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From the Editorial Board.....

The current issue features 12 articles covering the research developments in the institute during the period, July to Dec 2020. ICAR-CIFT plays a key role in ensuring responsible harvesting and post-harvest research besides giving guidance in handling and processing practices in seafood.

Maintenance of fishing vessel is an important activity for sustained fishing and an article in the present issue describes the maintenance of fishing boats along the Gujarat coast during off season. This is an era of soft technology and mobile applications are common in almost all spheres of life. An article highlights the ICT based mobile application developed by CIFT for the benefit of the stakeholders, on testing and training activities provided by ICAR-CIFT. A customized database designed and developed by the Institute on fish import using the different harmonized system (HS) code is elaborated which will be of use to students, researchers, academicians and policy makers.

Fish is an important food component as far as supply of quality protein is concerned. The observations of a study piloted by CIFT on fish consumption pattern in Kerala is included. The increased demand on fish protein and the utilization of unconventional fish species are important challenges in recent past and an article in the issue describes the potential of producing fish protein powder from a low value fish, red toothed triggerfish. The performance evaluation of aquafeed developed from fish processing discards is also provides useful information.

Fish and shellfish is identified as one of the eight common food allergens and an article describes the effect of house hold pressure cooking on the stability of shrimp allergic proteins. Besides, information on fucoidan, a fucose containing sulphated polysaccharide found in cell matrix of many brown seaweeds and their functional ingredient for novel food products development is discussed. Details of fucodon incorporated bioactive yoghurt developed by the institute are also featured in the current issue.

Antimicrobial resistance is a global issue as exemplified by the rapid increase in cephalosporin and carbapenem resistance in Enterobacteriaceae, limiting treatment options for infections caused by these bacteria. Extended-Spectrum Beta Lactamase (ESBLs) are considered as a major source of resistance in Enterobacteriaceae towards oxyimino-cephalosporins. The recent observations made in this regard are discussed. Molecular detection of antibiotic resistance genes in multidrug Listeria monocytogenes isolated from fish retail markets are also covered in this issue.

The COVID19 has created a havoc across the industries globally and the results of the survey conducted on immediate impact of COVOD-19 pandemic on seafood processing and exports from the country are presented in detail. Uncontrolled growth and excess effort in fisheries sector, demand technical interventions with regard to design and operational modifications for the sustainable exploitation of resource. A special emphasize is given in this current edition on Technical guidelines for sustainable small-scale fishing in India.

It is expected that the articles in the current issue provide an insight in to the areas of research acuities in tune with the requirements of the stake holders.

Contents

Protein powder from red toothed Triggerfish (*Odonus Niger*): An ingredient for food application

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The demand and awareness on fish protein has encouraged the food industry for developing value added /functional food products. Fish protein powder (FPP) finds application in the food industry for developing formulated food products with high quality and nutritional value. FPP is actually a dried, concentrated and stable fish based product and serves as a valuable protein supplement for the vulnerable populations. Protein content of the FPP depends on the raw materials, additives used and moisture content, but contains at least 65% proteins and can be used in the food industry for developing re-structured and ready-to-eat food products.

The red toothed triggerfish (*Odonus niger*), locally called as "klathi" was used for the preparation of fish protein powder by different extraction processes like hot and cold extraction. Trigger fishes are deep sea fishes belonging to balistidae family with deep body, large scales, small mouths, and high-set eyes. Red toothed triggerfish is also known as leatherjacket due to its thick and hard skin, constituting about 25% of the total body weight which makes it less prone to predators. These fishes are caught in abundance from the Kerala coast and huge landing of this less valued fish at times creates less demand and pose environmental problems in fishing harbours. A large proportion of these fishes are often used for making fertilizer or animal feed.

Fig. 1 *Red Toothed Tigger fish (Odonus niger)*

Compositional analysis showed that the fish contains about 75% moisture, 14.12% protein, 1.47 % fat and 9.51% ash on an average and the deskinned mince constitute about 79-80% moisture, 15.5% protein, 1.75% fat and 3.68% ash content. Protein powder was prepared from the fish mince is extracted by two different processes, cold extraction (T1and T2) and hot extraction (T3 and T4) with water and with and without ginger (0% and 1% ginger extract). The washed mince was oven dried at a temperature of 60-70˚C, powdered and sieved through a stainless-steel sieve (mesh size, 500 micron). The protein powder was packed in laminated pouches and vacuum sealed before storing.

Fig. 2 *Fish Protein Powder*

The nutrient composition of the powders revealed 75-80% protein, 0.8-1.78% fat, 12.8-17.9% ash content with a moisture content of below 10% and a water activity value of 0.53. The protein quality was high and rich in all essential amino acids. Also, it contains a high mineral content that encompasses all essential minerals like Ca, K, Mg, P, Cu and Se, with a very high content of Ca and Phosphorus.

The functional characteristics of the protein power extracted by cold methods were superior compared with that by hot method. A higher solubility in water was observed in T4 (78.13%) sample which was enhanced by the addition of ginger extract during the process of extractions. Both water absorption capacity and oil absorption capacity were higher in cold extracted samples. The powders observed a whiter (L*71.71 – 75.45) and less hygroscopic nature (0.2-0.28%). The bulk density (0.71) and tapped density (0.85) were higher for hot extracted samples. Hence the Carrs index value and Hausner ratio which indicates the cohesiveness of the powder was low (1.25) in hot extracted sample. The cohesiveness of powders determines their consistency and flow properties. Lower the cohesiveness, better the flowability and the hot extracted powders showed better flow properties. Both powders showed less oxidation indices value and have a good sensory acceptance.

The difference in the properties can be made use in formulating different food products such as extruded snacks, nutrient mixes, smoothies, pasta, noodles, cookies, ice- creams etc. which in turn enhances nutritional and functional value of the product. The utilization of this unconventional fish species has been one of the most important challenges in recent years. Developing functional FPP can be a viable option through which convenience, novelty and marketability can be added for a commercially low valued fish. FPP could also possibly used as a functional ingredient for many formulated/ ready-to-eat products having good functionality, stability and sensory quality.

Effect of house hold pressure cooking on shrimp allergic protein, tropomyosin

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Seafood associated food allergy, particularly due to shrimp consumption, is showing an increasing trend in recent times. Allergic or hypersensitivity reactions are inappropriate responses of the immune system to a normally harmless substance. Seafood allergy comes under type I immediate hypersensitivity reaction, mediated through immunoglobulin E (IgE). Tropomyosin, a major shrimp allergen, is a myofibrillar protein with molecular weight ranging from 34 to 38 kDa and linked with regulation of muscle contraction along with actin and myosin. It is a heat stable protein which can elicit allergenicity in sensitive individuals through the binding of IgE specific epitopes (Motoyama et al., 2006).

Flower tail shrimp (*Metapenaeus dobsoni*) is a locally preferred shrimp variety in India. The major allergen identified in *M. dobsoni* is tropomyosin of 37 kDa (Laly et al., 2019). Food processing can effectively alter the allergenicity of foods. The stability of food allergen depends upon processing condition, type of food and allergen content (Cabanillas and Novak, 2019). During food processing IgE binding epitope of allergen can get modified. Sometime new epitopes known as "neoallergen" may be formed impacting the allergenicity. Pressure cooking is a common culinary method followed in households. The combined effect of pressure and temperature during pressure cooking can alter the allergenicity of shrimp allergen. A study was carried out to evaluate the efficacy of pressure cooking on shrimp allergenicity in *M. dobsoni*. The extract of *M. dobsoni* in phosphate buffered saline (PBS) and peeled shrimps of *M. dobsoni* were subjected to pressure cooking at 5, 10 and 20 minutes duration. The changes in IgE binding ability of allergic proteins were evaluated by SDS PAGE and immunoblotting using pooled sera of shrimp sensitive individuals.

All the treatments in extract form showed a decrease in IgE binding ability, while the peeled shrimps showed an increase in IgE activity. In the SDS PAGE profile of all the pressured cooked *M. dobsoni* extracts, the tropomyosin band was observed to be absent. But in the pressure cooked *M. dobsoni* in peeled form, the tropomyosin band was retained at all time durations. Similarly, in the case of immunoblotting analysis, tropomyosin band was not observed in the pressure-cooked extracts, while it was showing immunogenicity in peeled shrimps after pressure cooking (Fig.1) demonstrating the stability of the tropomyosin in

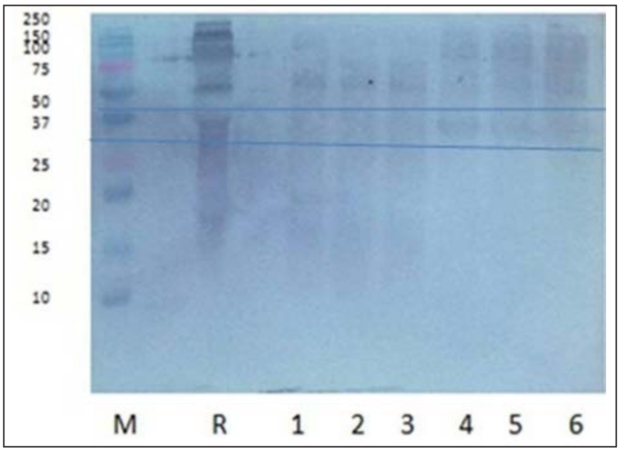

Fig.1 ***Immunoblott analysis of pressure cooked extracts and peeled shrimps. M – Marker; R – Raw extract; 1 – Extract (5 minutes); 2 - Extract (10 minutes); 3 - Extract (20 minutes); 4 - Peeled shrimp (5 minutes); 5 - Peeled shrimp (10 minutes); 6 - Peeled shrimp (20 minutes).***

tissue. As the allergenicity is effectively reduced in pressure cooked shrimp extracts, it can be further utilized as a hypoallergic material for seasoning purpose.

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Seaweed-supplemented bioactive yoghurt

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The nutritive potential due to presence of anti-oxidants, dietary fiber, essential amino acids, phytochemicals, vitamins and minerals along with their health promoting properties make seaweeds a promising option for inclusion in the human diet through supplementation in various food systems (Kumar et al., 2018).

Fucoidan, a fucose containing sulphated poly-saccharide is mainly found in cell matrix of many brown seaweeds with a variety of health-benefitting biological functions including anticoagulant, antitumor, anti-thrombosis, antivirus, anti-oxidation, and immune-modulation. Thus, fucoidan is a potential functional ingredient for novel food products development (Hanjabam et al., 2019). The bioactivity of fucoidan depends upon sulphate and fucose content and an attempt was made to incorporate the fucoidan into the common dairy product yoghurt for utilizing health gains of fucoidan in a palatable manner. The fucoidan extracted as per Hanjabam et al. (2019) by ultra-sonication was utilized for present work. The yield (dry basis) of fucoidan was 14.6% and it had contained 23.7% fucose and 17.6% sulphate content.

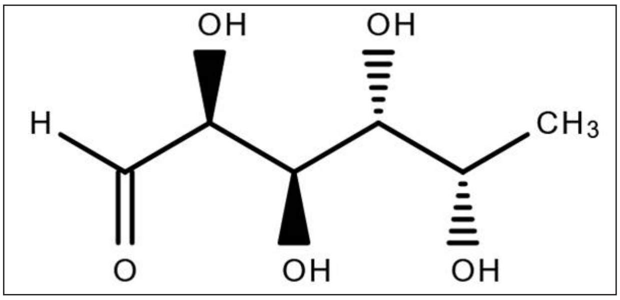

Fig. 1 ***Chemical structure of fucose***

The fucoidan incorporated healthy Yoghurt was prepared in collaboration with MILMA Products Dairy, Edappally, Ernakulam. Milk was thermized, standardized to required fat and solid non-fat levels and homogenized. The fucoidan powder along with sugar was admixed with milk. The admixture was pasteurized after the addition of pasteurized mango pulp. The mix was cooled and inoculated with thermophilic yoghurt culture comprising of *Lactobacillus delbrueckii* subsp. b*ulgaricus* and *Streptococcus thermophilus*. The milk was agitated to uniformly disperse the yoghurt starter culture. The milk was filled in polystyrene cups and incubated at 42°C, until it attained the pH of 4.6. The yoghurt was cooled to 5°C before analysis. The proximate composition and anti-oxidant activities of seaweed supplemented yoghurt are presented in Table 1. The yoghurt samples were liked 'very much- extremely' on 9-point Hedonic scale, by sensory panelists.

Fig.2 ***Seaweed supplemented yoghurt***

The incorporation of fucoidan helped in improving the nutritional attributes of the yoghurt without adversely affecting the organoleptic qualities. The shelf life of seaweed supplemented yoghurt was observed to be 15 days at 5°C. Seaweed

Table 1. Physico-chemical properties of seaweed-supplemented yoghurt

Parameter		Value
Moisture		77.2%
Fat		3.2%
Protein		3.9%
Ash		0.2%
Carbohydrate		15.5%
Hunter color parameters		
	L*	67.2
	a*	2.8
	b*	13.6
pH		4.6
acidity		0.8%
DPPH Activity		80.2%
Metal chelating activity		67.2%
Reducing power		0.5

supplemented yoghurt is a unique attempt to utilize the salubrious seaweed along with goodness of yoghurt. Usage of fucoidan as health promoting ingredient is well justified considering its health beneficial aspects. The functional benefits of seaweed can be utilized in human diet using yoghurt as supplementation vehicle.

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Molecular detection of antibiotic resistance genes in multidrug resistant *Listeria monocytogenes* isolated from fish retail markets

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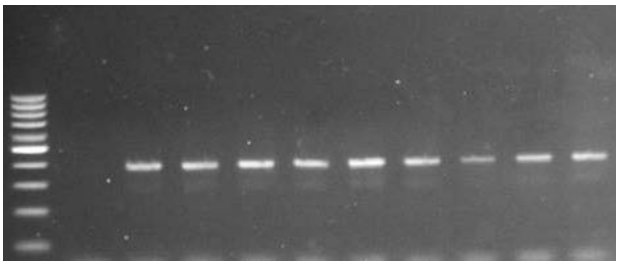
Listeria monocytogenes is a ubiquitous pathogen with an ability to contaminate a variety of foods during pre- and/or post-processing (Olaimat et al., 2018). Due to its ability to resist wide environmental conditions such as pH (4.7 to 9.2), high salinity (10% NaCl) and temperature (0.5 to 45°C), *L. monocytogenes* is recognized as significant food safety hazard, especially in ready-to-eat (RTE) foods. Owing to its high mortality rate (20 to 30%) and hospitalization rates of Listeria infection, the Food and Drug Administration of the United States implemented zero tolerance approach for *L. monocytogenes* in all the RTE foods (Hitchins, 1998). This organism causes severe human illness such as human listeriosis, which results in meningitis, meningoencephalitis, septicemia, and other serious complications during pregnancy such as abortions and stillbirth (Scallan et al., 2011). *L. monocytogenes* is usually susceptible to a broad spectrum of antibiotics that are generally employed effectively against gram positive bacteria but majority of strains show native resistance to fosfomycin, cefepime and cefotaxime (Hof et al., 1997). However, reports on increasing number of multidrug resistant *L. monocytogenes* strains is a major concern in humans and animal health care (Charpentier and Courvalin, 1999). The emergence of the antibiotic resistant strains of *Listeria* spp. might be due to the increased selective pressure of antibiotics or may be due to mutations or acquisition of mobile genetic elements like plasmids and conjugative transposons (Poyart et al. 1990; Charpentier and Courvalin, 1999) through conjugation methods (Perichon and Courvalin, 2009). The present study is aimed to detect the presence of molecular determinants of antibiotic resistance in *L. monocytogenes* isolated from fish and fishery environment which exhibited phenotypic antibiotic resistance.

Isolation of *Listeria monocytogenes* was carried out following USDA method as described by McClain and Lee (1998). Ten isolates of *L. monocytogenes* from fish and fishery environment showing phenotypic resistance to β-lactams, macrolides and tetracyclines were subjected to PCR amplification of antibiotic resistant genes viz., *blaZ* gene for penicillin (Olsen et al., 2006), *ampC* for ampicillin (Dallenne et al ., (2010) *ermA*, *ermB*, and *ermC* for erythromycin (Sutcliffe et al., 1996) and *tet* genes *tetA* (Randall et al., 2004), *tetB* (Van et al. 2008), *tetK* (Strommenger et al., 2003), *tetL* (Escolar *et al*., 2017), *tetM* (Ng *et al*., 2001) and *tetS* (Charpentier et al., 1993) for tetracylines. The results of phenotypic and genotypic resistance of *L. monocytogenes* isolates are provided in Table 1. The results showed that 40% of *L. monocytogenes* strains revealed the presence of two molecular determinants of antibiotic resistance. A high prevalence of *blaZ* (90%) was found in *L. monocytogenes* (Fig.1) followed by *tetS* (40%). The detection of *blaZ* genes in 90% of *L. monocytogenes* isolates suggests that *blaZ* is the chief means of penicillin resistance. The resistance of *L. monocytogenes* to penicillin may be transcribed through the production of the enzyme β-lactamase, controlled by *blaZ*, *blaI*, and *blaR* cluster (Firth and Skurray, 2000). It is reported that *L. monocytogenes* may have attained *blaZ* gene through selection pressure of penicillin or acquired from other bacteria through horizontal gene transfer. Conjugative transfer of antibiotic resistance from the plasmids of enterococci and streptococci to the *Listeria* spp., and the successive movement of such mobile genetic element to *L. monocytogenes* was reported (Charpentier and Courvalin, 1999). All the *L. monocytogenes* isolates showed phenotypic resistance to ampicillin and tetracycline, but none of the ten isolates harbored either *ampC* or *tet* genes, except *tetS*. The present study found that incidence of various antimicrobial resistance determinants did not constantly associate with the phenotypical antibiotic resistance demonstrated by *L. monocytogenes*. This implies that alternate mechanisms such as reduced permeability of outer membrane proteins (Farmer et al., 1992), activation of antibiotic efflux pump (Charvalos et al., 1995), transformation in a gene associated with ribosomal protein (Yan and Taylor, 1991) or co-resistance and cross-resistance may be important drivers of antibiotic resistance. Further work to understand the true mechanisms that contribute to the antibiotic resistance in phenotypic resistant *L. monocytogenes* is necessary.

Table 1. Comparison of phenotypic and genotypic resistance in *L. monocytogenes* isolates

Antibiotic	Interpretive criteria		Phenotypic resistant isolates*	ARG	Amplicon size (bp)	ARG positive isolates*
	Sensitive	Resistant				
Penicillin (10 IU)[a]	≥13	<13	10	*blaZ*	377	9
Ampicillin (10 µg)[a]	≥16	<16	10	*ampC*	630	0
Erythromycin (15µg)[a]	≥25	<25	10	*ermA*	645	0
				ermB	639	0
				ermC	642	0
Tetracycline (30 µg)[b]	>14	≤14	10	*tetB*	773	0
				tetK	360	0
				tetL	739	0
				tetM	406	0
				tetS	573	4

*number of isolates; [a]: EUCAST breakpoints; [b]:WHONET 5.6



L 1 2 3 4 5 6 7 8 9 10

Fig 1. PCR amplification of *blaZ* gene (377 bp) in *L. monocytogenes* isolates. Lane L: 100 bp ladder, Lane 1: negative control, lane: 2-10: *L. monocytogenes* isolates of retail fish market

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Performance evaluation of aquafeed developed from fish processing discards

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Industrial fish processing activities generate huge quantities of waste in the form of head, viscera, skin, scales and other trimmings. The unscientific disposal of these materials results in environmental pollution and proliferation of harmful agents. It has been observed that these discards can be better utilised by converting into poultry feed, fish feed and animals feed by incorporating with other feed ingredients. This not only adds value to the process discards, but also introduces as a major protein and mineral supplements/ingredient for feed industry.

Five different feed formulations were made from both sorted and bulk wastes, viz. squid, cuttle fish, sardine head waste, shrimp head waste and domestic fish market waste (contains discards of various fish/shrimp species). For feed preparations, the wet discards were directly fed to the feed line without prior dehydration or drying. Pelleted sinking fish feed was prepared by mixing with other ingredients like rice bran, soyabean powder, wheat flour, corn powder and sufficient water, followed by cooking the dough and pelleting using a pelletiser. It was dried in electric dryer to a moisture content of below 10%.

GIFT Tilapia fingerlings were procured from registered hatcheries and acclimatised for 10 days (figure 1). The fishes were made into 6 groups of 10 fingrelings having average weight of 5.6 g. Nutritional quality of the developed feeds was assessed by conducting feeding trials in plastic tanks for a period of 45 days keeping a commercial feed as control diet. During the feeding trials, 30% of water was exchanged daily. The change in weight of tilapia during the study period was assessed (Table 1).

Fig. ***Feeding trial set-up with monosex Tilapia fry***

Among the six formulations of aqua feed the highest growth rate was observed for shrimp head waste feed. The squid waste feed and domestic market waste meal feed performed equally good. The commercial feed and cuttlefish waste meal indicated significantly lower growth rate compared to the other four feed formulations.

Table -1 Average Body Weight of Tilapia Fed with Formulated Feed

	Cuttle fish waste meal feed	Shrimp head waste meal feed	Domestic market waste meal feed	Commercial feed	Sardine head waste meal feed	Squid waste meal feed
Growth % in 45 days	253.71	476.78	443.39	210.71	386.20	443.86

The higher weight gain and specific growth rate in shrimp head waste feed observed in the trial might be on account of the higher protein content and better feed attraction and subsequent higher level of feed consumption.

Prevalence of extended spectrum beta lactamase (ESBL) *E. coli* in fishes from the retail markets of Guwahati, Assam.

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It is reported that 90-95% of the population of Assam depend on fish as their main protein diet with per capita consumption of 9.00 kg (Bhuyan *et al.,* 2017). Fishes being a major food in a state like Assam and reports direct the possible transmission of antimicrobial resistance through fish, it is impending to conduct a surveillance to estimate the prevalence of antimicrobial resistance pathogen. The impact of drug resistant bacterial transmission from livestock and aquaculture resources/seafood to humans is poorly understood. Antimicrobial resistance is a global issue as indicated by the rapid increase in cephalosporin and carbapenem resistance in Enterobacteriaceae, leading to limitations in treatment options for infections caused by these bacteria (Bush *et al.,* 2011). Extended- Spectrum Beta Lactamase (ESBLs) are considered as a major source of resistance in Enterobacteriaceae towards oxyimino- cephalosporins (Bradford, 2001). The present study highlights the prevalence of ESBL *E. coli* in fishes sold in the selected retail markets of Guwahati, Assam. The microbiological identification and antibiotic susceptibility test (AST) profile of the isolates were carried out using BD Phoenix™ M50 automated system (BD Diagnostics, USA).

A total of 79 fish samples were collected from the retail markets situated in three selected locations (Silagrant, Garchuk and North Guwahati Town Committee region) in Assam in the month of August, 2019. The samples include the most common food fishes silver carp (*Hypopthalmichthys molitrix*), rohu (*Labeo rohita*), red belly piranha (*Pygocentrus nattereri*), catla (*Catla catla*) and native fish varieties caught from either river or beel (lake) namely singara (*Mystus tengara*), singhi (*Heteropneustes fossilis*), kawoi (*Anabas testudines*), puthi (*Puntius spp*.), bata (*Labeo bata*), aree (*Sperata seenghala*) *etc.*

Fish samples were collected in sterile polythene bags and transported (maintaining cold chain) to the laboratory in National Research Centre on Pig, Rani, Guwahati for initial processing. Samples were processed within 3-4 hrs of initial procurement. The gut portion of the fish were taken for the isolation of *E. coli*. Macerated fish samples were aseptically transferred to modified form of Brilliant Green Bile Lactose

Broth, EE broth Mossel enrichment media (pH 7.2) and were incubated for 18-24 h at 35- 37°C. A loopful of the enriched culture was streaked onto MacConkey agar plates supplemented with 1 μg/ml cefotaxime and incubated for 18-24 hrs at 35-37 °C. Typical pink colored colonies, indicative of lactose-fermenting characteristics of *E. coli* were picked and further streaked onto Eosin-Methylene Blue agar. Presumptive *E. coli* colonies with typical purple colour with or without dark purple center or with green metallic sheen were picked. Non duplicate isolates were inoculated further on to tryptic soy agar plates for identification and AST.

The BD Phoenix™ M50 automated system is specifically used for the identification and antibiotic susceptibility test of the isolates. NMIC/ID55 ID-AST combo panel used in this study of Gram-negative bacteria has a distinct 'BD Phoenix ESBL screening test' which is based on the growth response to selected second or third generation cephalosporins in the presence or absence of a beta-lactamase inhibitor, clavulanic acid. This feature enables to categorize an isolate as ESBL if it is resistant to the following antibiotics: cefotaxime/ clavulanate, ceftazidime/ clavulanate, cefpodoxime-proxetil, ceftazidime and ceftriaxone/ clavulanate. Other than these, the panel consists of 19 different antibiotic wells representing 13 different antimicrobial categories: amikacin (AN), amoxicillin/ clavulanate (AMC), ampicillin (AM), aztreonam (ATM), cefazolin (CZ), cefepime (CPM), cefotaxime (CTX), cefoxitin (FOX), ceftazidime (CAZ), chloramphenicol (C), ciprofloxacin (CIP), gentamicin (GN), imipenem (IPM), levofloxacin (LVX), meropenem (MEM), piperacillin (PIP), pipercillin/ tazobactam (TZP), tetracycline (TE) and trimethoprim/ sulfamethoxazole (SXT). Isolates were loaded to individual panels and procedures were followed according to manufacturer's instructions. Quality control using the reference strains *E. coli* ATCC 25922 was also performed. Susceptibility patterns were interpreted strictly adhering to CLSI, 2020. Multiple antibiotic resistance (MAR) index for *E. coli* was calculated based on the number of antibiotics to which the isolates showed resistance to the total number of antibiotics to which isolates were exposed (Christopher *et al.*, 2013).

In all, 66 non duplicate isolates from a total of 79 fish samples were subjected to identification in BD Phoenix™ M50, out of which 54 isolates were detected as ESBL *E. coli*. These were further confirmed at molecular level by using CTX-M genes (Sivaraman *et al.,* 2020). It is seen that 100% of the *E. coli* isolates showed resistance to beta-lactam antibiotics such as ampicillin, cefazolin, cefotaxime and pipercillin. Though 100% of the *E. coli* isolates showed resistance to cefotaxime, only 6% were resistant to ceftazidime, another third generation cephalosporin. It could be seen that 85% of the isolates showed resistance to fourth generation cefepime and 15% were categorized as susceptible-dose-dependent (SDD). Only two isolates were resistant to cefoxitin. Also 96% of the ESBL *E. coli* isolates were susceptible to β-lactam combination agents-amoxicillin/clavulanate and pipercillin/ tazobactam. Among the non β-lactam group of antibiotics, 33% of the isolates were resistant to ciprofloxacin and <33% to levofloxacin. Tetracycline resistance was significantly less. MAR index showed a range of 0.26-0.63 in ESBL *E. coli* isolates with 48% of the isolates with an index value of 0.31. In the present study, all the ESBL isolates showed resistance to more than three antimicrobial categories and hence were considered as multi drug resistant (MDR). 67% of the *E. coli* were found to have resistance to 4 antimicrobial classes whereas, two *E. coli* isolates were resistant to a maximum of 8 antimicrobial classes. The study highlights the prevalence of extended spectrum β-lactamase producing *E. coli* in the fish samples sold for consumption in retail markets. The prevalence of *E. coli* in environment is considered as a contaminant and any pathogenic strain can present several challenges in human health sector.

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"Caring the crafts": off season maintenance of fishing boats of Gujarat coast

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There are number of factors which influence the operation and maintenance of the fishing systems. The coastal districts of Saurastra and Kutch region of Gujarat, are well-known for skill and craftsmanship for construction of highly efficient fishing and cargo vessels (Prajith et al 2017). The fishery of Gujarat is mainly contributed by the mechanised fishing vessels (6.96 lakh t) followed by motorized fishing vessels (0.84 lakh t) and non-motorized fishing vessels (397 t). The catches from the mechanized sector are mostly contributed by multiday trawlers (CMFRI, 2019). Veraval, Mangrol, Okha and Porbandar are the major fish landing centres of the state. In Veraval coast, trawling is done with wooden and FRP vessels (only one steel vessel is engaged in commercial fishing). Maintenance and conditioning of vessel is mostly carried out every year during off season. As per the recent order of government of India, the trawl ban in the west coast of India was made uniform for a period of 45 days, starting from 15th June.

In Gir Somnath district of Gujarat, due to the presence of large number of fishing vessels and lack of space for maintenance, lifting of vessels for annual maintenance starts before the commencement of trawl ban (by the end of April). Cranes are usually used for lifting vessel from the water and costs 5000-6000 INR for a single vessel. Once the vessel is lifted, it will be kept on specially constructed iron tables to keep the vessel in stable upright position. Extra wooden blocks and empty metallic barrels are also used for additional support. After placing the vessel on supporters, the portion below the water line is scrapped and washed. This process lasts for few hours depending on the intensity of fouling and usually 5-6 persons are engaged in the scraping and cleaning process. If major maintenance works are needed, the boats are covered with old jute bags or green High-Density Polyethylene (HDPE) sunshade nets. After scraping and cleaning, wooden plates on the body of the boat are examined for damages by carpenters and the damaged portions are repaired (Fig.1).

Fig. 1 ***Replacement of wooden plank in progress***

The labourers employed for scraping and carpenters are paid 700 and 1000 INR respectively, daily. Wood from sal, *eucalyptus* and *acacia sp*. are usually used for the construction and repairing of fishing boats (Prajith et al., 2017). Depending on the quality and type, the price for the wood varies from 800-1300 INR/ cubic feet. The propeller of the vessel is dismantled, aligned, serviced and refitted. After carpentry work, inner (deck area) and below waterline area of vessel are coated with fish oil (locally known as Choppad) which costs 14000 INR for a 200L barrel.

Before application of wood primer, the outer part of the vessel is checked for gaps between the wooden planks and gaps, if any, are plugged with cotton threads and then covered with Damar Batu (locally known as Lappi), a petrified natural resin of ancient shorean trees (GVI, 2020). The Damar Batu is available in local market, which is applied after mixing with Kerosene or thinners (Fig.2). The primers used are either red, black or silver grey in colour.

Fig. 2 ***Mixing and application of Damar Batu***

As the recommended colour code for the state of Gujarat is orange and black, the wheel house and outer body are coated with dark orange and black coloured paints respectively (Fig.3). Antifouling paints are used for painting of outer body. Shalimar, International, Nerolac are some of the brands preferred by the fishermen. Finally the area below water line are provided with an extra coat of fish oil to reduce fouling. The places wherever nails fixed, are marked with white paint and this helps to identify the area where the planks are joined together besides providing aesthetic beauty

Fig. 3 ***Application of paint***

to the vessel. The total maintenance cost for a single trawler per annum is in the range of 25000 to 100000 INR. Maintenance of wheel house, deck and fish haul are done based on requirement. The annual repair work during the trawl ban period is fully dedicated for works below the waterline area of the vessel.

The boats, decorated with garlands and flags, are launched after repair with religious fervour and fanfare on an auspicious day according to the Gujarati calendar. Ladies and kids have important role in this function.

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Dried fish consumption patterns in selected districts of Kerala

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Fish drying is an age old practice followed for preservation of fish. Over the years, it has grown from a subsistence occupation to a full flourishing business. There has been an enduring demand for dried fish products in Kerala. Use of dry fish in different recipes is part of the culinary heritage of Kerala. The magical Kanji (rice porridge) - dry fish chutney amalgamation is a well-known combination of the state.

Dried fish segment constitutes to 20 % of the total fish production in India (Anon, 2016). Detailed studies on dry fish consumption pattern, sources of dry fish, import into the state, common fish species dried, consumer acceptance, economics of dry fish etc. pertaining to Kerala are relatively scanty. Madan *et al.*, (2018) reported that Sardine and anchovies contribute to 50% of the total dry fish produced, in Tamil Nadu. Dry fish production was found to be a profitable business with an internal rate of returns (IRR) of 75% and simple rate of returns (SRR) of 43.48% in Tamil Nadu.

Dried fish attracts greater demand during fishing ban period or lean seasons, as the fresh fish availability is relatively low (Das et al., 2013). However, of late, there is round-the-year availability of fresh fish for consumers in Kerala with stocks coming from other states as well. Dry fishes can be transported to areas where fishes have good market potential. They are presumably consumed more in the hilly and inland districts where the availability of fresh fish is low compared to coastal districts and expensive even if available. Dried prawns, anchovies, pony fish, ribbon fish, mackerel and shark are some of the most commonly marketed and relished dry fishes in Kerala. Dry fish has higher concentration of protein (in terms of weight) as compared to the wet weight of fish and therefore is a good source of animal protein thus contributing towards nutritional security of the population. They are widely sold in the domestic markets and commercially important dry fish species are also exported to other countries (Immaculate et al., 2013).

Considering the importance of fish as a dietary protein food, a study on dry fish consumption pattern was taken up in two coastal (Ernakulam, Kozhikode) and two non-coastal (Palakkad, Kottayam) districts of Kerala covering a sample of 399 fish consuming families. Based on the assumed prominence of dry fish in Kerala recipes, the dry fish consumption pattern of fish consuming families was measured as part of the study.

Contrary to popular assumptions, the study found that large majority of fish consumers in Kottayam (60%) and considerable share of population in Ernakulam (35%), Kozhikkode (44%) and Palakkad (48%) reported no/never consumption of dried fish. Majority of fish consumers in Ernakulam (65%), Kozhikkode (56%) and Palakkad (52%) reported consumption of dried fish in limited/ reduced frequencies. While 19 percent of respondents in Kozhikkode and 30 percent in Palakkad reported dry fish consumption once in a week, 25 percent in Ernakulam and 17 percent in Palakkad reported consumption once in a fortnight (Table 1).

Among the dry fish consumers, preference/liking for dry fish was recorded as the major reason for consumption of dry fish in Ernakulam (33%), Palakkad (33%) and Kottayam (24%)) districts while dry fish consumption due to unavailability of fresh fish during certain seasons was reported as the major reason in Kozhikode (37%) (Table 2). Drying of fish caught during recreational fishing, free access to fresh fish for drying, liking for certain dry fish recipes etc were some other reasons for dry fish consumption by few respondents.

Table 1. Pattern of dry fish consumption in study areas. (n=399)

Frequency	Ernakulam (%)	Kozhikkode (%)	Palakkad (%)	Kottayam (%)
Daily	0	0	0	0
2-3 times/week	9	8	7	0
Weekly once	13	19	14	30
Fortnightly once	25	13	17	2
Monthly once	19	16	14	8
No/Never	35	44	48	60

Table 2. Reasons for dry fish consumption (n=399)

Reasons	Ernakulam (%)	Kozhikkode (%)	Palakkad (%)	Kottayam (%)	All districts Avg. (%)
Preference/liking for dried fish	33	14	33	24	26
Unavailability of fresh fish during certain seasons	23	37	11	8	20
Other reasons	2	9	7	2	5

Table 3. Monthly family expenditure on dry fish (n=399)

Expenditure	Ernakulam (Rs)	Kozhikkode (Rs)	Palakkad (Rs)	Kottayam (Rs)	All districts (Rs)
Avg. Exp.	92	170	227	197	160
Lowest Exp. recorded	20	10	50	20	10
Highest Exp. recorded	750	500	700	600	750

Survey indicated that the average monthly family expenditure towards dry fish purchase as Rs. 160 for the districts with highest average expenditure of Rs. 227 for Palakkad and lowest of Rs. 92 for Ernakulam (Table 3). Limited purchase of dry fish in reduced quantities was recorded in all the districts studied contributing to low average monthly family expenditure towards dry fish purchase.

Dry fish consumption pattern was found to be declining with majority of the fish consumers reporting no consumption in Kottayam and reduced frequency of consumption in three other districts studied. It is reported to be attributed to the belief among consumers that dried fish contribute to lifestyle diseases and fear of the use of harmful chemicals in fish drying were the major reasons attributed for decline in consumption of dry fish by respondents.

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Design and Development of Customized Database on Fish Import to India

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A customized database on fish import to India in terms of quantity and price under different harmonized system (HS) code has been designed and developed in Microsoft Office Access (MS Access). The aim of the database is to provide customized fish import data to the user. The database design comprises of creating various database objects such as tables, queries, forms and reports; these objects are intended to store data, write, search queries for retrieving data, add, edit or delete data records from the table and to generate compiled and formatted data outputs from the database. Although, the objects are designed as independent elements, they interact with each other to perform the process of storing, compiling and fetching data to the user. The advantage of this database over the existing database is that the user can fetch either summarized or customized data on fish import to India on a single click. The developed database will be useful to students, researchers, academicians and policy makers and is available with ICAR-CIFT, Cochin.

Formulation of Tables

A database stores data as rows and columns called tables. In Microsoft Access, each row in a table is considered as a unit of information, here the table holds particulars such as commodity code, commodity name, quantity of item imported in the unit of kilogram, price of the commodity in United States (US) $ and the year of import. Likewise, each column categorizes information on the basis of their data type. The data fields such as HS code, year, quantity (kg) and price (US $) were declared as number and name of commodity as text, respectively. The tables defined for storing input data are given in Figure 1.

Formulation of Queries

Queries are specific search conditions defined to search, compile and retrieve data from the database. The sample screen shot of queries to retrieve all the data records is given in Figure 2. Similarly, different queries were designed to retrieve commodity wise data, year wise data, period wise data, commodity - year wise data and commodity - period wise data.

```
SELECT * FROM [Table Fish Live]
UNION
SELECT * FROM [Table Fresh Chilled Whole Fish]
UNION
SELECT * FROM [Table Frozen Fish Excluding Fillets]
UNION
SELECT * FROM [Table Fillets Meat Mince Except Liver Roe]
UNION
SELECT * FROM [Table Cured Smoked Fish Meat]
UNION
SELECT * FROM [Table Crustaceans]
UNION
SELECT * FROM [Table Molluscus]
UNION
SELECT * FROM [Table Aquatic Invertebrates]
ORDER BY [HS Code];
```

Fig. 2 ***Sample Query to retrieve the data***

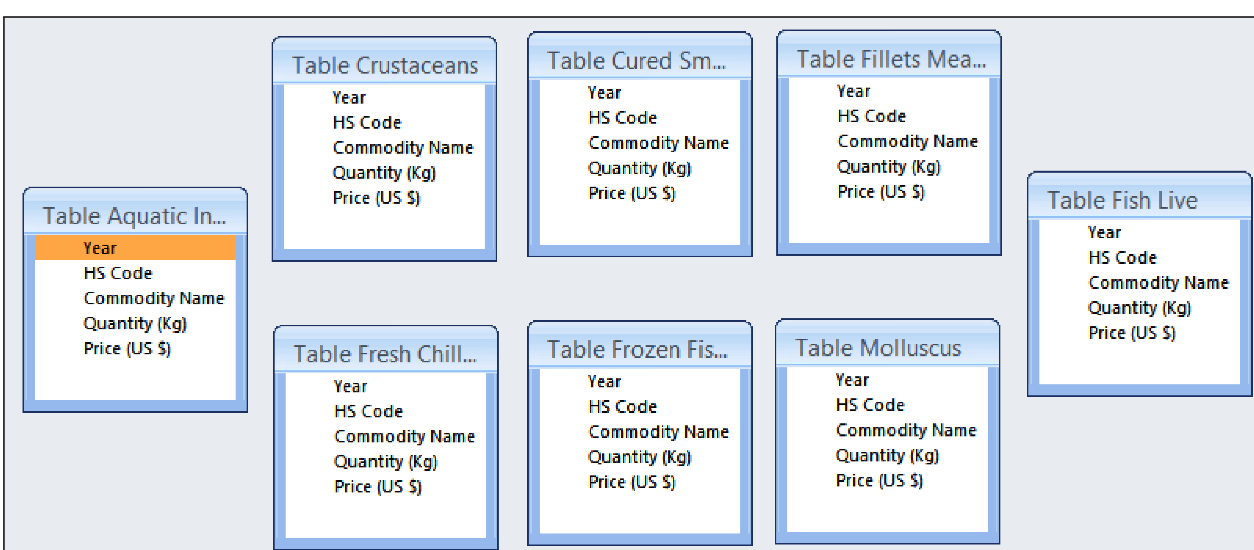


Fig. 1 ***Tables created for the database***

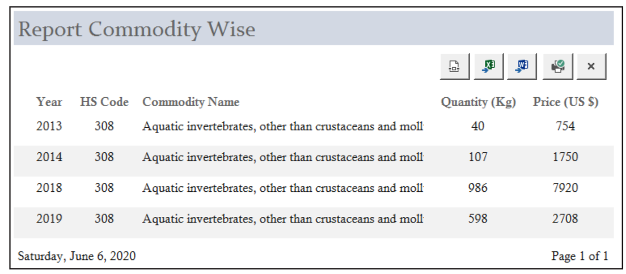
Formulation of Forms

The forms intend the users to add, modify and view records. User panel form has been designed and customized to generate various reports to different queries. The designed user panel is given in Figure 3. Form Controls are provided that directs the user to generate various customized report like general report, commodity wise report, year wise report, period wise report etc.

Fig. 3 ***User panel Form of customized database***

Generation of Reports

Reports enable the user to format, view and print the information from the database. The database facilitates making various reports through customized query such as general report, commodity wise report, year wise report, period wise report, commodity – year wise report and commodity – period wise reports. A sample of commodity wise report is given in Figure 4. Different buttons are provided to export the contents of report to external documents in the forms such as PDF/ MS Excel/ MS Word. The user can print or save the report to desired destination of the local computer.


Report Commodity Wise

Year	HS Code	Commodity Name	Quantity (Kg)	Price (US $)
2013	308	Aquatic invertebrates, other than crustaceans and moll	40	754
2014	308	Aquatic invertebrates, other than crustaceans and moll	107	1750
2018	308	Aquatic invertebrates, other than crustaceans and moll	986	7920
2019	308	Aquatic invertebrates, other than crustaceans and moll	598	2708

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Fig. 4 ***The sample of commodity wise report***

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ICT mobile applications for laboratory testing and training facilities provided by ICAR-CIFT

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ICT application in fisheries

Potential stakeholders in fisheries sectors remain underprivileged due to lack of their access to critical information which limits them from availing the benefit of government incentives, support service, markets and credit facilities to improve their productivity and quality that support their livelihood. Presently, the advancement of ICT technologies has brought a radical transformation in the existing extension information system and envisaged ICT enabled innovative fisheries information system to meet the emerging challenges in the sector by making it easy accessible by all section of the society with a variety of advantages like timeliness, 24 hours X 7 days connectivity, time saving and cost effective. As a global initiative towards digital agriculture, the Interactive Information Dissemination System (IIDS 2.0) platform has gained momentum in fisheries to create a major breakthrough in information diffusion process as a means of providing knowledge based inputs regarding improved technologies on various aspects, capacity building programmes, weather forecasts, best fishing zones, market prices, quality of water, soil etc. The android based smart phone application is considered as the most effective tool allowing access to a broad spectrum of stakeholders both to ensure effective sharing of information and proper use of services rendered by extension agencies, to improve their productivity and family income.

Today, India is one of the fastest growing digital market in the world with a record of 1.2 billion mobile phone users next to China and 560 million internet subscribers, which is increasing day by day (*GOI,2019)*. As per the *Newzoo's (2019)* Global Mobile Market Report, in India about 36.69 per cent of total population (502.2 million) are actively using smart phone. With this immense strength, digital India has rightly ventured into fisheries sector to empower the relevant stakeholders to innovate and expand the network so as to realize the full potential of transforming Indian fishery ushering into knowledge based blue economy.

Now-a days, ICT is used effectively for the growth of fisheries sector, particularly on seafood export both at domestic and international market which significantly reduce its operational cost. In addition, HTML based Webpage & expert systems have been developed by different fisheries organization, research institutions and industries for easy and convenient information flow to fishery stakeholders on various technologies, schemes, facilities and services.

ICAR-CIFT promotes ICT based information system

ICAR-CIFT, being a premier research institute in harvest and post-harvest realm of Indian fisheries, has a prominent role in strengthening the sector with cutting-edge technologies, capacity building of human capitals, quality inputs and services. Further, the institute has a significant contribution towards modernization of seafood industries in India, thus establishing its strong hold to make India as one among the major exporter of seafood products in the world. With the unique recognition by FSSAI as the only Referral and Reference Laboratory in the country for fish and fish-based products, ICAR-CIFT acts as one-point solution for testing of all fishery products of commercial importance mainly for its export purpose as well as gear materials, packaging materials microbiological aspects, quality of ice and water etc. ICAR-CIFT, Kochi has rightly utilized the digital platform to bring new generation of information diffusion system with more sustainability, scalability and replicability beyond certain boundaries. **"CIFT Lab Test"** and **"CIFTraining"** are two interactive mobile applications developed by ICAR-CIFT to widen its reach to all stakeholders.

Block based android mobile applications

1. ***CIFT Lab Test* Mobile App**

ICAR-CIFT developed ***CIFT Lab Test*** is an android based Mobile Application envisages to provide the real time information related to different types of sample testing and analysis as mentioned above covering more than 221 parameters **(Fig.1).** Each sample information contain quantity of sample required for the analysis, as mentioned above in the different laboratories of the institute approximate duration required for completion of sample analysis days, acceptable limits etc. **(Fig.2).** This real time android based mobile application is working in online mode efficiently in a good network coverage area. The changes if any in the analytical protocol

Fig. 1 ***Screen shot of "CIFT Lab Test" Mobile Application***

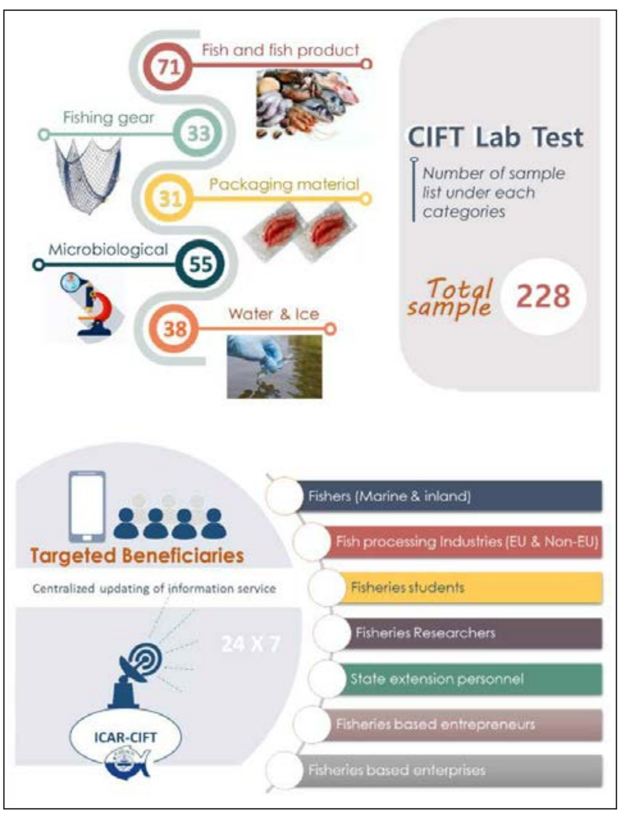

Fig. 2 ***IIDS platform of "CIFT Lab Test" Mob App***

would be updated automatically in the software. Finally, the user can click the payment link which directly connect to the payment gateway. They can select the category of sample, test fee and payment can be made. The link for brochure has been provided in the reference section. The Mobile App can be directly downloaded from the Google Play Store for use.

This Mobile App may be useful for the aquaculture farmers, processing industries and other stakeholders in the sector to access the desired information round the clock for test report and cost particulars etc. available at 24 Hours X 7 Days.

2. *CIFTraining* Mobile App

ICAR-CIFT developed, innovative Mobile Application "*CIFTraining*" provides a complete package of information on ICAR-CIFT Training programmes. This App is highly useful for the fisheries students, researchers, industry personnel of training programmes in the field of Fishing Technology, Fish Processing, Biochemistry & Nutrition, Microbiology, Quality control, Engineering and Extension & Economics. The "*CIFTraining*" Mobile App has embedded with a total list of 68 types of clientele based trainings programmes available in ICAR-CIFT (Fig. 3), which contain 60 regular training courses along with 2 comprehensives, specialized and certified courses.

The "*CIFTraining*" mobile app will help the stakeholders to search the training of their interest and see the training programme details like course

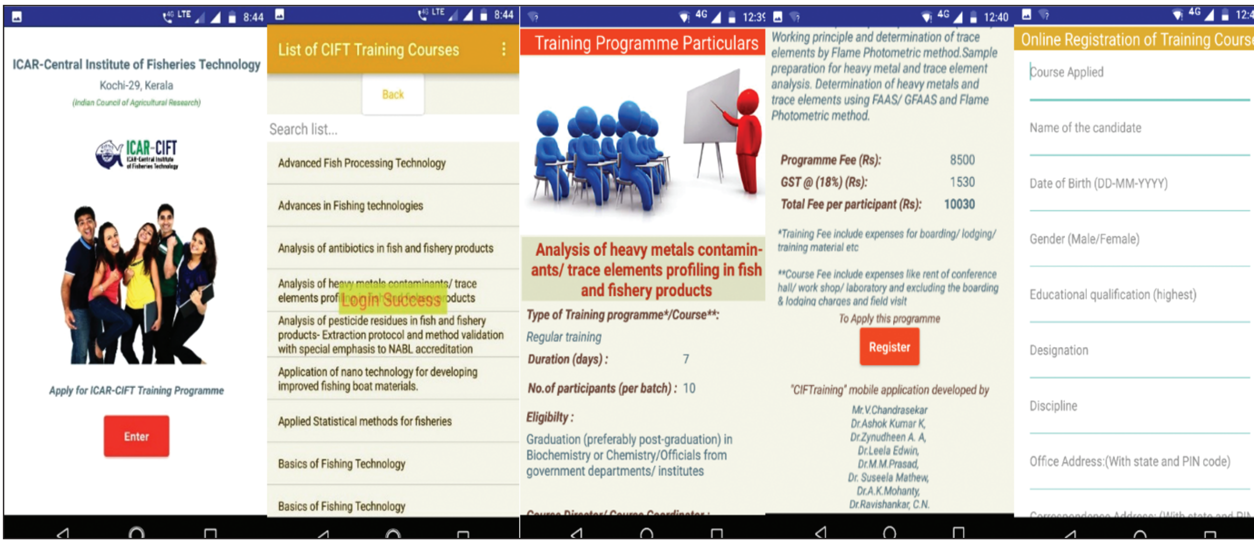

Fig. 3 ***Screen shot of CIFTraining Mobile Application***

contents, course fee, duration, eligibility course content, place (Kochi, Visakhapatnam, Mumbai & Veraval) and other facilities at fingertips. Apart from that the online registration form is provided for the interested candidate filling their information details and facilities for online payment.

Google play store link to access the CIFT Lab Test & *CIFTraining* Mobile Applications and leaflets were given below:

Google play store link

1. https://play.google.com/store/apps/details?id=com.vcsecon.CIFT_Lab_Test
2. https://play.google.com/store/apps/details?id=com.vcsecon.CIFT_Training_new

Leaflet link:

1. https://krishi.icar.gov.in/Technology/downloadpatent?action=download&fileName=mediaResourceUpload1575358598_CIFT%20Lab%20Test%20final.pdf
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Immediate impact of COVID-19 pandemic on seafood processing and exports

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As part of regulatory measures to contain the COVID-19 pandemic lock down was enforced in the country on 25 March 2020. The lock down was extended twice with the phase 3 being upto

17 May 2020. Fisheries and related activities was exempted from the lock down with effect from 10 April 2020, though it took several months for near normal activities to resume. This communication is a brief on the immediate impacts on the seafood sector.

The Indian seafood processing sector has been almost entirely oriented to export right from its infancy in the 1950s. Only in the very recent past has processed seafood found its way into the domestic supermarket chain, largely restricted to urban areas (Gopal et al., 2016). Availability and preference for fresh fish by the consumers; the profits that international seafood trade fetched; and the pro-active trade promotion policies of the government were the reasons for the export oriented approach of seafood industry in the country. Indian seafood exports reach about 106 countries in the world and it is one of the largest exporters of shrimp to countries like USA, Europe and Japan. Besides, it also exports cephalopods like squid, cuttlefish and octopus; crustaceans like lobsters and crabs; fish etc. in frozen or chilled forms and very small volumes in live form. In the year 2015-16 the export value of seafood had reached an all-time high of USD 6.84 billion. In 2019-20, the exports stood at USD 6.68 billion (table 1), with an export quantity of 12.89 lakh ton[2].

There are 613 processing plants in the country with a total installed capacity of 33,730.02 MT. The country also has 3.88 lakh MT of cold storage, 0.23 lakh MT of chilled storage, 0.3 lakh MT of dry fish storage and 0.31 lakh MT of other storage capacities. There are also 718 MPEDA registered pre-processing units with a total capacity of 10,871.53 MT. The impact on the seafood processing factory will probably be felt in the months to come. Though till provisional figures in January 2020 (Ministry of Commerce & Industry, GoI) revealed that the quantity exported in comparison to January 2019 has decreased by 22.32% (in value terms it is positive at 1.24%) (Fig. 1). However, it has been clear subsequently that there was a dip of about 16.75% when April-September 2020 data was taken over the same period the previous year (April-September 2019), indicating that the spread of the pandemic in importing countries has had an affect on Indian seafood exports. This was actually followed by the spread of the pandemic in India, which led to containment measures by the government. The dip in quantity exported was visible to several countries especially in SE Asia, EU, Japan and UAE (Fig. 2a & 2b).

Latest available information from the Ministry of Commerce & Industry, Government of India, reveals that the export during April-September 2020 was Rs. 18015 crore which indicates that the exports during the first six months of the year, which is just 30% of the total export of last year.

From primary data collected from processing factories it was observed that the percentage reduction in production was an average 46% in March 2020 and had further fallen by 74% in April 2020. The resultant losses stood at about Rs. 2 crore to 5 crore per unit. The total losses is expected to be about INR 2500 crore in March 2020 with about 30% fall in quantity and value over the previous year.

Table 1: Seafood exports from India (2017-20)

	2017-18	2018-19	2019-20	2020-21 (till September 2020)*
Quantity in ton	1377244	1392559	1289651	432956
Value in Crore	45106.89	46589.37	46662.85	1,801,5.05
US$ Million	7081.55	6728.5	6678.69	2403.00

Source: MPEDA & *Ministry of Commerce & Industry, GoI

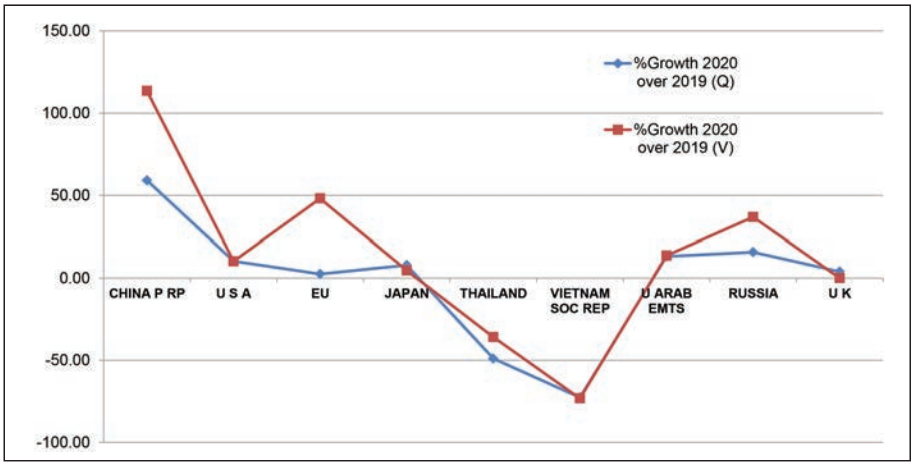

Fig. 1 ***Percent growth of seafood exports January 2020 over January 2019 Based on data from Ministry of Commerce & Industry, GoI***

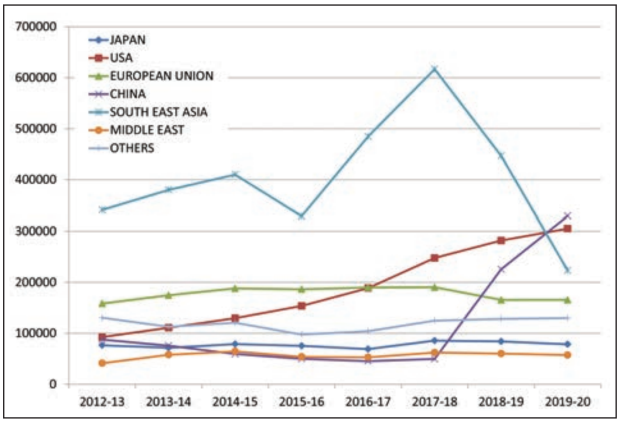

Fig. 2a ***Change in quantity (ton) of seafood exports to various importing countries***

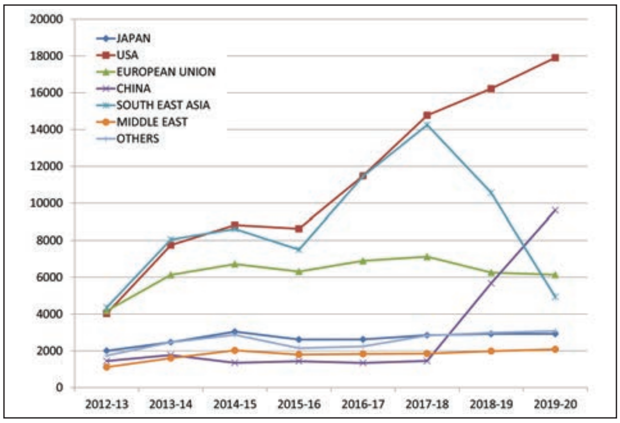

Fig. 2b ***Change in value (Rs. Crore) of seafood exports to various importing countries***

> *The pending orders of export to different countries were cancelled by the buyers. Our 28 Purchase Orders were cancelled by the buyers from USA, China, Vietnam and Middle East.*
>
> *Seafood exporter, Andhra Pradesh*

The problems of the industry has been the difficulty in sourcing raw material due to restrictions on transportation. About 80% of production is based on material from aquaculture and movement of this was heavily restricted, as the raw material had to come from states like Andhra Pradesh. There was blockages in working capital flow for many units. During the lock down firms could not send original documents to buyers, which is an important requirement for shipments to be off loaded, due to couriers not functioning. Though some buyers accepted electronic versions, this caused delays. Factories have also been finding it difficult to get consignments tested with external laboratories as most of the labs are not operating due to lockdown. For compliance of drawn sample requirement, external lab representatives are not available on time to draw samples from the factory and in the process shipments were delayed.

There is low demand in the global market and some of the buyers cancelled orders and some renegotiated process, depressing the same. There was decrease of upto 1 USD in products. Payments for already shipped products were also held up with the buyers. Even after the lock down is lifted the processors are unsure of whether required volumes will be demanded as the situation needs to improve in the importing countries as well.

Labour shortages were faced by several factories. Where there were in-house staff they were able to operate, but in most units the local staff were not able to reach work places. The direct labour costs were also very high considering very low raw material availability and low exports. When the migrant labour in the sector from Assam, Jharkhand, Karnataka etc. will leave there is also a situation that there may be difficulty in bringing them back. As this may warrant testing and quarantine costs. Exports to countries like China are facing issues of virus detection on consignments. While this could be an issue of handling after the processing and packing, this needs to be sorted out as China is banning imports from such countries in the short term.

The initial days of the lockdown also opened up opportunities for online sale of fish. Owing to the inability of people to access markets and the general fear of the spread of the pandemic, there was a shit to online purchases. This could be a trend for the near future as the fear continues to persist and this offers an opportunity that can be exploited. Buying behavior is affected by several aspects, and this may be a short-time panic response. But atleast a small percentage of the consumers may continue with this for the coveninece it offers.

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https://tradestat.commerce.gov.in_Export Import Data Bank (commerce.gov.in)

Technical guidelines for sustainable small-scale gillnet fishing in India

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Background

Gillnet is the most popular fishing gear in the small-scale fishing sector due to its simplicity in design, construction, operation and its low investment. The gear is highly versatile as it can be operated in marine as well as freshwater with or without the aid of a vessel. Besides, it can be operated in any area of the water column *viz*., surface, column or bottom layers as drift, set or encircling gillnets. Gillnets of varying mesh sizes, target a variety of fishes ranging from small anchovies to large fishes such as seer fish and tunas. The gillnet vessels constitute about 67% of the total fleet of the country, consisting of 19,850 mechanized, 61,873 motorised and 49,435 non-motorised vessels (Thomas *et al*., 2020) and that gillnets constitute 83% of the 5.1

million fishing units operated in India (DAHDF, 2005) underline the importance of this fishing gear in the Indian fishing sector. Gillnets were considered as resource specific, eco-friendly and responsible fishing gears without imparting any damage to the ecosystem. However, the unscrupulous expansion of the gear, use of very small mesh sizes and very thin monofilament material in recent time make gillnets a threat to the ecosystem and the environment. This necessitates monitoring and intervention in the design and operation of the gear.

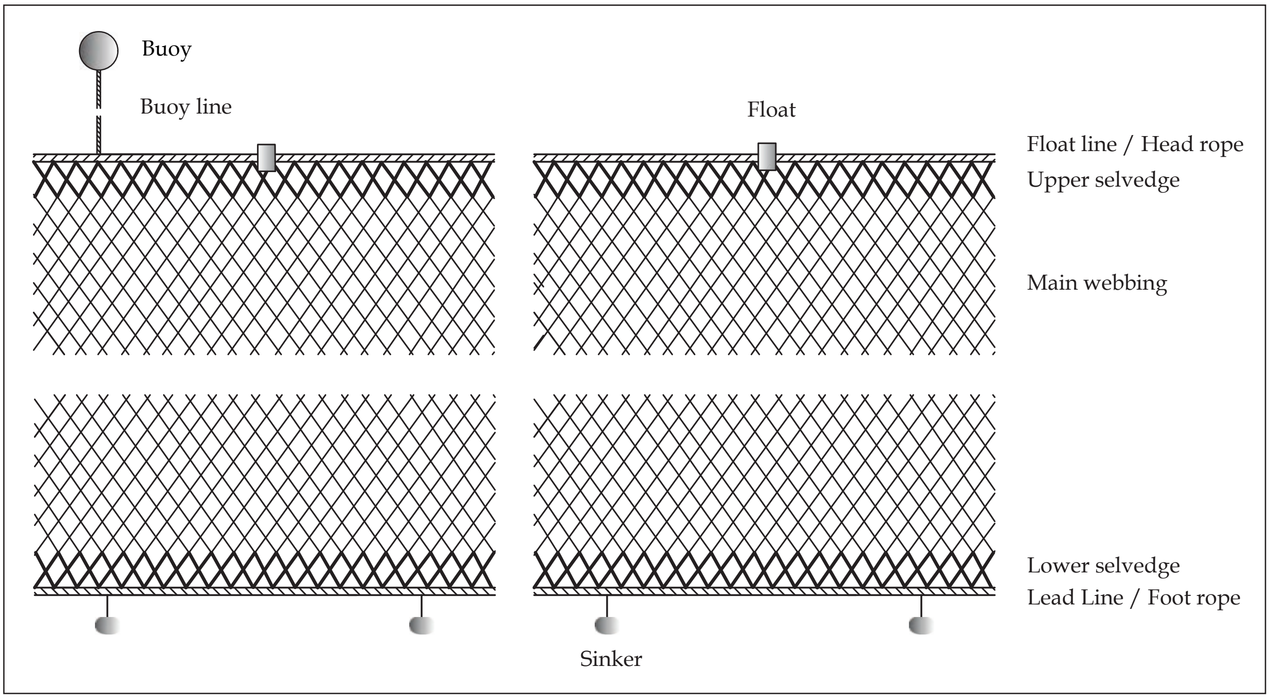
Small scale gillnet fishing in India

In India gillnets are mainly operated in three sub-sectors, the non-motorised where vessels do not use any mechanical device for propulsion and fishing; the motorised sub-sector where vessels are smaller, engine is fitted outside the boat (outboard motor) and used only for propulsion while the gear is operated manually and mechanized where vessels are relatively larger with the engine fitted inside the vessel (inboard engine) and used for propulsion and gear operation. The sub-sectors, non-motorised and motorised with the area of operation limited to coastal and nearshore areas are considered exclusively as small-scale gillnet sector.

Based on mesh size, gillnets are classified into small (<45 mm), medium (45-70 mm) and large mesh (>70 mm). The non-motorised sub-sector operates small and medium mesh gillnets, from wooden and FRP canoes and fishing is confined to single day operations. The motorised gillnet sub-sector includes two categories, first category where vessels are fitted with outboard engines of up to 15 hp and undertake single day trips and usually carry small and medium mesh gillnets and trammel nets onboard, targeting mainly mackerel, sardine, anchovy, shrimp and pomfret. The second category of motorized sub-sector includes vessels of larger size which undertake multiday fishing of 3-5 days and fitted with 15 to 28 hp outboard engines targeting seer fish and tuna, using large mesh gillnets.

Design & operation

Gillnet basically is a long wall of netting kept erect in water by having floats at the upper side



Design of a typical simple gill net

and sinkers at the lower side. The net consists of a main netting panel of specific dimension, twine size and mesh size, selvedge, head rope, foot rope, float line, lead line, gavel line/ side ropes, floats, sinkers, buoys and buoy lines depending on the target fishery. Main netting material is either polyamide/nylon (PA) monofilament or multifilament. Selvedge, generally of thicker material than the main netting is provided along the edges to give protection to the main webbing during handling and operation. The netting is mounted to the ropes by a continuous hanging twine which is passed through the meshes and tied to the headrope using staples or loops. Netting is rigged to the head rope based on particular hanging ratio which determines the looseness of the netting and thereby the shape and opening of the mesh as well as hung depth of the net. Nets have a hanging coefficient varying from 0.4 to 0.7 but mostly at 0.5. Floats are attached either directly to the head rope or to a separate float line, which runs along with the head rope and sinkers are attached either directly to the footrope or to a separate sinker line. Required number of gillnet units are tied end to end depending on the size of the vessel, availability of fish and area of operation.

Nets are operated as drift, set or encircling while drift nets are the most common. Driftnets drift freely as one end of the net is tied to a fishing vessel or to a buoy while the other end flows freely and are deployed to catch fishes swimming in mid-water or near surface layers. Set gillnets are fixed to the bottom by using anchors, heavy weights or are tied to poles or sticks fixed to the ground. Surface set gillnets target surface dwelling fishes and are operated in shallow coastal waters where current is negligible. Bottom set gillnets are used for capturing bottom dwellers and the nets are rigged with more sinkers and fewer floats so as to balance the net in water without falling to the ground. In encircling nets, the fishes are surrounded by the net and are driven from the centre by making noise and other means. Encircling type of nets are rarely seen nowadays probably due to the widespread use of efficient surrounding nets like ring seines targeting shoaling fishes.

Once set-in water, nets are soaked for periods varying from 30 min to 24 h depending on the targeted fishery and size of the net. Set gillnets on the other hand have long soaking time extending from 12 to 24 h. Setting and hauling of the nets are done manually in all types of gillnets operated in the small-scale sector.

Issues

Gillnet considered as a responsible gear, lost its reputation in early 1980s due to its large-scale operation in the high seas. Bycatch and incidental catch of non-targeted species including endangered species such as marine mammals, turtles etc and the incidence of gillnets or its part becoming ALDFG (abandoned, lost, or otherwise discarded fishing gear) leading to ghost fishing are serious problems alleged to gillnets.

Switching over of gillnet material from natural to synthetics resulted in an increased fishing effort as the volume of gear that can be carried onboard increased considerably and correspondingly the size of the vessel also increased to accommodate the large volume of gear. This gives more chances of gear loss and these lost gears cause financial loss to fishers as well as negative impacts in environment. Regulations on volume of gear to be taken are not available in many states of India except Kerala under the amendment of KMFRA rules & Act, 2018.

Commercial fishers often use gillnets consisting of units of different mesh sizes attached end to end, even though the optimum mesh sizes are suggested for several fishes. Besides, fishers use mesh size smaller than the optimum for a particular target species. These practices led to capture of juveniles and non-target species in coastal waters of India (Thomas, 2010). Also fishers rig the nets loosely which increases incidental capture of juveniles incidence and non-target organisms.

Introduction of nylon monofilament in late1990s and its wide spread use is another matter of concern. This material lasts hardly for one fishing season spanning 3-6 months and unlike nylon multifilament netting, it is difficult to mend monofilament netting of very thin diameter. Abandoning or discarding causes considerable threat to marine species (Ayaz *et al*., 2006). ALDFG has detrimental impacts such as destruction of habitats, entangling with marine turtles, seabirds, dolphins, whales, seals etc, introduction of invasive species, hazards to navigation, adverse effects on tourism, human health, and safety. First study from India on ALDFG reported annual gillnet loss rate as 24.8% of the total gear per vessel per year (Thomas *et al*., 2020). Considering the enormous number and quantity of gillnets operated in the Indian fisheries, this is an indicator of a serious problem requiring attention of the authorities and become a major contributor to plastic debris and to ghost fishing in the coastal environment.

Thus, the several issues associated with small-scale gillnet fishing, in the Indian fisheries sector demand technical interventions with regard to design and operational modifications as well as administrative and enforcement level measures.

Guidelines for sustainable small-scale gill net fishing

Technical and operational guidelines

- Maximum allowable dimension (length x depth) for the netting has to be specified for each fishery/state and the maximum dimensions to be followed for small scale gillnet fishing are 2000 m length x 10 m depth.
- Mesh size regulation would help to a considerable extent in sustainable harvesting of resources. The minimum mesh size recommended for specific fishery are; sardine (33 mm), mackerel (50 mm), croaker (40 mm), pomfret (126 mm), tuna (80 mm) and prawn (38 mm).
- Reduction in height of the net, setting the net just below the surface, use of aquatic pingers, increasing the reflectivity of net by treating with barium sulphate ($BaSO_4$) and use of stiff ropes are some mitigation measures to reduce mammal interaction with nets thereby reducing their incidental catches.
- Use of biodegradable materials in rigging floats on the nets would reduce ghost fishing ability of lost nets as once the material is degraded, the nets lose its configuration or collapse, thereby preventing further capture.
- Avoidance of operation in very rough weather/ areas with bottom obstructions, usage of materials with standard quality specification as the use of low quality and old/damaged netting give more chances for gear loss.

Administrative and enforcement level guidelines

- Restrictions for uncontrolled increase in volume of gear are required.
- Implementation of mesh size regulation and enforcing minimum legal size of fish to be caught would help in reducing juvenile capture as well as bycatch.
- Providing proper disposal facilities at the harbour and landing centres for damaged nets would be useful for reducing plastic pollution by these nets.
- Incentives to fishers would encourage them to bring back damaged and retrieved nets to shore.
- Awareness creation among fishers to address these issues through meetings and workshops.

Strict adherence to appropriate gear dimensions as well as incorporation of suitable measures to reduce bycatch and associated mortality in gillnets would be helpful for sustainable gillnet fishing in the small-scale sector.

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