FISHTECH REPORTER

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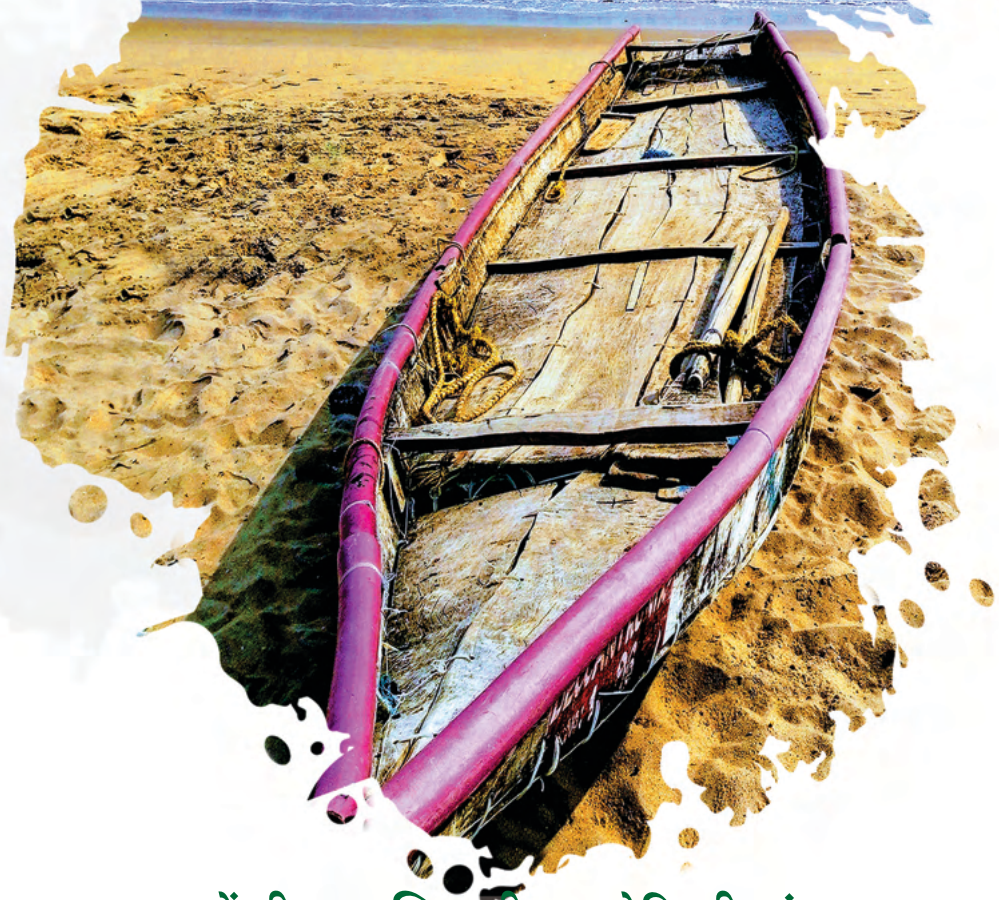

भा कृ अनु प - केंद्रीय मात्स्यिकी प्राद्योगिकी संस्थान

ICAR - CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY

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FROM THE EDITOR'S BENCH

The export of seafood from India has achieved an all-time high of 7.74 billion USD (61,285 crores) during 2021-22 with a noticeable 30% higher export, in terms of value, compared to the previous year. This indicates the increased demand for fish and fish products and the preference of the population for fish and shellfish, probably related to its taste or its health benefits. In general, the preference of people has shifted from traditional food to value-added products. This shift demands newer types of high-value products, both edible and nonedible applications, thus increasing research in frontier areas. There is also a need to disseminate the information to the stakeholders for value realization.

This issue of FISHTECH Reporter has fourteen communications highlighting the significance behind it, based on the original research. There are articles discussing the gillnets contributing to ghost fishing, the fate of fishing nets and accessories, alternate sinkers for fishing nets and operations of CIFT-TED. There are a few articles on post-harvest technology discussing the composition of shrimp waste from different regions, fish protein hydrolysate as an ingredient in fish value addition, mechanical deproteinization process to facilitate chitin process and a demerit scale-based mobile application for quality evaluation. There are also articles discussing the health/safety issues of Kuttanad aquaculture, the incidence of extended-spectrum lactamase genotypes of E.coli from aquaculture farms and an article providing preliminary information on the epidermal mucus from tilapia. There are a couple of articles describing the incidence of β-lactamase genotypes of *E.coli* in farmed fishes, tilapia lake virus incidence in tilapia fingerlings and incidence of EUS infections in genetically improved tilapias. There is also an article discussing the fishing capacity estimation in trawl fishery based on revenue.

I am sure that the articles will be of interest to the readers and encourage everyone to write research-based technical articles for disseminating the concept of science among the readers.

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CONTENTS

Lost gillnet entangled with murex shells: An evidence of ghost fishing

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Fishing gears are sometimes accidentally lost, forcibly abandoned by fishermen with no other choice or deliberately discarded, due to various reasons such as rough weather, interaction with other vessels including fishing vessels, obstruction at the sea floor, irresponsible way of gear operation etc. These gears are termed as ALDFG (Abandoned,Lost or otherwise Discarded Fishing Gear). Lost gears have many environmental impacts, including the continued capture of target and non-target species (ghost fishing), interaction with threatened/ endangered species, physical impact on the benthos, becoming a vector for invasive species, as well as the introduction of synthetic material into the marine food web (Macfadyen *et al.*, 2009). One of the most adverse impacts of ALDFG is that it leads to ghost fishing. Ghost fishing is the phenomenon by which lost gears continue its fishing activity even after the fishers lose control over the gear (Breen, 1990; Brown and Macfayden, 2007). The gear loss and consequent impacts studied worldwide revealed that passive fishing gears such as gill nets, trammel nets, and traps are the major gears contributing to ghost fishing as these gears when lost at sea may continue to fish with significant efficiency, at least for a short term (Kaiser *et al.*, 1996).

Specific measures to address the problem of ALDFG are either to prevent (avoiding the occurrence of ALDFG); mitigate (reducing the impact of ALDFG) or cure (removing/ retrieving ALDFG from the environment). ICAR-CIFT has done pioneering work in addressing the ALDFG problem in the country by locating and retrieving lost gears through scuba diving, grapnel devices/creepers and bottom trawling. Retrieval attempts through bottom trawling have been made from the CIFT department vessel FV Matsykumari-II along Cherai coast (0"9° 97N; 76° 27E) at a depth range of 25-35 m), Kochi, Kerala during June-August 2019. A total of nine trawling operations were made during the period and the retrieved gear and gear components were identified. Among the retrieved gears are gillnet panel (Polyamide multifilament 210 x 9 x 3, mesh size 105 mm) weighing 2.3 kg (Fig.1a). The retrieved netting panel was entangled with shells of mollusc *Murex trapa* showed clear evidence of ghost fishing (Fig. 1b). A total of 114 murex shells of size range from 20 to 80 mm were found entangled with the retrieved netting panel (Fig. 1c).

***Fig. 1a** Gillnet piece entangled with Murex (Murex trapa) shell*

Fig. 1b *Murex trapa shells from retrieved gillnets*

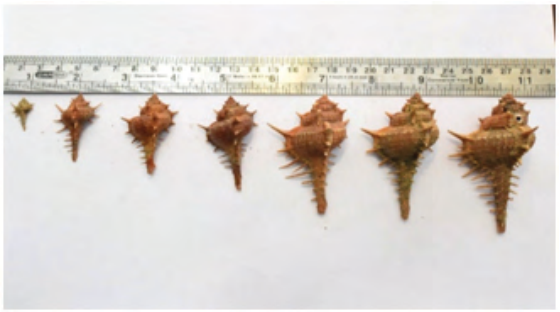

Fig. 1c *Size range of Murex trapa observed in retrieved gillnet panel*

All the organisms were dead and only empty shells remained on the net indicating that the net had been lost much earlier. Studies across the world have reported the negative impacts of ghost nets including injuries and mortalities to marine organisms including fishes, crustaceans and molluscs (Revill and Dunlin, 2003; Egekvist *et al.*, 2017). Retrieval attempts will be helpful to locate possible gear loss sites as well as to reduce further environmental impacts of lost gears.

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CIFT-TED operations along East coast of India

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Endangered marine turtles were protected under Schedule-1 of the Indian Wildlife Protection Act 1972. Field trials were conducted using the existing ICAR-CIFT- Turtle Excluder Device (TED) along east coast from February to March 2020 off Visakhapatnam, Andhra Pradesh and Dhamra and Balasore Districts in Odisha to quantify the catch losses and escapement of marine turtles. The study was conducted in collaboration with WWF-India.

CIFT-TED was installed in the trawl between the hind belly and codend. A small mesh (25 mm diamond mesh) exit cover cod-end was additionally provided in order to retain the catch excluded due to the installation of TED. Catches were sorted species-wise and weighed separately for both retained catch in the main cod-end and excluded catch in the exit cover cod-end.

Field trials were conducted onboard private marine fishing vessels off Visakhapatnam between Latitude 17^{0}41' to 17^{0}42' and Longitude 83^0 24' at a depth range of 30-40 m.

A total of 3 hauls each of 1- hour duration was under gone onboard a 13.5 m LOA commercial wooden trawler. The installed engine power was 102 hp. Details of the vessel and trawl used for experiments are given in Table 1.

Table 1. *Details of Fishing Vessel & Gear*

Vessel	**Particulars**
Type	Wooden trawler
Length over all	13.5 m
Engine	Ashok Leyland Marine Diesel
Horsepower	102 hp
Navigation, fish finding and communication equipment onboard	Global Positioning System (GPS); Echo Sounder; VHF
Crew complement	7
Gear	**Particulars**
Type	Bottom trawl
Size (head rope length)	35 m
Mesh size: wing end and belly sections	160-80 mm diamond mesh
Cod - end mesh size	25 mm diamond mesh
Otter boards	1600 x 760 mm; 60-65 kg each.

The escapement of fish, shrimps and cephalopods from cover cod-end from 1st, 2nd and 3rd, hauls by the attachment of TED consist of 4.2%, 3.2% and 3.8%. The total escapement from the 3 hauls was 10.9% with total retention at the main cod-end of 89.1% from operations off Visakhapatnam. An average escapement through the main cover cod-end from Visakhapatnam fishing harbour was 3.81%.

Field studies with CIFT-TED operation were conducted at Dharma (Lat 20^0 50' to 20^0 54' N & Long 87^0 07' to 87^0 08' E) At depths ranging from 30-40m.

A total of 2 hauls of 1 hr duration was conducted. The catch from the first haul and 2nd haul was 35kgs and 105kgs respectively amounting to a total catch of 140kgs. The escapement percentage from 1st and 2nd haul was 1.7% and 2.8% from the cover cod-end with a total retention of 97.4% from the main cod-end. The average escapement percentage from the 2 hauls was 2.35%. (Table 3)

CIFT-TED operation was conducted at Balasore (Lat 21^0 25.21'N & Long 087^{0}07.75 'E) at depth of 28-30 m. The total catch recorded was 8.5kg. The escapement percentage was 2.9% of the total catch with 97.1% retention rate (Table 3). The

Table 2. *Retained and escaped catch from the main cod end and cover cod end from CIFT-TED operations at Visakhapatnam*

	1st haul	*2nd haul*	*3rd haul*	*Total*
Main cod-end catch (kg)	*35*	*25*	*20*	*80*
Cover cod-end catch (kg)	*1.5*	*0.80*	*0.75*	*3.05*
% of escapement	*4.2*	*3.2*	*3.8*	*Average % 3.81*

main species recorded were *Lepturacan-thussavala, L.bindus, E.malabaricus, P.stylifera, S.indicus, Sepia inermis, L. devauceli, S.longiceps, S.gibbosa, Ilisha megaloptera* etc. from the three fishing experimental fishing areas. Species such as catfish, *T.corringerii*, goatfish, catfish, barracuda, mullet, horse mackerel, flat fish, pomfrets, and *A.chacunda* showed 100% retention. No turtles were encountered in the study. Previous studies have shown that CIFT-TED was efficient in 100% exclusion of turtles from trawls with minimal catch loss. The study shows that the catch loss percentages of fish are minimal with the use of CIFT-TED.

Table 3. *Retained and escaped catch from the main cod-end and cover cod-end from Dhamra & Balasore, Odisha*

Dhamra, Odisha			
	1st haul	*2nd haul*	*Total*
Main cod-end (kg)	*35*	*105*	*140*
Cover cod-end (kg)	*0.6*	*3.0*	*3.6*
% of escapement	*1.7*	*2.8*	***2.57%***
Balasore, Odisha			
	1st haul		*Total*
Main cod-end (kg)	*8.5*		*8.5*
Cover cod-end (kg)	*0.25*		*0.25*
% of escapement	*2.9*		***2.9%***

Stainless steel sinker: An alternative to conventional lead sinker

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Lead is used as a sinker in fishing nets from time immemorial. Lead is a heavy metal which is denser than most commonly available materials, and could be used as sinkers. The specific gravity of lead is about 11.34 kg/m^3, because of which it sinks very fast in the water column. This is a desirable characteristic of many encircling gears like seine nets. Because of its heavy weight per unit volume it acts as a good material to use as sinkers. It is soft and malleable, relatively low melting point (327°C) facilitating it easier casting to acquire the required shape. The casting cost is very low and it is widely available. These all criteria make lead a prime choice for sinkers of fishing net and elsewhere, viz. in batteries, weights, solders, paints, gasoline, radiation shielding etc. Most of the fishing gears use sinkers as it is one of the most important accessories which helps fishing gear to go down in water column. Depending upon type of gear such as trawl, seine nets, gillnets, lines etc. and their type of operation sinker used are of different shapes and sizes. Lead is normally unreactive metal but slow oxidation results in the formation of lead oxide which turns the metal grey, while in use. According to trawl fishermen, the total weight of the sinkers is reduced to one-third within one year due to abrasion, which affects the performance of bottom trawls significantly. The leached-out product of lead is a neurotoxin (Dart *et al.*, 2004; Needlemann, 2004) which slowly accumulates in living tissue and creates several health problems (Merill *et al.*, 2007). The other problem associated with lead is ingestion by marine mammals and birds (Carrier, 2012). Many times, lead sinker imitates with food items which is ingested by marine scheduled animal causes choking in the gastro-intestinal tract which further leads to death of the animal. There are several other types of sinkers used in fishing gear which are made of different materials, viz. concrete, cement, clay, stone, iron bars, iron chain etc (Fig. 1,2,3 and 4). These sinkers are used by fishermen, mainly in artisanal and small-scalesectors. Though these sinkers are cheap, and easy to fabricate and rig over the nets, the major disadvantage associated with these sinkers is strength. They are highly fragile and there is every chance to lose while operating. The bars and chain sinkers (tickler chains) made of iron are highly susceptible to corrosion (Tateda *et al.*, 2014).

With this background, there is a need to develop sinkers made of materials which can overcome these problems. In this regard, ICAR-CIFT has taken a study to develop eco-friendly sinkers for fishing gear. Initially, stainless steel was selected for developing sinkers for bottom trawls. These sinkers are having numerous advantages over the lead and conventional sinkers (Fig 5.). Marine grade stainless steel is rust-proof and also it does not leach to the marine environment. In this regard, it helps in preventing hazardous chemicals accumulating in the marine ecosystem. The strength of stainless steel is higher than the lead so while the operation of fishing nets, the chances of wear and tear are almost nil. There are some drawbacks associated with stainless steel sinkers. Among them, cost of production is the most important one. Due to its high melting point (1400-1450°C) the casting of the sinker is cumbersome and require an expensive facility which makes

higher cost of production. Though the unit price of stainless-steel sinkers is higher than the lead sinker, to make the marine environment cleaner and also to enhance the life of sinkers, stainless steel sinkers can be an alternative. Application of a strong coating on the surface of lead sinkers used in trawl is another possible method for preventing abrasion and leaching of lead. The Fishing Technology Division of ICAR-CIFT has also taken a study for the development of the best surface coating for lead sinkers.

Fig.1 and 2 *Sinkers made of concreate and stone*

Fig.3 *Sinkers made of Iron chain*

Fig.4 *Sinkers made of Lead*

Fig.5 *Prototype of stainless steel sinkers made for bottom trawls*

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The fate of used fishing nets and accessories: Field observation from Kerala

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Fishing gears and accessories are the important component of marine pollution which causes severe ecological and economic problems (Barnes *et al.*, 2009, Peng *et al.,* 2020). There is no clear estimation of the quantity of abandoned, lost or otherwise discarded fishing gears (ALDFG). Based on a rough estimate, globally 640,000 tonnes of ALDFG contribute to marine pollution every year (Macfadyen *et al.,* 2009). For the control of ALDFG, proper management measures are required. One of the reasons for increased pollution by the fishing gear is the poor waste management systems in the coastal region, where it ultimately dumbed. But in recent years, there are reports on the recycling and reuse of fishing nets from different parts of the world (Prajith and Parmar, 2018, GGGI).

In a recent field visit to Baypore harbour of Kozhikode, Kerala, operation of few scrap shops dedicated to the collection and reselling of used fishing nets, ropes and fishing accessories was noticed (Fig.1). A detailed discussion with the shop keepers indicated that used trawl nets (High-DensityPoly Ethylene - HDPE), and seine nets (nylon multifilament) are mainly taken by the sellers (Fig.2). Irrespective of the material, all the nets are collected for 30-40INR/Kg. In the case of polyethylene rope, good quality ropes are collected for 35-40 INR and the poor quality one is priced 8-10 INR.

Retail sale of the used net is mainly happening in the local market. Agriculture farmers from the nearby Districts, Wayanad and Malappuram are mainly procuring these nets to ward off wild animals which cause damage to agricultural crops. Depending on the area of the farmland, 5-50kg of nets are purchased by individual farmers. Besides agricultural use, the nets are used in poultry farms and aquaculture ponds. In poultry farms they use as fencing whereas in fish farms they serve as a barrier to protect fishes from aquatic birds and other predatory animals.

The bulk quantity is exported mainly to Gujarat and Maharashtra for recycling. There are some agents who collect the nets and ropes in bulk at a definite interval. Transportation of nets in bulk is done by means of the road (Fig.3). Sale and procurement of the net vary depending on the season. During off-season (Trawl ban period), the sale will be less compared the active season. A maximum of one ton of used gear materials per month is procured by the scarp shops in the active season.

Material recycling and chemical recycling are the two most efficient methods for the disposal of fishing nets (Kanehiro, 2004). In fishing nets and accessories, polyethylene and nylon are dominant groups subjected to material and chemical recycling. Using the discarded fishing materials for the production raw materials like nylon, substitution/partial replacement of material in construction works (Eg: road tarring), reshaping into decorative articles etc. are the some of the innovative options. Turning used fishing gears into raw material is not only good resource management, also a great win for the environment as the discarded equipment will not end up in the marine environment .

Fig.1 *One of the scrap shop at Baypore, Kozhikode , Kerala*

Fig.2 *View of used fishing nets and ropes made ready for sale*

Fig.3 *Loading of fishing nets for the transportation*

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Composition profile of shrimp waste collected from retail markets

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Shrimp waste, including the head and exoskeleton, is an important discard from local retail shops as well as from seafood processing industry. It has gained global interest from research as well as sustainability point of view (Mathew *et al.,* 2020). Currently, shrimp processing waste is utilized for the production of shrimp meal and chitin. As a country, India has a huge amount of shrimp discards, especially from seafood export industries which offer no difficulty in sourcing the raw material for secondary fish processing industries. ICAR-CIFT expand is actively working on various aspects of utilization of shrimp processing discards including process development, development of machinery and product innovation (Prabhu and Radhakrishnan, 1975; Joshy *et al.,* 2016; Renuka *et al.,* 2020).

This present report is on the proximate composition of shrimp discards collected from local fish retail shops. The waste collected comprises of head waste and cuticles. Thorax and cuticles were manually separated and excess moisture was removed using tissue paper. To obtain the shrimp head extract, the whole waste was ground in a household blender and squeezed by placing between two layers of cheese cloth. From the shrimp extract, the protein isolate was prepared by adjusting the pH to 4.5 followed by centrifugation to collect the pellet, referred as isolate. The proximate composition was analysed as described in AOAC (2019). Chitin content was calculated from alkali-insoluble nitrogen content using the factor value of 14.51(Díaz-Rojas *et al.,* 2006). Protein content was calculated after subtracting the chitin nitrogen and multiplying the value with the factor of 6.25.

The compositional data was generated parts wise which is essential as a baseline information for obtaining better insight into the process as well as product development. It is well established that the proximate composition is subjected to variation with reference to species, size, age, sex, feeding ground, body parts, biological stages, storage conditions, pre-treatments, state of raw material etc. Despite such variations, from the commercial point of view, making such data available for the use of stakeholders will open new innovative thinking and expand the uses of whole waste/parts for different purposes. Among the parts/products evaluated, the moisture content was high (more than 80%) in shrimp protein extract and followed by whole waste. The lowest moisture content was found in the thorax followed by the cuticle. This information will be much useful while designing the dryers and developing any preservation techniques. Adjusting the pH followed by centrifugation to obtain the shrimp pellet, reduces the moisture content from shrimp protein extract by 12%. Hence, such operation can be employed to reduce the volume of material, for further processing. However, one should be careful in assessing recovery of the protein from such biological fluid (supernatant).

Among the samples studied, the highest protein content was found in isolate (15.00%; w.b). The cuticle has got around 11% proteins. The whole waste had an average protein content of

5.6%. Generally, in retail shops, the wastes are kept along with wash water which is likely to increase the water holding of proteins resulting in lower protein content on the basis of unit mass. However, in the present study care was taken to drain the excess free flow water while collecting the samples. The whole shell waste contained average protein content of 6.80%. Protein recovery is an active area of research as it has many applications including in food, feed and agricultural industries.

Chitin content was found to be highest in the thorax followed by cuticle. The appendages also contribute to significant amount of chitin as revealed by the head sample prepared without thorax. The average chitin content in whole waste was 4.31%. The crude lipid was highest in protein isolate. This could be due to emulsification, interaction with protein molecules and entrapment while proteins form aggregates at iso electric pH (4.5). It should be mentioned that in the present study isolate was prepared by direct pH lowering without alkali solubilisation. In general, the shell fraction had very low lipid content and the least was recorded for cuticle.

Ash content was highest in the thorax (21%), followed by whole shell waste (14%). In the commercial conventional chitin process, HCl is employed to demineralize the chitin. The whole shell waste contained 4.54% ash. The processor should be careful in using the acid with reference to type, strength and volume depending on the type of raw material used. Fresh whole shell waste requires less acid, compared to soluble protein removed whole shell waste (thorax, cuticle and appendages). However, the interference of protein in demineralizing the whole waste as raw material cannot be ruled out. It may equalize a certain amount of HCl to make it unavailable for demineralization reaction.

The present report form a baseline information on shrimp waste which are used by stakeholders, researchers and students towards shrimp waste utilization, process innovation and product development.

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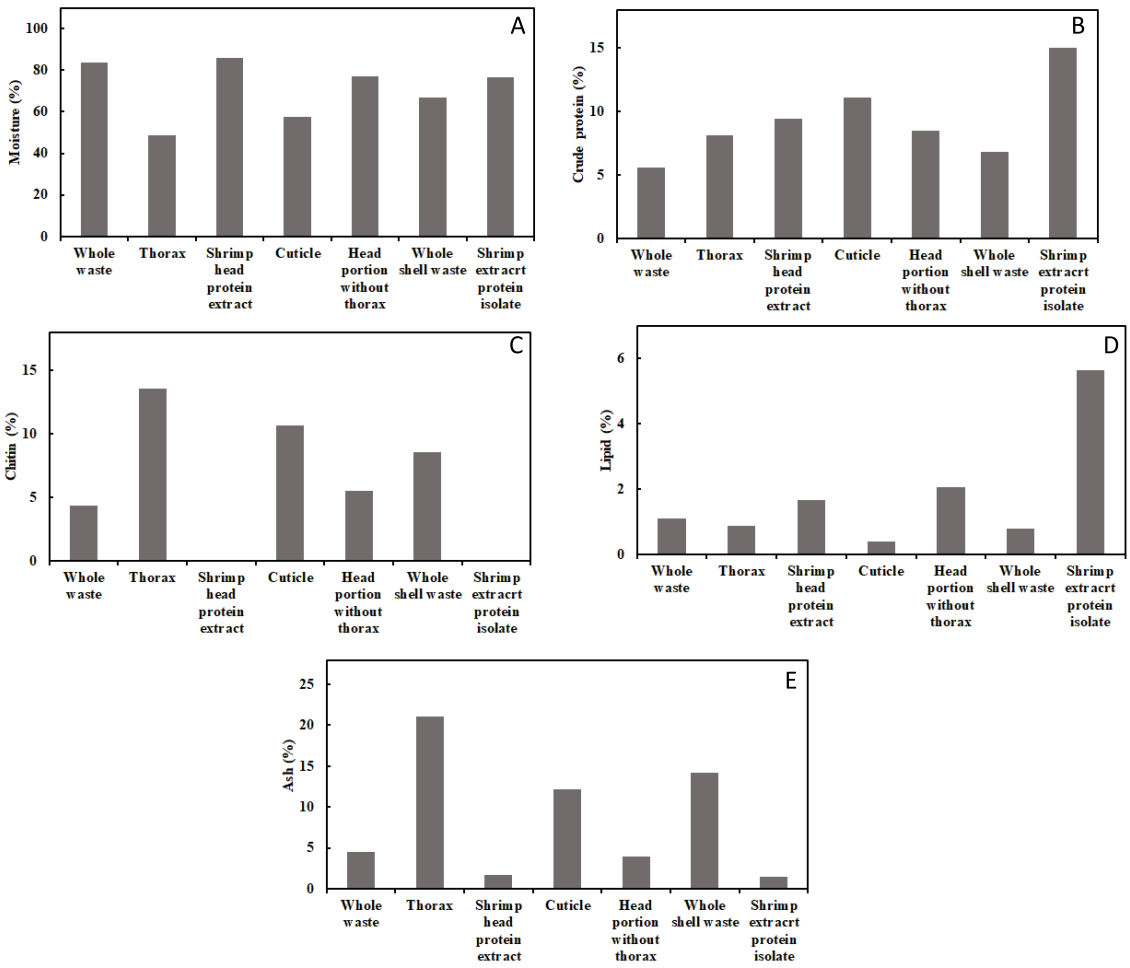

Fig.1 *Proximate profile of shrimp waste. (A) Moisture content; (B): Crude protein (%); (C): Crude Chitin (%); (D): Lipid; (E): Ash content (%)*

Fish protein isolate as an ingredient in pasta product

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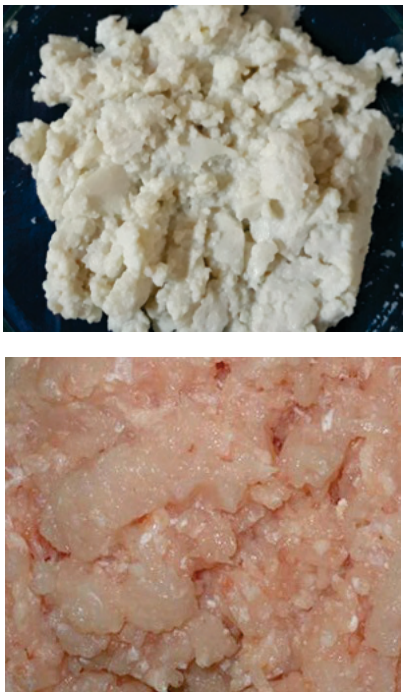
Fish protein is the cheapest among animal proteins. Though highly nutritious, it is one of the most perishable food items. Hence, the processing and preservation of fish play a major role in maintaining its quality. There is increasing consumer demand for high-quality, minimally processed, additive-free sea foods. Tilapia, *Oreochromis niloticus,* one of the emerging fresh-water species, is most productive and gaining commercial importance in the domestic as well as export market. Generally, it is in whole or steak form. Moreover, the development of mince-based products from tilapia is limited due to the presence of pin bones. Fish protein isolate (FPI) is prepared from fish meat and discards different kinds of raw materials by the pH-shift technology. Fish protein isolate is a concentrated source of complete muscle protein (i.e., myosin and actin). FPI can be used as an ingredient for the production of value-added and ready-to-eat products based on minced fish or surimi.

In the present study, fish protein isolate was prepared from Tilapia meat using alkali solubilization method and its impact on pasta products was evaluated. Briefly, proteins of the muscle tissue are first solubilized at alkali pH near 10.5 and centrifuged. Then, the top lipid layer and sedimentation (insoluble impurities such as bones and skin) at the bottom were discarded. The middle layer of protein solution is collected and precipitated by adjusting the pH to a value near the isoelectric point (5.5) Then it was centrifuged and the precipitate was collected as protein isolate (Kristinsson *et al.,* 2005) was used for preparation of pasta product after neutralization. Wheat flour and refined wheat flour was used as base material. Fish protein isolate was incorporated in to base mix at 5%, 10% and 15% concentration for pasta preparation. Pasta products prepared using pasta maker (Dolly, Italy). After the extrusion process, pasta was subjected to drying at 60°C for 2hr and packed. Pasta prepared without incorporation of fish protein isolate was kept as control. Biochemical and microbiological quality of fish pasta were evaluated up to 5 months.



Tilapia fish mince & Isolate

Tilapia

Fish protein Isolate incorporated pasta

Fresh Tilapia fish mince had 80.15 ± 0.15% moisture, 17.25 ± 0.20% protein, 0.65± 0.15% fat and 1.05 ± 0.02% fat. Isolate prepared from fish mince had 75.95% moisture, 17.73% protein 0.35 fat and 1.02%. Proximate composition and color value of pasta product is given in Table 1. Highest protein content (14.58%) and L* value (60.23±0.45) was observed for 15% FPI incorporated sample.

Table 1. *Proximate composition and color value of pasta product*

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	*L**	*a**	*b**
Control	9.75±0.25	10.55±0.10	0.35±0.01	0.94±0.02	44.5±0.50	0.07±0.01	11.04±0.40
5% FPI	10.13±0.15	12.79±0.25	0.35±0.03	1.02±0.03	56.76±0.45	-1.22±0.02	10.05±0.12
10% FPI	11.01±0.20	13.45±0.15	0.40±0.04	0.99±0.02	58.65±0.60	-1.34±0.05	8.08±0.25
15% FPI	11.25±0.15	14.58±0.32	0.40±0.02	0.98±0.02	60.23±0.45	-1.23±0.04	8.40±0.35

Biochemical analysis revealed that TVB-N, TBA values showed increased trend and were within the acceptable limit during storage. PV value reached 20.8% during third month in 15% FPI incorporated sample. Other sample had a PV values within the limit of 20meq.O_2/kg up to four month. Microbial quality revealed that total plate count in all sample was with in acceptable level (5log cfu/g) for four month of storage. Sensory analysis revealed that incorporation of fish protein isolate up to 10% was comparable with control.

It can be concluded that fish protein isolate can be utilized for development of protein rich value-added product. Storage stability study of pasta stored at ambient conditions revealed its shelf stability up to four months without any quality loss.

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FISHQCheQ –A Demerit Score-Based Mobile Application to Assess the Quality of Fish

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Fish is an important food item that ensures both food and nutritional security of the fish-eating population, but at the same time fish is considered a highly perishable commodity. The biochemical and biological changes that happen during different storage conditions affect the quality of the fish (Ashie *et al.,* 1996). Apparently, these changes directly affect the sensory characteristic of the fish before it reaches the consumer. Consumers do a primary assessment of the quality of fish on a certain tangible/sensory quality parameter before purchasing fish. The most commonly used method to assess the quality of fish is the quality index method (QIM) (Dalgaard, 2000). Joshy *et al.,* (2020) discussed the short comings of the commonly used QIM method and proposed a modified computational method to assess the quality of fish. The modified fish quality index (FQI) was ranged from 0 to 1, where FQI value of 0 indicates the quality of fish is excellent and 1 indicates the quality of fish is worse.

Now, the question was how to make the available modified FQI system to the consumer orend-user to assess the quality of fish. India is promptly progressing towards the digital India platform and half of the total population will have internet access by 2023 (https://digitalindia.gov.in, 2020). This brought an idea to bring the new FQI system to a digital platform mode so that the consumer/end user can access the system. By keeping this in view, FISHQCheQ - a mobile app-based system was designed and developed to assess the quality of fish. The system was designed using the computer language hypertext markup language (HTML) and a computational algorithm was developed in JavaScript. The designed system for both mobile and web applications, the same can access through mobile phones as it is responsive to different types of screens. The internet of things (IoT) plays an important role in accessing the system and assessing the quality of fish using the system. The user can get access to the system through the internet, which will communicate to the server and back to the user.

The home page of the mobile application contains three components viz: FQI home page, Instructions for FQI and Assessment of FQI (Fig. 1).

Fig.1 *Home page of FISHQCheQ*

A part of the FISHQCheQ provides instructions on performing the quality assessment of fish and the user can read to understand the procedure. Another important part of FISHQCheQ is the FQI page, where the user has to select the available demerit score as input for each quality attribute based on the quality evaluation of the fish. If any quality attribute was found to be irrelevant for a particular species of fish, the users always have to select 0 from the demerit score. Finally, the users have to click on 'compute FQI', then the system will communicate to the server through the internet ,then compute the FQI on the demerit score selected by the user and communicate back. The FQI score will have a quality description based on the score like fish quality is 'excellent', 'very good', 'good', 'moderate', 'moderate to bad' and 'bad to worse'. The user can take this as an indicator on quality of fish and decide whether to buy or not to buy fish.

The mobile application 'FISHQCHEQ' is available in the following link of google play store (Fig.1). https://play.google.com/store/apps/details?id=com.cift.fishqcheq

Fig.2 *The icon of FISHQCheQ in google play store*

The link for the web application of the same is available in the institute website https://www.cift.res.in/. The advantage of the system is that it is available in the fingertips of the user with an active internet service provider and overcomes the drawback of offline quality assessment of usual QIM methods. Ultimately, the system helps the consumers not to compromise on their need of quality fish.

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A mechanical deproteinization system for the chitin production line

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India exported around 590275 Mt of frozen shrimp in the fiscal year 2020-2021 (MPEDA,2021) and peeled shrimp (deveined and undeveined) formed the major part. During pre-processing operations of shrimp/prawn, about 60 per cent material handled is generated as shell/head discards. Prawn shell contains protein, minerals and chitin as the major constituents. A portion of these discards is utilised for making chitin which has a lot of industrial applications.

The conventional method of chitin extraction primarily involves deprotei-nization and demineralisation processes. Deproteinization is chemically achieved using 3 % sodium hydroxide and deminera-lisation by dilute hydrochloric acid. The separated protein solution and mineral solution are normally mixed together for neutralisation and settling, and the aqueous portion is sent to the treatment unit.

ICAR-CFT has developed a machine for separating the protein by mechanical means after repeated trials. The unit can effectively remove the protein as a thick slurry. The machine is attached with a 2hp motor and has a capacity of 100 kg per hour for separating protein. This machine can be upscaled as per the requirement of the industry.

The protein slurry separated is found to be about 42-50 % of the total weight of the shell, which may vary according to species. The volume of the shell after processing has also reduced to 40 percent of the actual volume, which inturn reduces the transportation cost of the shell material to the chitin manufacturing units. *The compositional analysis of protein liquor separated has indicated 80 % moisture, 10 % protein, 3 % fat and 2-3 % ash.*

Uniqueness of the technology

This process is relatively a clean process, i.e. almost all waste produced are recycled off-site. The use of chemicals at each stage of extraction and the organic load in the effluent line is considerably reduced. The NaOH used in the deacetylation step can be reused in the initial deproteinization of shell after dilution. Astaxanthin, a carotenoid pigment found in shrimp shells is recovered from the press liquor. This pigment is very valuable mainly in the medical field and hence has high sale value. Astaxanthin has also got immense potential as an animal and aquafeed supplement. The carotenoprotein-rich slurry separated during the process is a good source of protein. Apart from that, the slurry serves as a good source of nitrogen and can be best utilized for foliar spray and manure production.

The process of separation of protein before the chemical extraction has multiple advantages.

- The volume of shells handled can be reduced, which enables handling and processing of more quantity in the given time.
- The quantity of alkali used for deproteinization can be reduced considerably resulting in the reduction of the process cost.
- Because of the use of the reduced quantity of alkali, the quality of both chitin and chitosan is far better than the normal chitin.
- This process enhances the quality of discharge effluent water since most of the protein and pigments are removed during the initial separation itself.
- The spent acid after demineralisation process can be reused after enhancing the concentration, resulting in reduced water use.

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MPEDA,(2021) Annual Report 2021, The Marine Products Export Development Authority, Kochi, 323p.

Evaluating the pressure of agrochemicals on the health and safety of polder-based aquaculture in Kuttanad, Southwest coast of India

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Kuttanad is an agriculturally unique ecosystem that is composed of the southern part of internationally important Ramsar site-Vembanad wetland ecosystem (location no. 1214) in Kerala, lying 0.6 to 2.2 m beneath the mean sea level in the South-west India. It is one of the three Globally Important Agricultural Heritage Systems (GIAHS) in India. More than two-third of the total land area of Kuttanad is used for paddy cultivation (Swaminathan, 2007). However, the high cost of production and low profit severely diminished thepaddy cultivation in Kuttanad leaving the polders fallow (Thomas, 2002).

One paddy–one prawn farming system (Fig. 1) turned out to bea feasible solution to support the heavily indebted farmers. The culture of scampi (*Macrobrachiumr osenbergii*) alternating with rice came out with an economically appealing production of 70 to 500 kg/ha of scampi with aprofit of Rs. 5,000 to 20,000/ha (Kurup & Ranjeet, 2002). However, the scampi population in the Vembanad lake and its confluent rivers (Kerala, India), have abated drastically in recent years due to human interventions in the ecosystem. Toxicity induced by pesticides used in the paddy fields is one of the major factors contributing to the threats posed against scampi.

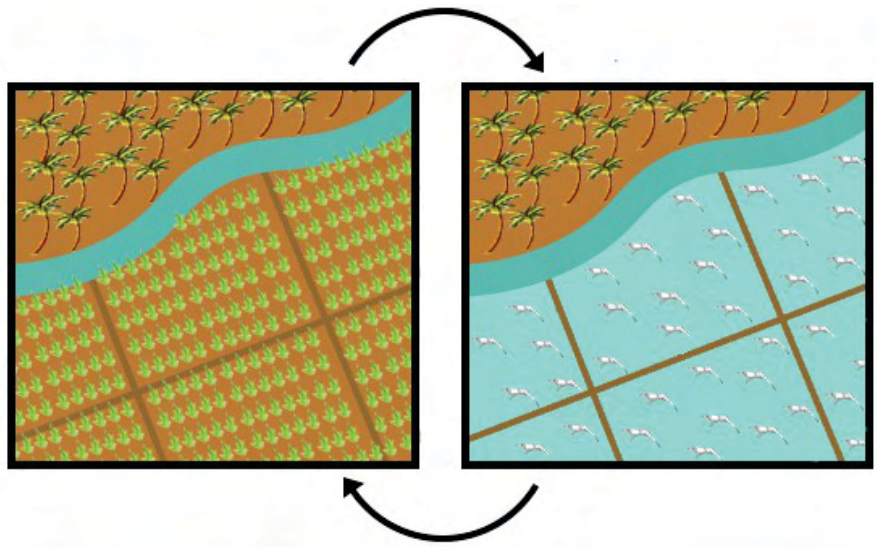

Fig.1 *One paddy–one prawn farming system*

The closure of Thanneermukkam bund has permanently obstructed the natural flow of water that washed off the pesticides used in the paddy fields, resulting in its accumulation and increased acidity of the soil, contrarily influencing rotational farming practices of paddy and prawn in Kuttanad (Lakshmi, 2018). Chlorpyrifos, hexaconazole and imidacloprid are pesticides commonly used in the paddy fields of Kuttanad. The leaching potential and persistence of pesticides, viz. chlorpyrifos, hexaconazole and imidacloprid were evaluated by the method of Aslam *et al.*(2015). The results revealed that imidacloprid has the highest leaching potential and persistence followed by Hexa conazole and Chlorpyrifos (Fig. 2).

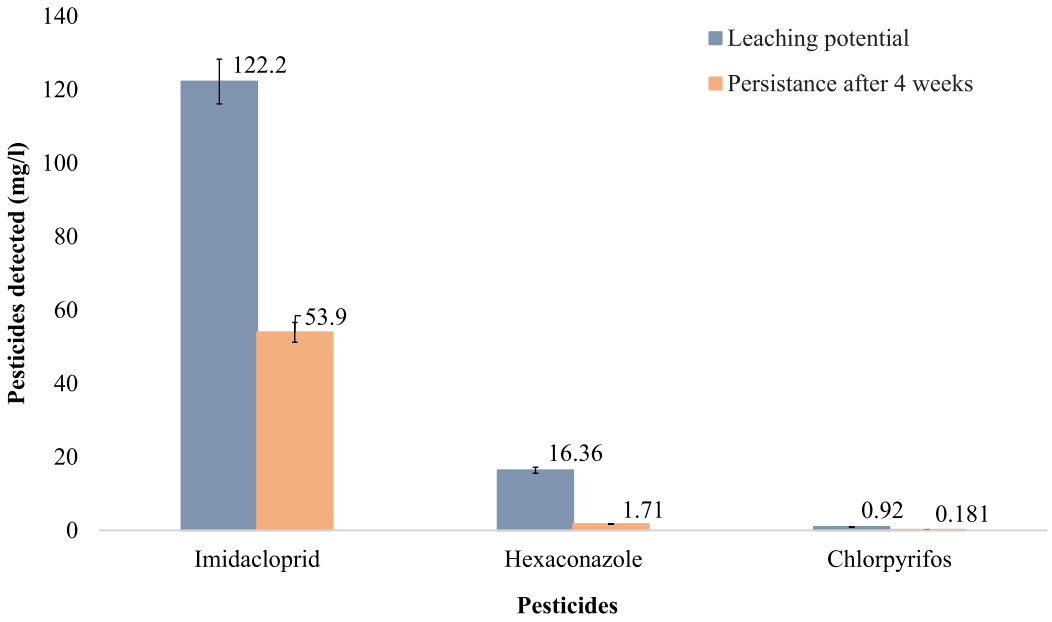

Fig.2 *Leaching potential and persistence of pesticides in water 4 weeks after application.*

Imidacloprid (Fig. 3) is one of the potentneo-nicotinoid insecticides used against sucking pests in the paddy fields of Kuttanad. It is found to cause adverse effects in a wide range of non-targeted organisms, especially *M.rosenbergii* once the most valuable export species of Kerala. Hence, it is important to investigate the toxicity of imidacloprid in *M.rosenbergii.* Acute toxicity study of imidacloprid in postlarvae of *M.rosenbergii* was carried out based on the manual of the Environmental Protection Agency USA (Peltier and Weber, 1985). The24, 48, 72 and 96 h LC_{50} values were determined using SPSS version 16.0 (Finney, 1952 which ranged between 0.009 – 0.046 mg/l (Fig. 4).

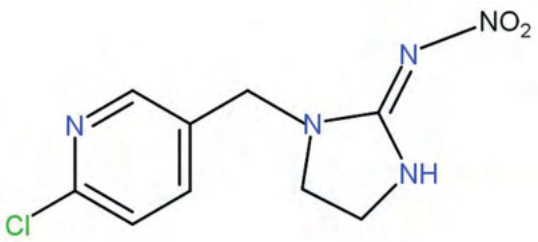

Fig.3 *Structure of imidacloprid*

Lake reclamation, over fishing, migratory barriers and habitat destruction are the other factors contributing to the alarming stock reduction of this species. These ecological alterations also resulted in diminished freshwater prawn culture in this area. As a solution to this problem, the Department of Fisheries, Government of Kerala has implemented a scheme 'Social Fishery' by which reared hatchery-reared seeds (post larvae) of *M.rosenbergii* are ranched in the lakes and confluent rivers ata large scale for stock replenishment. Still, this scheme becomes less effective as the field application concentration of imidacloprid (0.003mg/l) is higher than the safe concentration (0.002mg/l) determined for post larvae of *M.rosenbergii*. Hence, the investigators of the present study suggest to reduce the use of imidacloprid in the paddy fields of Kuttanad, promote bio safe pest management practices and to restrict the fishery of *M.rosenbergii* until its revival to avoid complete devastation of the species in its homeland.

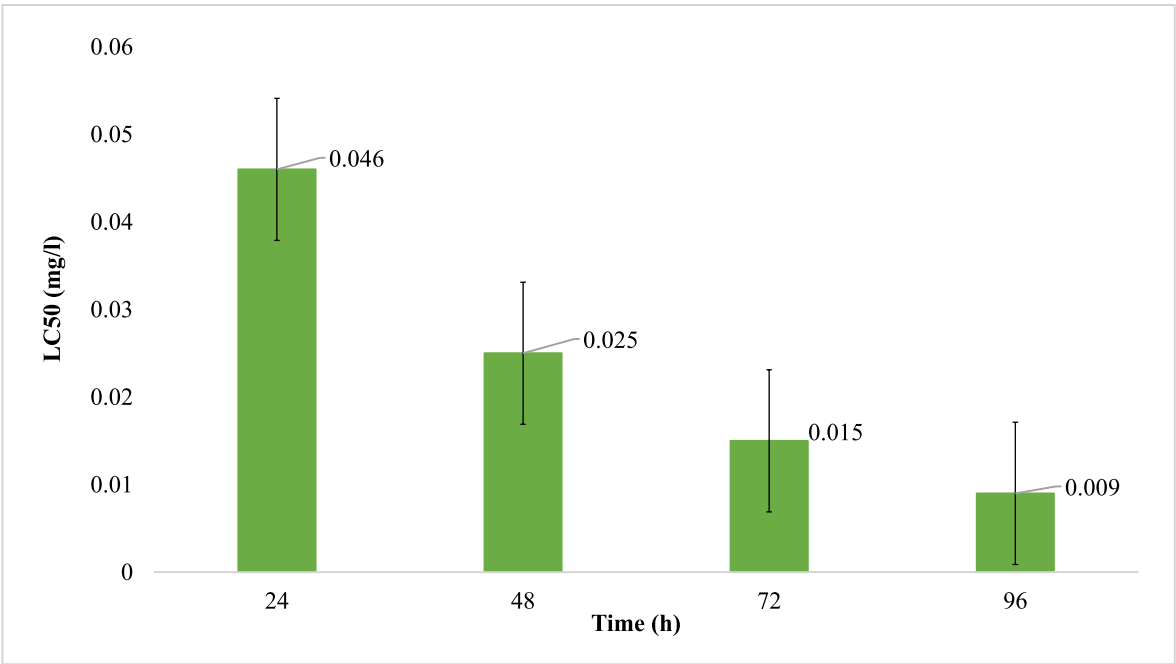

Fig.4 *Acute toxicity (24, 48, 72, 96 h LC_{50} values) of imidacloprid in postlarvae of M. rosenbergii.*

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Epidermal mucus from Nile Tilapia (*Oreochromis niloticus Linnaeus, 1758*)

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Fish are known for their ect other micadaptation which regulate their body temperature with respect to the environment. Fish can change their body temperature in accordance with the change in temperature of the water surrounding them. They intake oxygen from water using gills or employ accessory organs to inhale atmospheric oxygen. Fish encounters several pathogenic organisms from its surrounding water body. Hence they possess several defence mechanisms to defend themselves. Skin mucus present on its body plays a major role as a primary defence barrier against pathogenic infection. The mucus is present as an incessant lining, covering its body and body openings, also covering the fins. It is known that the antimicrobial agents present in the fish mucus help in the defence mechanism. Mucus on the fish body always coexist with the scales where in it completely controls the movement of the water into and out of the body. It helps to reduce the drag while the fish swims. Consequently, aids in maintaining a stable atmosphere inside the fish. Mucus contain several compounds such as transfer in, creative protein, lysozyme and antimicrobial proteins etc which are having specific functions. The antimicrobial property exhibited by fish mucus is due to the shielding property of the peptides against pathogens. Production of mucus is stirred by various factors, including microbial exposure, stress, water temperature, pH. It varies between the species, and the rate of microbial incidents. This can in turn effect the mucus production, level of proteins and immune molecules present in the mucus.

Studies on fish mucus have improved over the years and had led to the discovery of various bioactive compounds. These bioactive compounds have a variety of applications in human medicine and aquaculture - related activities. The extraction and characterization of immunity-associated molecules and AMPs have been carried out from fish mucus. Also, the studies pertaining to the fish mucus and their ecological role in the environment were also reported. Hence, the study on mucus aids in the primary detection of infections and examines the contact of environmental pollutants on probe health. This communication reports on the biochemical properties of fish mucus from the farm-reared Nile Tilapia.

The live tilapia were collected directly from a nearby farm. Mucus collection was carried out in accordance with Chong *et al.* (2005) & Ebran *et al.* (1999), with minor modifications. Briefly, skin mucus was collected through gentle scrapping of the dorsal-lateral part of the body of the fish using clean glass slides into the clean and sterilized petri plates. This stimulated the fish to create fresh mucus layer which was further collected. The mucus was not collected from the ventral portion in order to avoid intestinal and spermial contamination. The mucus thus collected was centrifuged at 13,000 x g for 20 min at 4°C. The resultant supernatant was collected, freeze-dried immediately and stored until further analysis.

Fig.1 *Collection of mucus from Nile tilapia*

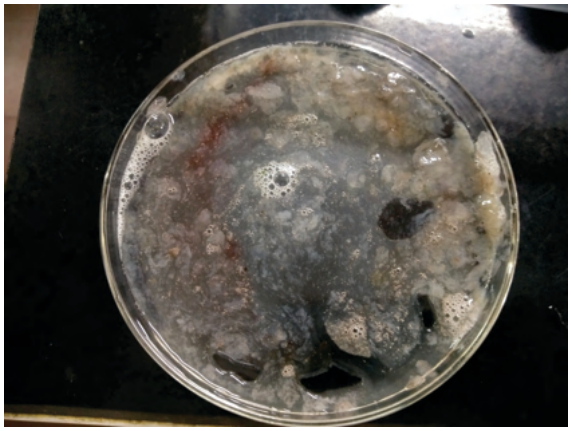

Fig.2 *Extracted mucus*

The biochemical characterisation revealed the presence of protein (206.31± 1.16 ug/ml)), carbohydrates (49.65 ± 0.86ug/ml) and lipids (3.4 ± 0.23 mg/ml). Further characterization is in progress.

Protein (µg/ml)	206.31± 1.16
Carbohydrates (µg/ml)	49.65 ± 0.86
Lipids (mg/ml)	3.4 ± 0.23

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Extended-Spectrum Beta-Iactamase (ESBL) genotypes among *Escherichia coli* and *Klebsiella pneumoniae* isolates recovered from shrimp aquaculture farms

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In recent years, aquaculture has gained much attention as an environmental gateway to the development and spread of antimicrobial resistance (AMR); however, studies pertaining to AMR in aquaculture are scanty from India. The prevalence and molecular features of extended-spectrum beta-lactamase (ESBL)-producing *E. coli* and *K. pneumoniae* recovered from shrimp aquaculture farms in Kerala are addressed in this communication. ESBLs are enzymes capable of hydrolyzing oxymino-cephalosporins and monobactam antimicrobials and are generally found in Enterobacteriaceae and *Pseudomonas aeruginosa*. ESBL renders penicillins, first-, second- and third-generation cephalosporins, and aztreonam ineffective. Apart from their widespread occurrence in clinical settings, ESBL-producing bacteria are increasingly being reported in livestock, companion animals and various environmental settings (Hordijk *et al.,* 2019; Toombs-Ruane *et al.,* 2020).

In the present study, a total of 261 samples comprising shrimp (n=77), water (n=92) and sediment (n=92), collected from shrimp aquaculture farms (n=37) in Kodungallur and Thuravoor- two major shrimp farming zones in Kerala were screened for the presence of ESBL-*E. coli* and *K. pneumoniae* (Sivaraman *et al.,* 2021). Briefly, samples (10 ml of water; 10 g each of sediment and shrimp) were incubated in 90 ml of EE broth Mossel (BD Difco, pH 7.2) overnight at 37 °C, and a loopful of the enriched culture was streaked onto MacConkey agar plates supplemented with 1 µg/ml cefotaxime (Sigma Aldrich, USA) and incubated for 18-24 h at 37 °C. Bacterial identification and susceptibility testing were performed using BD Phoenix™ M50 automated system (BD Diagnostics, USA), with the ID-AST combo panel, NMIC/ID55. A total of 32 and 15 isolates were identified as ESBL-producing *E. coli* and *K. pneumoniae*, respectively. All of them were cefotaxime-resistant with minimal inhibitory concentration (MIC) ≥32 µg/ml. The percentage of resistance among the *E. coli* isolates towards other antibiotics was as follows: tetracycline (40.6%), trimethoprim-sulfamethoxazole (34.4%), ciprofloxacin & levofloxacin (34.4%), chloramphenicol & gentamicin (6.3%). Among the isolates of *K. pneumoniae,* 13 (86.7%) showed simultaneous resistance to tetracycline, ciprofloxacin and trimethoprim/sulfamethoxazole. Based on

phenotypic resistance patterns, PCRs were performed to identify various ESBL genes and other resistance determinants among the isolates. This included detection of genes conferring resistance to cephems ($bla_{CTX-M,}$ $bla_{TEM,}$$bla_{SHV}$), tetracycline (tetA and tetB), chloramphenicol (cmlA and catA), fluoroquinolones (qnrA, qnrB, qnrS, qepA, oqxA, oqxB and aac (6')-Ib-cr), aminoglycosides (aadA1, strA and strB) and sulfonamides (sul1 and sul2). Among the ESBL-genes screened CTX-M group 1 ($bla_{CTX-M-15}$) was found to be the predominant type, with 23 *E. coli* (71.9%) and 15 *K. pneumoniae* (100%) isolates testing positive for the same. CTX-M group 9 was detected in 9 (28.1%) isolates of *E. coli,* but not in any of the *K. pneumoniae* isolates. Concerning TEM and SHV-type ESBL determinants, 11 isolates (73.3%) of *K. pneumoniae* harboured both types. CTX-M-15, reported for the first time in India in 2011, has now become a widespread ESBL genotype and has been reported in humans, livestock and fishes (Palmeira and Ferreira, 2020). Screening for other AMR genes identified tetA & tetB (13, 40.6%), sul1 (11, 34.4%), sul2 (9, 28.1%), catA & cmlA (11, 34.4%), qepA & aac (6')-Ib-cr (9, 28.1%) and strAB & aadA1 (2, 6.3%) in *E. coli*; and qnrB (13, 86.7%), qnrS (3, 20%), oqxB (13, 86.7%), tetA (13, 86.7%) and sul2 (13, 86.7%) in *K. pneumoniae* isolates.

The plasmid incompatibility (InC) types present in the isolates were also analysed in the study using the PCR-based replicon typing (PBRT) as described by Carattoli *et al.* (2005). This revealed the predominance of IncFIA & IncFIB plasmids in *E. coli*; however, in *K. pneumoniae,* the major replicon type detected was IncHI1 (Figure 1). It has been shown previously that resistance genes harboured on the narrow host range. IncF-type plasmids in Enterobacteriaceae spread readily in *E. coli* (Mathers *et al.,* 2015). Moreover, IncF plasmids carrying $bla_{CTX-M-15}$ have been reported in Enterobacteriaceae isolated from clinical, environmental and livestock settings (Zurfluh *et al.*, 2015). This perhaps indicates the role of IncF plasmids in disseminating CTX-M-15 across different settings. IncHI1, the plasmid type found in the *K. pneumoniae* isolates from our study, has a broad host range and has been reported in various environmental Gram-negative species (Villa *et al.,* 2012).

The distribution of phylogroups (A, B1, B2, C, D, E, F and cryptic clade) among the ESBL-producing *E. coli* isolates were analyzed using the PCR method described by Clermont et al. (2013). Phylogenetic groups identified among *E. coli* isolates included B1 (4, 12.5%), B2 (6, 18.8%), C (10, 31.3%), D (3, 9.4%) and E (9, 28.1%). This is a worrisome information from the public health point of view as most of the virulent extra-intestinal strains of *E. coli* are primarily from group B2 and to a lesser extent from group D. Also, it is noteworthy that CTX-M-15-producing isolates from this study were spread over different phylogroups viz., B1, B2, C, D and E, whereas all CTX-M-group 9 isolates belonged to phylo-group C.

In summary, there are the multidrug-resistant isolates of ESBL-producing *E. coli* and *K. pneumoniae,* with resistance mainly towards cephalosporins, fluoroquinolones, tetracycline and trimethoprim-sulfamethoxazole drugs, in samples from various shrimp aquaculture farms in Kerala. To the best of knowledge, this study provides the first data on the molecular features of ESBL-producing isolates prevailing in shrimp aquaculture settings of this region. In the investigated isolates of *E. coli* and *K. pneumoniae,* bla_{CTX-M} was found to be the predominant ESBL genotype. This, along with a high prevalence of tet, suland various plasmid-mediated quinolone resistance genes may be a public health concern. The findings of our study shed light on the importance of monitoring aquaculture settings for the possible emergence of antibiotic-resistant bacteria.

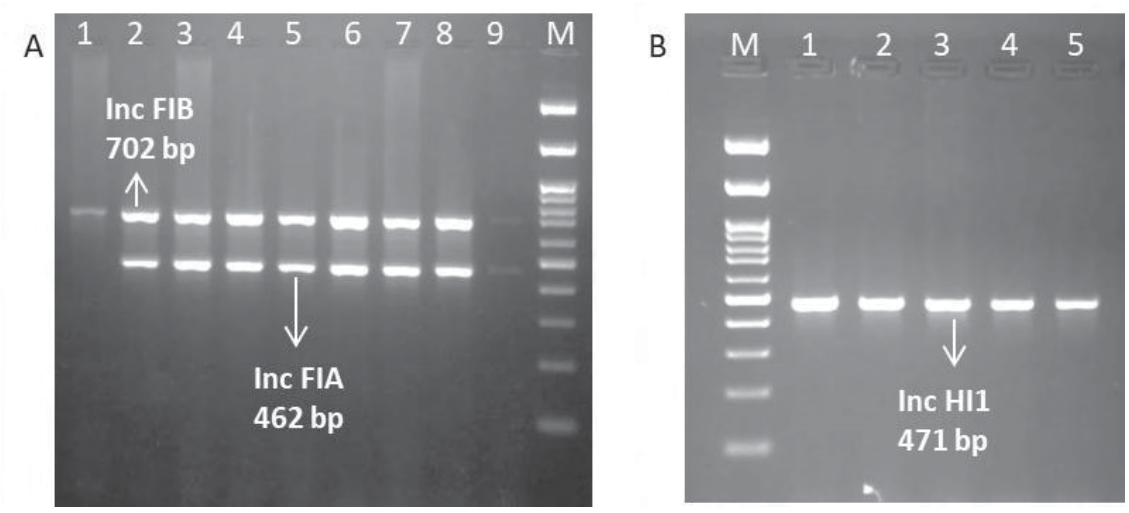

Fig.1 *Gel image showing the amplicons of (A) IncFIA / FIB type plasmids in E. coli and (B) IncHI1 type plasmid in K. pneumoniae.*

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Tilapia lake virus infection in fingerlings of tilapia, Kerala

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Globally, tilapia (*Oreochromis* spp.) has occupied the second position as a species of importance in the aquaculture trade. Tilapia contributes to the nutritional security of the economically low-income group. The first incidence of tilapia lake virus (TiLV) infection was documented in Israel during 2013 and subsequently in Ecuador (Eyngor *et al.*, 2014; Ferguson *et al.*, 2014). Later the disease was reported in many parts of the world and caused substantial economic loss to tilapia fish farming. The incidence of TiLV in India was reported in 2018 (Behera *et al.*, 2018).The mortality due to the virus varies between 20 to 80% and TiLV has emerged as a major viral pathogen that causes serious risk to the tilapia industry. TiLV is a negative-sense, single-stranded RNA virus. TiLV has been identified as the causative agent in diseased tilapia in the continents of Asia, America, and Africa. TiLV-related fish deaths have been reported in wild tilapia (*Sarotherodon galilaeus*),x farmed tilapia (*Oreochromis niloticus*), and commercial hybrid tilapia (*O. niloticus* X *O. aureus*) (Ferguson *et al.*, 2014; Eyngor *et al.*, 2014; Bacharach *et al.*, 2016). They can infect tilapia including fingerlings and adults. Mortality was mostly reported in tilapia fingerlings. The disease gets transferred within ponds and between ponds and both horizontal and vertical transmission has been documented (Eyngor *et al.*, 2014;Yamkasem *et al.*, 2019). Clinical presentations associated with TiLV infections can vary between regions (Jansen *et al.*, 2019).Clinical signs include lethargy, ocular alterations, skin erosions, discolorations and abnormal behavior.

In this report, TiLV infection from a fin fish farm in Kerala is reported. In the month of June, 2020, Tilapia fingerlings were brought to ICAR-Central Institute of Fisheries Technology, Cochin laboratory to check the quality of seeds (Fig 1). The gills, liver and kidney from individual fish were pooled together and Trizol reagent was used to extract RNA from the samples. RevertAidH minus first strand cDNA synthesis kit was used to synthesize cDNA from the extracted RNA (Thermo scientific, USA).

Fig.1 *Seeds tested with TiLV*

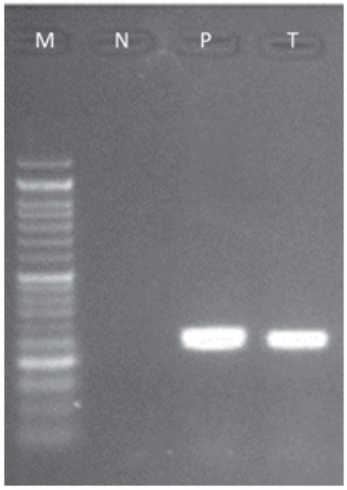

Fig.2 *PCR picture showing TiLV positive tissue (Lane M: DNA Ladder, Lane N: Negative Control, Lane P: Positive control. Lane T- seed sample)*

PCR was carried out using the cDNA of the 8 samples using TiLV ME1 and TiLV ME2 primers as described by Eyngor *et al*. (2014). All the positive PCR products were subjected to DNA sequencing analysis and the sequences showed 100% similarity to TiLV sequences. Based on this study it is recommended that the broodstock of tilapia used for breeding and tilapia seeds used for culture have to be screened for the presence of TiLV for the control of TiLV infection.

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Epizootic Ulcerative Syndrome in genetically improved farmed tilapia- A case report

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Epizootic Ulcerative Syndrome (EUS) is an epizootic infection caused by *Aphanomyces invadans* or *A. piscicida*. *Aphanomyces invadans* and *A. piscicida* are oomycetes which affects wild, farmed, fresh water and brackish water fish (OIE, 2022). EUS causes lesions due to the localization of the pathogens under the scales of fish, causing haemorrhagic spots and protruding scales with bloody areas underneath the scales. The spores initially damage the skin and germinate to produce hyphal filaments. The skin invaded by infiltrating hyphae finally enters the underlying muscular tissues, causing severe ulceration and tissue loss (Kamilya and Baruah, 2014). More than 50 fish species are affected by EUS, however, important varieties such as tilapia, milkfish, and carp have been shown to be resistant. EUS was first recorded as an outbreak in Japan in the 1970s (Egusa and Masuda, 1971). EUS was first documented in India in 1989 (Mohan and Shankar,1994).

In this report, two cases of EUS infection were reported in Kerala. Both the infection occurred in Genetically Improved Farmed Tilapia (GIFT) (Fig.1), one during the month of Dec 2019 from an aquaculture farm in Kothamangalam, Ernakulam and another during the month of November 2020 in an aquaculture farm in Alappuzha. In both cases, the water quality parameters viz., pH, dissolved oxygen, salinity, nitrite and nitrate were determined. In farm 1, fishes had haemorrhagic lesions on the surface of the body. Examination of internal organs revealed cotton wool appearance over the kidney region. In farm 2, the external body surface was observed with bloody mucilage, rotten fins and gill necrosis. Nitrate and nitrite levels were 40 mg/l and 1 mg/l respectively for farm 1. The nitrate and nitrite levels of the other farm were within the limits.

Samples such as haemorrhagic lesions on the skin surface, gills, kidney and liver were collected from the infected fish. DNA and RNA were extracted from the tissues and analysed by PCR/RT-PCR for the economically important pathogens as described by OIE. In both farms, EUS was confirmed based on the amplification of a specific amplicon (550 bp) by PCR. In farm 2, additionally *Aeromonas* sp. were also isolated from the skin lesions. None of the other pathogens screened could be detected. Although complete elimination of EUS causing *A. invadans* in finfish aquaculture is very difficult, the infections can be controlled effectively by increasing the salinity of farm water to 2 ppt in the water and treating the water with disinfectants before the release of seeds in farms affected with EUS.

Fig.1 *Haemorrhagic lesions on body of GIFT Tilapia*

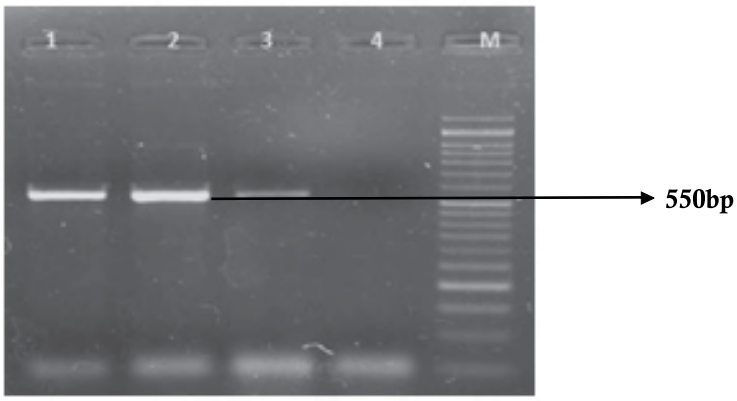

Fig.2 *PCR amplification for detection of A.invadans*
(Lane1 and 2: *Test sample 1 and 2;*
Lane 3: *Positive control plasmid;*
Lane 4: *Negative Control; M: Molecular Weight marker)*

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Revenue Based Fishing Capacity Estimation of Trawl Fishery - An Economic Approach

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The problem of overcapacity in fisheries is common and rebalancing the fishing pressure on available fish stocks is the challenging task at the global level. FAO (1998) highlighted that effective fishing capacity management is a major concern both at national and international levels. It has also been specified clearly that every country should develop a national level fisheries management plan including assessment of domestic fishing capacity and introduce measures to prevent or eliminate excess fishing capacity. Accordingly, initiatives were taken to assess the fishing capacity in the countries such as USA, Europe, China etc. and India has started the same in the slow pace.

In physical terms, capacity is defined as "the maximum output that can be produced per unit of time from existing plant and equipment and unrestricted availability of variable inputs". In economic means, capacity is "the maximum revenue attainable for the given fixed inputs using relevant outputs and output prices". The common methods used to estimate fishing capacity are Peak-To-Peak Analysis (PTPA), Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA).Of which, Peak-To-Peak Analysis and Data Envelopment Analysis are the two methods that are recommended by the FAO Technical Working Group on the Management of Fishing Capacity as the practical methods of measuring fishing capacity. Among this, DEA is a popular tool used extensively for the estimation of fishing capacity.

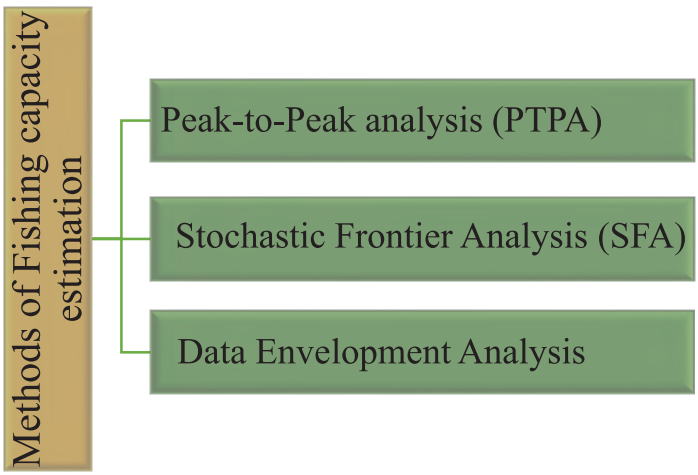


Fig.1 *Various methods of fishing capacity estimation*

Estimation of fishing capacity is mainly confined to industrial fisheries where there is likelihood of imposing control on fishing capacity. But, in semi-industrial fisheries it is very complex due to lot of uncertainties. This study aims the revenue-based fishing capacity with the help of both physical and economic indicators using data envelopment analysis.

Generally, fishing capacity estimation is limited to physical indicators viz., Gross Tonnage or Horse power towards estimating the fishing effort and the earlier studies on these aspects are on physical indicators rather on economic indicators. Generally, the number of fishing vessels, size of fishing vessel, technical efficiency of vessel operation and potential fishing time of each vessel at a specified period of time are the four components of fishing capacity which is also stated as fleet capacity. In practice, due to scarcity of data, economic capacity analysis is seriously considered in fisheries context (Herrero and Pascoe, 2003).

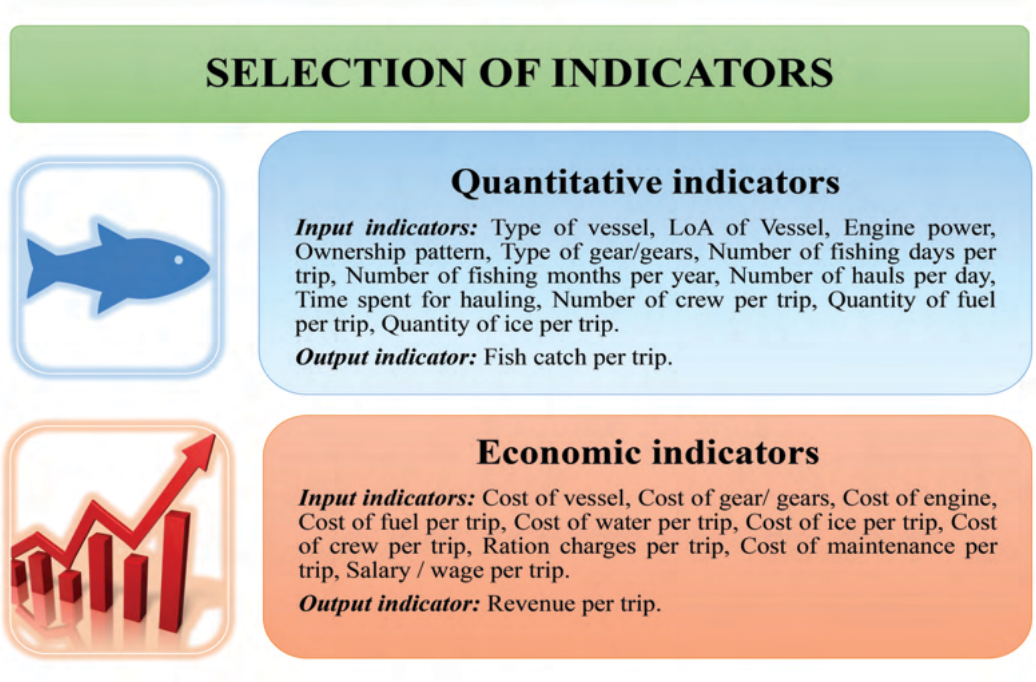
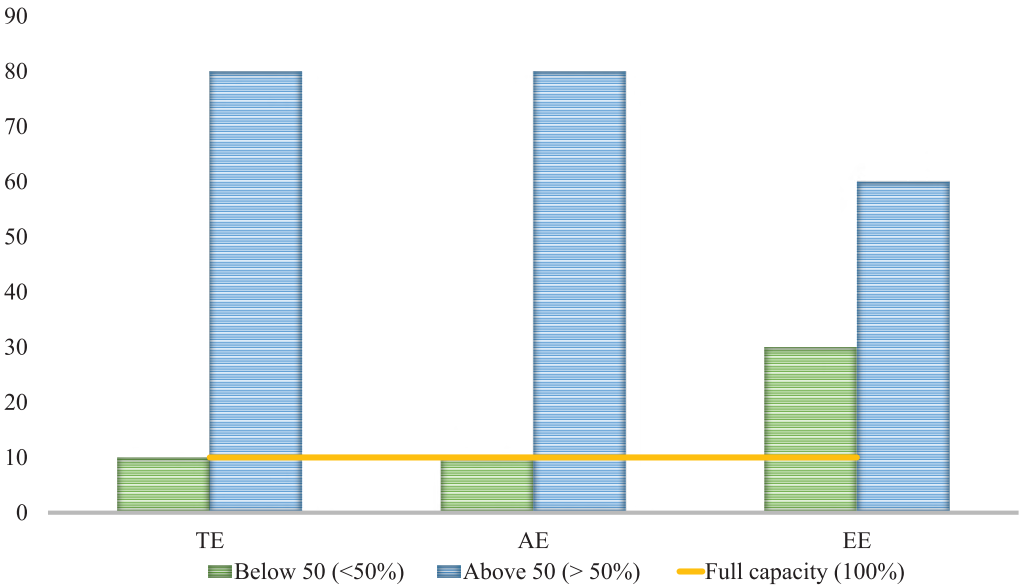


Fig.2 *Quantitative and economic indicators of DEA*

The trawl fishery with LoA ranged between 15 to 25 metre and were categorized into small, medium and large trawlers for the purpose of the study. The study reveals that the mean capacity utilized by the trawlers (16.5-22.5m) was 0.72 and 0.53 by using physical (quantitative) and economic indicators respectively. This showed that there are scope for increasing the technical efficiency of the trawlers by 28 percent. The Economic efficiency of trawlers was 0.53 implied that certain vessels which are operating at high technical efficiency are showing low economic efficiency.



TE – Technical Efficiency; AE – Allocative Efficiency; EE – Economic Efficiency

Fig.3 *Revenue-based capacity of trawl fishery*

The comparison of Technical Efficiency (TE) and Economic efficiency (EE) revealed that there were 80 per cent of fishing vessels operated with more than 50% efficiency levels. While the same under economic efficiency was only 60%. Besides, it was revealed that 21.15 and 24.58 per cent of trawlers operating with full efficiency were not proportionate with the economic efficiency levels.

Increase in fishing capacity is the resultant of combination of factors viz., increases in number of vessels, improvement in efficiency and expansion of effort. As fish resources are finite and limited in size, indiscriminate exploitation resulted in biological, social and economic consequences. Several measures/ initiatives had been taken by various countries towards addressing the capacity issues. In India, the policy intervention based on the revenue-based fishing capacity of various fleets is necessary towards enhancing the fisheries sustainability both at biological and economical measures.

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