puthi Shidol* than *Phassya Shidol*. Coliform were detected at the end of the second month in both the samples and showed the count to be 0-1 log cfu/g in control samples of both the products, whereas the coliform count were detected in case of irradiated samples, only after fourth month of storage. But the count was less in both irradiated *Shidol* samples (*Puthi Shidol* and *Phassya Shidol*) at 3 kGy (<1) compared to irradiated at 5 kGy (1.08-1.15 log cfu/g). *Salmonella* spp. were not detected in all irradiated and control samples throughout the storage period.
15. The moisture content of both control and irradiated *Shidol* samples (3 kGy and 5 kGy treated) was recorded as 37.75-38.80%, 35.86-36.25% and 34.46-35.60%, respectively and showed a significant decrease ($P<0.05$) after irradiation. Whereas the protein, fat and ash content was increased after treatment, but there were no significant differences ($P>0.05$) between control and irradiated samples. There was a significant effect on the biochemical quality between the control and 5 kGy treated samples just after treatment (0 day) and subsequent storage period but not between control and 3 kGy treated samples.

16. The irradiation process reduced the microbial load in the treated *Shidols* to a greater extent, making the product safe and free from the possibilities of food poisoning. Though the biochemical analysis showed little loss in the nutritional quality of *Shidols* after treatment and the subsequent storage period, yet the products were in an acceptable condition. As the higher doses of gamma irradiation have greater effect in the changes of nutritional quality, therefore, low dose irradiation i.e. 3 kGy may recommended as a safe preservation method for fermented fish products *Shidol* in the region.

17. According to the experimental results of gamma irradiation of *Shidol*, low dose gamma radiation i.e 3 kGy may be administered for the microbial safety of *Shidol* and shelf life extension during storage at an ambient temperature.

18. *Mowa Shidol* was prepared from sundried *Amblypharyngodon mola*, by improved traditional fermentation process at an ambient temperature, maintaining all possible hygienic conditions during the preparation process. An in-process study was done at monthly intervals to record the biochemical, microbiological and sensory qualities at the different stages of fermentation. *Mowa Shidol* was perfectly mature after 120 days of fermentation with the characteristic strong *Shidol* smell, moist and sticky surface, dark brownish colour, moderately soft texture and with shape of the fish intact.

19. The protein and ash content of *Mowa Shidol* were recorded to be 31.28% - 31.70% and 9.95%-11.11%, respectively, thus showing the high nutritional value of the product. The physico-chemical analysis
revealed that the product was of acceptable quality. The pH of Mowa Shidol was 5.8 in 120 days of fermentation and found to be in the range of 5.8 - 6.6.

20. The TPC of Mowa Shidol was in the range of 4.57 - 5.86 log cfu /g during the 180 days of fermentation at ambient temperature. Most of the isolate was found to be Staphylococcus aureus in the product. After the third month of fermentation, S. aureus reached 54% of total count (5.49 log cfu /g) and thereafter the count decreased in subsequent fermentation reaching 4.04 log cfu /g in 180 days. Though the Staphylococcal count was high in the sample, it occurred within the acceptable limit. This species might play an important role in the fermentation process of Mowa Shidol. Careful handling during the use of this product is recommended to avoid food poisoning. Pathogenic bacteria like salmonella spp., E. coli were absent, showing good sanitary practices during processing. Yeast and mould count were minimal in the product. From this experiment, it can be concluded that good quality Shidol can be produced from A. mola with high nutritional quality and consumer acceptability.

21. From this investigation, it is proved that A. mola might be a good species for Shidol production and can reduce the pressure on Puntius spp. and dried S. phasa. Further, Mowa Shidol will be a value added product, as the price of fresh mola was much less during heavy catch.

22. A survey was carried out to explore and document the prevailing lore about the fish and fish products used by the different communities of the northeastern region of India. Most of the beliefs/stories were related to medicinal/therapeutic value of the fish preparation and fish product used in the region. The present study includes information on fish preparations and fish products used for remedies for malaria, small pox, jaundice, dysentery, anemia, deficient eyesight, common cold, pimples, piles etc. The lore about the indigenous methods of treatment based on the fish products and fish preparations still form an important part of rural social life. The claimed therapeutic values of the reported fish preparations and fish products are to be critically
studied to establish their safety and effectiveness, which may otherwise be lost with time.

Recommendations/ suggestions

1. The production of *Shidol* is still carried out at home or on a small scale industrial scale with limited or no quality control. Bestowed with versatile qualities, this indigenous product of north eastern India suffers from a proper processing technology for product enhancement and value addition. Since the production of *Shidol* is confined to only local fisherfolk and a few commercial processors, this needs serious attention from the State Fisheries Department and also Central Institutes in order to develop a better quality product and to bring about an increase in the production capacity by providing financial support to the producers.

2. There is an urgent need for an intensive multi-institutional research collaboration and improvement effort to develop the production technology of *Shidol* by reducing the processing/fermentation duration and health-risk free product. The development of a value added product by selecting microorganisms, process improvement, raw material improvement etc. will lead to the industrialization of the *Shidol*. This will provide scope for exporting the product to the neighboring states and will contribute to the all-round socio-economical development of the society.

3. There is a need for a detailed study of the fermentation process in order to identify the specific species of micro-organisms involved in the different stages. It is also necessary to analyze the biochemical pathways of fermentation and determine the nature of the chemical compounds produced, and their role as well as textural changes. Though different researchers have studied the role of microorganisms during the fermentation of *Shidol*, yet there are variations in their results which need to be confirmed to isolate and to use the fermentative microorganisms to accelerate the fermentation process to
reduce the fermentation period. Thereby, the producer can produce a more desirable quality product to fulfill the demand of the consumers.

4. Packaging forms an important part of food processing because it facilitates handling during storage and distribution within the marketing chain. In the present study, as the packaging of Shidol was done in the plastic bottles during storage; there was chance of contamination and spoilage due to oxidation during retailing by opening of the mouth of the bottle. Therefore, the development of proper packaging materials and presentation for a more competitive retailing of fermented fishery product like Shidol is the need of the hour.

5. There is an urgent need to intensify the education of processors on the advantages of drying fish on raised platforms to get the better raw materials for Shidol preparation. Governmental and non-governmental organizations (NGOs) should assist processors to construct and use these platforms.

6. Training/ awareness regarding product quality, hygienic handling of raw materials and utensils used, safe processing of the product and marketing is essential for producers.

7. Scientific study on the prevailing lore about Shidol needs to give priority so that many curative substances present in Shidol can be determined.

8. The demand of Puntius sophore used in Shidol production is also a big question as far as the development of this industry is concerned. Efforts should be made towards successful farming and breeding of this species in the region to meet the increasing demand by the Shidol producers.

9. Apparently, the exploitation of microorganisms for fermented fish product preparation are seen to be the only contribution of indigenous people. But a careful analysis may reveal the intellectual richness of indigenous people of our country in terms of their ability in preparing
microbial products for varied purposes in addition to food and beverages. Further such a type of undocumented knowledge system is in the danger of extinction due to various causes. It is important to enforce protection based on the mandates of convention on biological diversity (CBD) like *Sui generis* system or to involve suitable IPR measures with a safeguard for benefit sharing with holders of such traditional knowledge (Sekar and Kandavel, 2002; Sekar and Kandavel, 2004).