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Contents

From the Editorial Board.....

The January-June issue of Fish Tech Reporter covers 18 articles on different aspects of fisheries research and discusses the recent developments in various sectors.

The commendable work carried out at ICAR-CIFT in the sustainable fishery development of the country is quite well known. Recent addition to this is the work carried out on acuostic pingers to avoid depredation and dolphin entanglement. The high levels of craftsmanship in making handmade wooden fishing boats and cargo vessels along the coast of Gujarat is well illustrated in the issue.

lntensification of aquaculture activities has also resulted in issues with regard to consumer safety in the form of antibiotic residues, heavy metal contamination and pesticides in the catch. This scenario has lead to the susceptibility of fish and fishery products to various hazards of physical, chemical and biological nature. ICAR-CIFT puts enormous efforts on identification or rapid detection of chemical and biological hazards with their well established Research and Development facilities. ln addition to this, globally there is an increasing concern on antibiotic residues and antibiotic resistant bacteria in fish and fishery products. A special emphasize has been given in this current edition on antibiotic resistance from pathogens of significance for seafood industry such as *Escherichia coli*, *Salmonella*, *Staphylococcus aureus* etc. and their pattern of resistances.

The recent advancements in processing like air frying and its benefits are discussed and compared with the normal oil frying. The article on recent interventions like fish descaling machine which is the new addition to the indigenous machineries of ICAR-CIFT is also appearing in the issue.

All the research highlights are either to improve the production or reduce the loss in various stages of production chain including capture and culture fisheries. We hope that the present issue will be helpful for the stakeholders and researchers in planning their future work.

Acoustic pingers: Prevention of fish catch depredation and dolphin entangling

Leela Edwin, Rithin Joseph and Leena Raphel

ICAR-Central Institute of Fisheries Technology, Cochin

The ring seine operation is the most popular gear among traditional fishers of Kerala and has spread to other coastal states of India. Ring seining involves surrounding schools or other accumulation of fish with a net, impounding the fish by pursing the net from below, and drying up the catch by hauling the net so that the fishes are crowded in the bunt and can then be brailed out. In recent years the major problem associated with the operation of the ring seine is the attack of dolphins and other Cetaceans during the time of aggregation and brailing of the catch. In India, interaction between humpbacked dolphin and trawl/purse seine fisheries is common. During ring seine operation, it was observed that groups consisting of up to 30 animals congregate in the fishing area and surround the ring seine net and cause disturbance to fishing by preying on fishes from the net.

In order to prevent this disturbance, two types of measures are practised by the fishermen. Some fishermen use crackers to drive away the dolphins from their fishing area. However, fishermen are cautious to avoid causing physical injury to dolphins. Others patrol the fishing area in small boats. Boat anchors, tyres or hard objects covered with plastic operated from carrier vessels are some of the indigenous objects used by fishermen to drive away the dolphins from fishing grounds. This will lead to the death of the animal. In order to overcome this problem without harming marine Cetaceans, ring seine fishers of central Kerala have fabricated a new wall net known as Dolphin Wall Net (DWN) using locally available materials with low investment to prevent the damage caused by dolphins. Dolphin Wall Net is a 1000-1500 m long wall of netting framed with float line and steel rings hanging from the lower edge. The Dolphin Wall Net is made up of 300-400 mm high density polyethylene (HDPE) webbing of 1.5 mm diameter and 25 meshes in depth. DWN is operated from the carrier vessel with an L_{OA} 9-13 m (Prajith *et al.*, 2014).

Fishers believe that dolphins come near the shore due to the scarcity of fishes in the sea. The major species occurring in the Cochin region are *Stenella longirostris* and *Sousa chinensis*. Other species are *Turisops aduncus*, *Delphines capensis* and *Gampus gristeus*. Bottlenose dolphins are often victims as they come close to the fishing nets and get entangled. Humpback dolphins are the most common near shore Cetaceans found along the Indian coast (Dipani *et al.*, 2015). Once entangled in the fishing nets the animals suffocate and in an attempt to break loose they damage the nets and causes economical damage for the fishermen.

One solution to prevent this is the use of pingers. Pingers are devices that produces ultrasound which keep the bottlenose dolphins and porpoises away from the nets. Pinger is designed to work by emitting a sound wave signal beyond 70 kHz that is known to be in the best hearing range of most dolphin species. The signal acts as an alarm, and in some cases the pinger stimulates dolphins to use their echolocation which alerts them to the presence of the pingers and fishing nets. This sound wave is not audible to human beings, but it creates disturbance to dolphins and results in checking approach of dolphins near to fishing net. The dolphin pingers use re-chargeable battery.

Marine mammals have highly developed species-specific senses of hearing, which appear to influence the effectiveness of different types of acoustic devices (Kraus, 1999). A thorough review of marine mammal acoustics is given by Ketten (1998). Acoustic devices fall into two main categories: Acoustic Deterrent Devices (ADDs) and Acoustic Harassment Devices (AHDs).

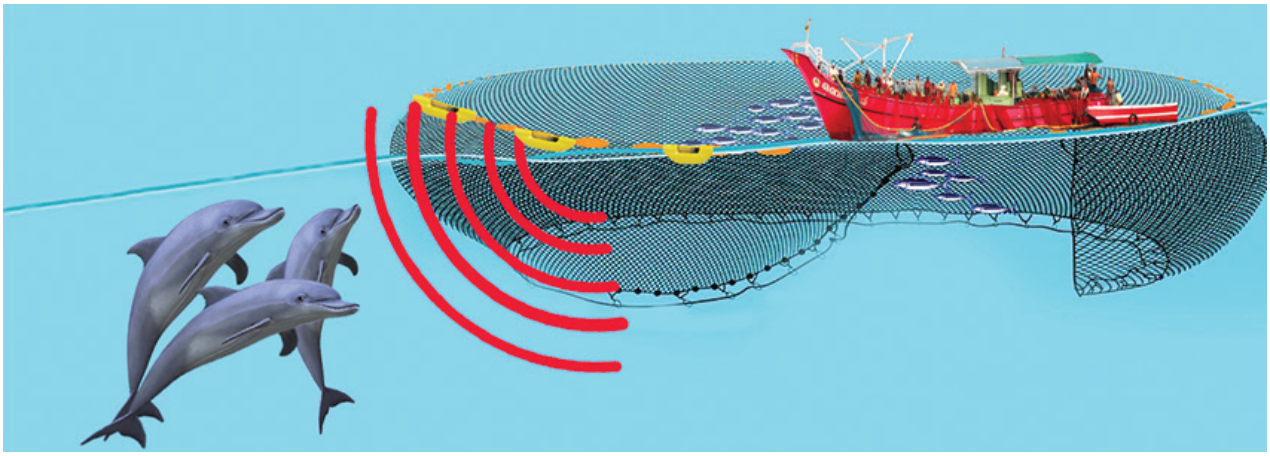


Illustration of how a pinger works

The use of pingers has become mandatory in the European Union in an attempt to limit Cetacean bycatch (Culik *et al.*, 2001). The standard pinger emits a signal of 10 kHz (with harmonics to at least 60 kHz) with a source level of 132 dB re 1 micro Pascal at 1 m, which is within the hearing range of most Cetaceans and Pinnipeds (Reeves *et al.*, 1996). Different pingers can emit sounds differently, with regular pulse intervals and random intervals or frequency sweeps. Pingers are often referred to as acoustic alarms, as they are designed to alert marine mammals of the presence of nets without causing pain or damage to the animal's auditory system.

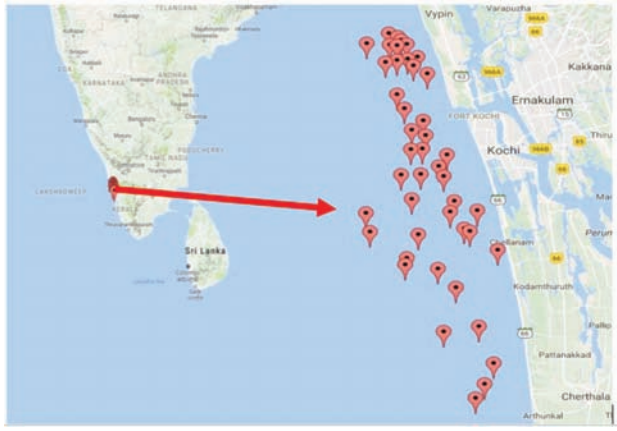
Initiative by ICAR-CIFT

In order to avoid damage to Cetacious fishes in net, ICAR-CIFT introduced Pinger in Kerala. A fishermen group from Chellanam fishing village, Kerala was associated with ICAR-CIFT for this operation. After the three month study it is observed that pingers were effective against dolphin attack.

The pingers were deployed in a ring seine fishing vessel of 24 m length using fishing gear with a mesh size of 20 mm, hung length of 1010 m, hung depth 105 m and weight 2500 kg. A total of 44 fishing operations were carried out and the prelimenary study showed a reduction in the marine mammal entanglement and depredation of the target fish caught (Fig. 1). Experiments on commercial seines are being continued with variable frequency devices.

Different types of acoustic pingers

The economic loss caused by dolphin attacks



Experimental locations

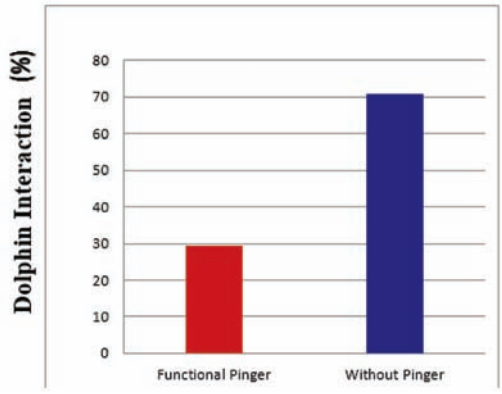


Fig. 1. Performance of ring seine with acoustic pingers

ranges from ₹10000-15000 per month and in some cases when the attack is severe, up to ₹ 300000/- is spent for repair. Loss of fishing days for repair is another associated loss.

Conclusion

Depredation by Cetaceans is a growing problem not only in ring seines but also in other fishing gears and have serious economic implications on fisheries. Several studies such as experimenting with other acoustic deterrent/ harassment devices and *in situ* underwater studies regarding the behaviour of depredating organisms are necessary to reduce the problem such as depredation. Pingers did not adversely affect fish catch. Nets equipped with functional pingers suffered less damage, both in terms of catch loss and net damage. In this scenario the use of pingers will help the fishermen to reduce Cetacean attack and incidental entangling in fishing net.

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Fuel saving through material substitution in trawls

Remesan M.P., Madhu V.R., Sayana K.A., Prabeesh Kumar, M.V., Harikrishnan K.R. and Leela Edwin

ICAR-Central Institute of Fisheries Technology, Cochin

Fishing consumes 15 to 20 times more energy than it produces (Endal, 1980) and the average fuel consumption by the fishing industry is estimated at 15-21.5x10^6 t (Thomson, 1988). Increased use of fuel intensifies the carbon foot print and green house gas effect which leads to global warming, climate change, etc. Fuel consumption assumes prime importance to fishermen due to hike in operational costs apart from its environmental effects. According to Tyedemers *et al*. (2005), world fishery fuel consumption is 50 billion (5 x 10^9) liters. There is an 8% increase in the contribution of fuel cost to the total operating expenses within a time of two years (Fødevareøkonomisk Institut, 2011). Annual fuel consumption of mechanized and motorized fishing

sector of India is estimated to be 1220 million liters (Boopendranath, 2000) and about 60-80% of the operational cost is contributed by the cost of fuel consumed.

Trawling is the most energy intensive fishing activity and trawlers are one among the most fuel consuming fishing systems. Compared to passive fishing methods like gillnetting and long lining, trawling consumes five times more fuel and it is 11 times more compared to purse seining. To catch one kilogram of fish, trawling requires 0.8 kg of fuel while for gillnetting 0.15 kg, for long lining 0.25 kg and for purse seining 0.07 kg are required (Gulbrandsen, 1986). The fuel consumption of trawlers which depends on installed engine horse power and duration of voyage constitute 45 to 75% of operational expenditure. The resistance offered by the gear has a large effect upon speed of vessel and fuel consumption.

Even though the fuel price is in an increasing trend, its usage is also increasing due to the increasing size and power of vessels. Fuel consumption is the factor which contributes more than 60% to the total economics of the trawler. Hence reducing the fuel consumption will optimize the economics and carbon footprint of the fishing industry and it is the reason for intensification of research on energy efficiency.

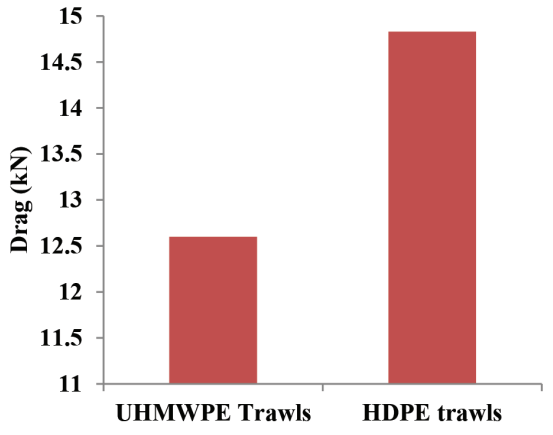
Under the National Agricultural Science Funded (NASF) project on Green Fishing Systems for Tropical Seas (GFSTS), ICAR-CIFT designed and fabricated low drag trawls for fish and shrimp of head rope length 24.47 m and 3.00 m, respectively. The drag reduction measures included in the design are increased mesh size and new material. The material used is ultra high molecular weight polyethylene (UHMWPE). As UHMWPE provides same strength at a lower diameter, the twine size was reduced which results in reduced twine area. For evaluation of new designs, trawl nets using conventional material, high density polyethylene (HDPE) is also fabricated and used as control. The experiments for evaluating the new design were conducted onboard M.V. Matsyakumari II. Data regarding drag and fuel consumption experienced for each operation were recorded using Warp tension meter and Fuel flow meter fitted to the fuel line of the vessel. The depth of operation ranged from 10 to 20 m, the fishing speed was 3 to 4 kn and the warp length varied from 40 to 100 m.

Warp tension meter in use

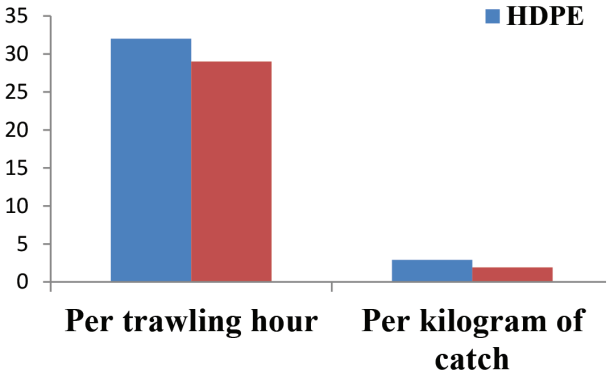
Operation of UHMWPE trawl nets onboard M.V. Matsyakumari II

From the trials conducted, the average reduction in drag of new design is estimated to be 17%. The drag of control and experimental gears at different operational parameters was also analyzed and UHMWPE trawls showed lesser drag than HDPE trawls.

The average fuel consumption per hour of



Average drag of HDPE and UHMWPE trawls during one hour of trawling



Comparison of fuel consumption of conventional and low drag trawls

trawling for HDPE trawls was estimated to be 30 L and for UHMWPE trawls 26 L. The average reduction in fuel consumption was found to be 10%. The fuel consumption per kg of fish captured estimated was 2.9 L. for HDPE trawls and 1.9 L. for UHMWPE trawls and the average reduction was 35%.

The drag and the fuel consumption of low drag trawls are 17% and 10%, respectively lower when compared to conventional HDPE trawls. Hence it is evident from the study that, use of energy saving material like UHMWPE will reduce the drag and thereby fuel consumption of trawlers considerably.

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Handmade wooden boats of Gujarat: Craftsmanship for the ocean

Prajith K.K., Paradva J.B. and Pungera H.V.

Veraval Research Centre of ICAR-Central Institute of Fisheries Technology, Veraval

Indian boat technology and navigational knowledge dates back to the IIIrd Millennium BC. Historical records show that Harappans not only built unique docks but also provided facilities for handling cargo. In Gujarat, Traditional wooden fishing boats and cargoes building takes place mainly in Kutch, Valsad, Mangrol and Veraval. Mandvi is the one of the oldest place synonymous

for the wooden boats and cargoes construction for centuries. Even the boat construction in other parts of the state is done under the supervision of people from Kutch region locally known as "*Kutchees*".

Boat construction in Gujarat is carried out throughout the year and maximum numbers of boats are built during non-fishing season. Fishing season in Gujarat is usually of nine months from September to May. In the remaining months, fishing activities remain closed from 10 June to 15 August as per the Marine Fishing Regulation Act of Gujarat - 2003 and also due to monsoon as well as rough conditions in the sea. Types of trawlers common in Gujarat are wooden and FRP trawlers. Wooden and FRP trawlers are common in Gujarat. While wooden boats are constructed fully with wood, in FRP boats, only the main ribs are constructed with wood and the external cover is provided with FRP sheath. Shri Prabhudas Bensala, an active fishermen of Veraval says "Initially the space between each ribs in FRP boats were maintained as 15-20 inches. This resulted in less stability and tilting of vessel during navigation, especially at high speed wind conditions. Realizing this difficulty, presently, the distance between the wooden ribs are maintained as 9 inches. This

Data collection in progress

Various stages of boat construction and tools used for construction


Mould used for FRP Boat construction and inner wooden ribs of FRP boat


Wooden Boats under construction

FRP Boats under construction

increases the stability of vessel". The length of the vessel ranges from 12.8-20.0 m and the construction (including engine) cost of FRP and wooden boats are approximately ₹ 30 and 40 lakhs, respectively. 12.8 m boats are considered as the old classes of vessels and construction of such vessels are almost stopped. Presently most of the vessels are coming under the length class of 14-15 m. The wood used for construction is coming from various parts of the state. Babul and Sal wood are the major wood used. In the case of wooden boats, big wooden planks are curved with the help of fire. Babul wood is used for the construction of the inner ribs and Sal wood is used for the rest of the construction. Teak wood is used for the construction of wheel house. Almost 40 and 60 tons of wood is used for the construction of an FRP and wooden boats, respectively. The time required for constructing the entire vessel is four months. Engine power of the vessel ranges from 165-230 hp. Construction is mainly done with the simple traditional tools like harmer, chisel, driller etc. Electric instruments for cutting and polishing the wood were introduced recently. Once the construction finishes, treated fish oils and antifouling paint coating is applied in the parts which are susceptible to boring and degradation. The design of the vessel is decided by the person locally known as *Mesthri*. There will be a main contractor for monitoring the work. He will manage the workers and assign duties to the workers. About 8-10 workers will work under the supervision of contractor. Boat owner will provide ₹ 3-4 lakhs to the contractor as the labour charge. The contractor will distribute wages to the workers from this share. The per day wage of skilled labour is ₹ 500-1000 depending on the nature of work. Once the construction is over, the boat will be

Wooden Kotia under construction

lifted to specially designed lorry and transported to the respective berthing area. With the help of cranes, the boat will be transferred to water. This transportation cost for the lorry and crane will be ₹ 15,000 and 10,000, respectively. Average life of the wooden vessel is estimated as 20-25 years and it depends on the hydrographic conditions and maintenance. FRP trawlers were introduced in fishing sector of Saurashtra region nearly 5-7 years back. Presently, there is no report on steel fishing vessels from Saurashtra coast.

***Kotias*: Wooden cargoes connecting India to Middle East and North Africa regions**

Besides fishing vessels, there is another class of vessels used for cargo purposes. In local parlance, these vessels are known as Kotias, Vaahan etc. These vessels have a total length of 30-40 m and a width of 12-14 m. Similar kind of vessels known as 'Dhow' are constructed in the Middle East countries. The wooden cargo vessels of Kerala are known as *"Uru"*. The construction details are same as that of the fishing vessel. As these are very big vessels, it may take 2-3 years to complete the construction. The cost of construction will be around ₹ 3-4 crores. After construction, vessels are transported to Middle East countries. During this voyage the vessels transport rice, wheat, sugar, cattle, sheep etc. from India. During the journey, there will be 15-18 crews including *Tandal*, *Malam* and one mechanic from the engine side. *Tandal* is considered as the captain and navigational operation is done by the *Malam*. From the respective port, further transportation of various goods will takes place within Arab nations and African countries like Mozambia, Somalia, etc. If the owner gets a good price for the *Kotia*, he will sell the vessel even to the persons outside the country. For this, registration of the vessel need to be cancelled from India, and reregisration should be done in the respective nation. Wooden fishing vessels and Kotias are the symbol of exceptional craftsmanship of the Indian traditional boat builders and these are part of our great culture, history and civilization.

Melanosis inhibition in ice stored *Litopennaeus vannamei* using alternaives to sodium metabisulphite

Viji P., Jesmi Debbarma and Madhusudana Rao B.

Visakhapatnam Research Centre of ICAR-Central Institute of Fisheries Technology, Visakhapatnam

Melanosis or black spot formation is a serious but, common quality defect in Crustaceans during post harvest handling and storage. Although melanosis causes no health issues, it diminishes the sensory appeal of the product, ultimately leading to low commercial value. This is being considered as a

major quality/economic problem in the trade of highly priced commodities such as shrimp. Melanosis is caused by the enzymatic oxidation of colourless phenols to quinones which further undergoes oxidation to black or brown melanin. The intensity of melanosis varies among species as it is dependent on substrate and enzyme concentration (Benjakul *et al.*, 2005). Black spot formation is rapid in *L. vannamei*, especially on the carapace, pleopods and telson, making it unacceptable to consumers, but does not necessarily indicate spoilage. Sulphite-based additives have widely been used to control melanosis in shrimp. However, increasing regulatory attention and consumer awareness regarding the safety of sulphite chemicals have generated the necessity of exploring safe chemicals or natural additives for melanosis inhibition. In this context, a study has been carried out to evaluate the efficacy of a blend of reducing agent Sodium citrates (SC) chelating agent (EDTA) and a natural antioxidant, pomegranate peel extract on controlling melanosis development in *L. vannamei* during iced storage.

Fresh shrimp were procured from the farm and brought to the laboratory in iced condition within six hours of harvest. Shrimp was deiced, the specimens which already indicated melanosis formation were removed and the remaining quantity was divided into five lots. Samples were treated in water without any additive (control) for 5 min. (A), solution containing 1.25% Sodium metabisulphite (SMS) (w/v) for 1 min., (B), solution containing 0.5% SMS, 0.5% Sodium citrate (SC) and 200 ppm EDTA for 5 min., (C), solution containing 0.5% SC and 200 ppm EDTA for 5 min. (D) and, solution containing 0.5% pomegranate peel extract (PE) for 5 min. (E). The shrimp after treatment were packed in polyethylene bags and stored in ice in insulated boxes. The melted ice was not replaced at any time during the storage period and the samples were withdrawn at 0, 12, 24, 36, 48 and 54 hrs for evaluation of melanosis score, total volatile base nitrogen (TVB-N), instrumental hardness and total plate count (TPC).

The results of the study revealed a significant effect on controlling the black spot formation by the different alternatives used, in which the treatment with solution containing pomegranate extract and those containing 0.5% Sodium citrate and 200 ppm EDTA was more effective than the treatment with 1.25% Sodium metabisulphite alone (Fig.1). At the end of 54 hrs, melanosis score reached 8, 5.5, 5, 4 and 5, respectively for A, B, C, D and E samples (Fig. 2). TPC of PE treated and combination of SC+EDTA treated samples was significantly lower than that of other treatments and control samples. The TPC at the end of 54 hrs of iced storage was 2.2 $x10^5$ cfu/g, 1.2$x10^5$ cfu/g, 4.5$x10^5$ cfu/g, 2.3$x10^4$ cfu/g and 2.2$x10^4$ cfu/g, respectively for A, B, C, D and E samples. TVB-N and pH of pomegranate extract treated samples remained lower compared to other samples. In general, the hardness values reduced over the storage period in all samples, but the effect of treatment was not apparent. The result of the

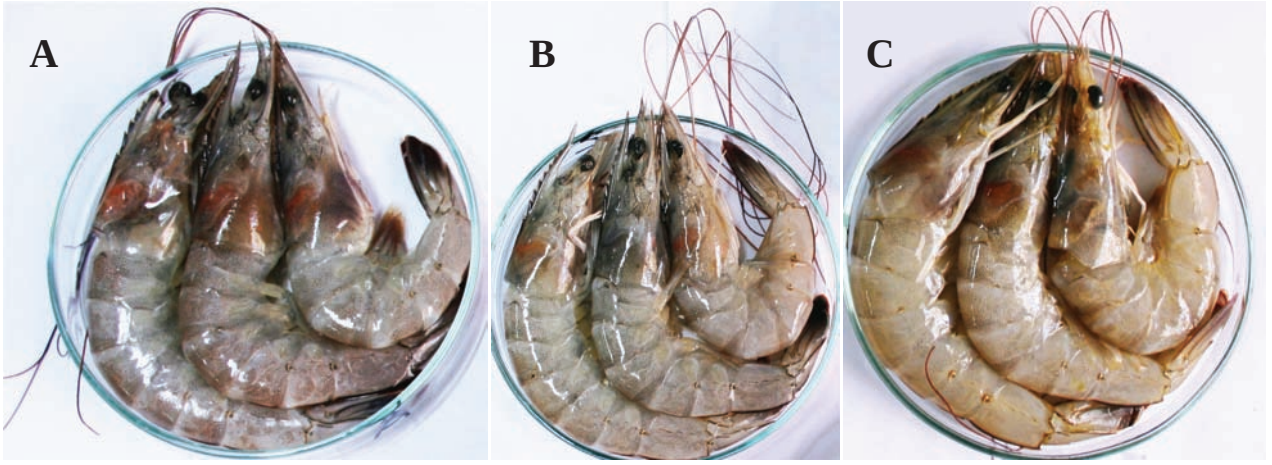

Fig. 1. Melanosis at 48 hr of iced storage (A) Control: Water without any additive (control) for 5 min., (B) Treated with 0.5% SMS for 1 min., and (C) Treated with 0.5% pomegranate peel extract

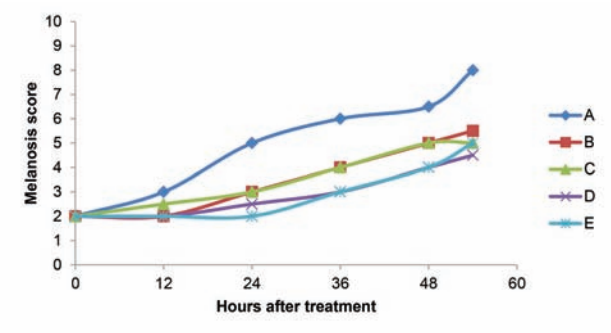

Fig. 2. Melanosis score of *L. vannamei* during iced storage

Melanosis scoring (0-10) (Nirmal and Benjakul, 2009): 0: Absent, 2: Slight (up to 20% of shrimp surface affected), 4: Moderate (20-40% of shrimp surface affected), 6: Notable (40-60% of shrimp surface affected), 8: Severe (60-80% of shrimp surface affected) and 10: Extremely heavy (80-100% of shrimp surface affected)

study indicated that pomegranate peel extract and chemicals like Sodium citrate and EDTA can be used as alternatives to control melanosis development in cultured shrimps. However, the use of proper concentration of the blends of chemicals and use of colourless pomegranate extract has to be further investigated.

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Protein isolate from Bombay duck mince: Ideal for value addition

Jeyakumari A., George Ninan, Narasimha Murthy L. and Parvathy U.

Mumbai Research Centre of ICAR-Central Institute of Fisheries Technology, Mumbai

Bombay duck (*Harpodon nehereus*) is one of the most important pelagic fishery especially along the west coast of India. Due to its high moisture content (90%), it is unsuitable to use as mince for the development value added products. Generally, bulk of Bombay duck catch is consumed in fresh and sundried form. This study is aimed to explore the possibilities of better utilization of this fishery resource for the development of value added products. Fish protein isolate (FPI) is prepared from fish mince or shell waste by using pH-shift technology and it mostly contains myofibrillar proteins extracted from the fish muscle (Hultin *et al.*, 2005). FPI can be used as an ingredient for production of value added and ready-to-eat products based on minced fish or surimi (Shaviklo *et al.*, 2010).

Fresh Bombay duck were procured from Vashi fish market and brought to laboratory under iced condition. The average length and weight of fishes were 24.5 ± 0.5cm, 200 ± 1.5 g, respectively. Fish mince was used as raw material for preparation of protein isolate. Fish protein isolate was prepared by alkali solubilization method. The solubilization can be accomplished by adding 5-10 volumes of water followed by adjusting the pH approximately to 11 (Hultin *et al.*, 2005). The mixture was then centrifuged. This allows the light oil fraction to rise to the top of the suspension. At the same time the lipids of the membrane are removed due to density differences compared to the main protein solution. Other insoluble impurities are also sedimented at this stage. Then, the muscle proteins were precipitated by adjusting the pH to a value near the isoelectric point (pH – 5.5) and collected by a process such as centrifugation. Fish protein isolate (FPI) obtained from this process can be stored in frozen condition

or might be dried for further utilization.

In the present study, the recovered wet protein isolate was used for the preparation of restructured fish products by incorporating salt and sodium alginate followed by steam cooking (Fig. 1). Based on the preliminary sensory analysis, combination of 1% salt, 1% sodium alginate and 0.5% calcium was selected for the study. Products were kept under chilled condition (2°C). Biochemical and microbiological quality of the products were evaluated up to 16 days.

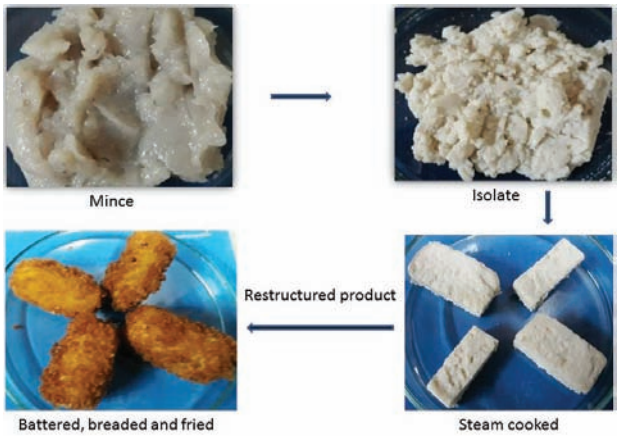

Fig. 1. Restructured product from Bombay duck isolate

Proximate composition of the mince, isolate and products are given in Table 1. pH of the Bombay duck mince, isolate and restructured product were 6.6, 5.7 and 6.2, respectively. Colour analysis revealed that higher *L** value for isolate (78.80) than the product (78.25) and mince (54.05).

Biochemical analysis showed increasing trend for pH, TVB-N, PV and TBA during storage. Initial TVB-N and peroxide value of the product were 4.2 mg% and 3.9 meq.O_2/kg, respectively and it increased to 5.3 mg% and 22.03meq.O_2/kg at the end of storage. A peroxide value of more than 20 meqO_2/kg for fish usually gives rancid taste (Romeu-Nadal *et al.*, 2006). Accordingly, in the present study, peroxide values of the products were within permissible limit up to 13th day (15.45 meq O_2/kg). Initial TBA value of the product was 0.37 mg MDA/kg and it increased to 1.02 mg MDA/kg. TBA values of 1-2 mg MDA/kg are usually regarded as the limit, beyond which fish will normally develop an undesirable odour (Adenike, 2014). Total viable counts increased gradually during storage. A 5 $\log_{10}$ is considered as acceptable limit for restructured product (Gilbert *et al.*, 2000). In the present study, total bacterial count reached 5 $\log_{10}$ on the 16th day. Sensory evaluation revealed that products were acceptable throughout the storage. It can be concluded that restructured product prepared from Bombay duck isolate had an acceptable level of TVB-N, TBA and total plate count during chilled storage. Since the fish has only limited scope for consumption in the fresh form, development of value added products is a better option for the utilization of the species.

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Table 1. Proximate composition

Sample Moisture	Protein	Fat	Ash	Unused steel
Mince	89.65 ± 0.25	12.25 ± 0.10	0.40 ± 0.02	0.55 ± 0.05
Isolate	80.14 ± 0.10	16.50 ± 0.05	0.35 ± 0.04	2.5 ± 0.02
Product	76.04 ± 0.15	17.8 ± 0.15	0.45 ± 0.05	4.5 ± 0.01

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Air frying - A healthy alternative for conventional frying

Priya E.R., Sarika K., Lekshmi R.G. Kumar and Greeshma S.S.

ICAR-Central Institute of Fisheries Technology, Cochin

Breaded and battered products are well established in both domestic as well as commercial practice. They often have high consumer value as convenient foods. The deep fat fried and pan fried products are palatable as well as highly desirable for consumers as snack foods. At the same time, excessive consumption of fried foods may cause health risks like cardiovascular diseases, hypertension, diabetes, obesity and even cancer. The estimates show that, about 20 million tons of frying fats and oils are used for frying purpose in restaurants, commercial and household practices annually. The high level of degradation products in reused oil causes major health concerns, rather than eating fat and oil fried products directly. Economic concerns like high oil requirements, oil price etc. is the main driving force behind the reuse and abuse of oil in the food processing sector. The introduction of new technology like air frying with less/no use of oil for production of fried foods pave a new dimension to the value addition of food sector. The current trend of the society to have fat-free convenient health foods also support the less oil/oil-free technology. At the same time, there exists a need to understand the technology in a scientific manner for the benefit of consumers, on health, economic and environmental aspects.

Air frying is an emerging convenient technology specially intended for domestic consumers. During the process, the product is in constant motion and contact with super-heated air flow in a frying chamber, thus the product get dehydrated and the typical crust of fried products gradually get developed. The constant motion of the product and air circulation enables the uniform cooking of ingredients from all the angles. The present study aims to understand the possibility of air frying as an alternative technology for conventional frying method.

The experiment was conducted to optimize the process parameters such as frying time, and temperature with a two factorial central composite design in Response Surface Methodology (RSM). The overall acceptability of air fried fish fingers prepared from Pangasius fish fillets were statistically optimized with 13 different combinations. The sensory characteristics of the products with different combinations were evaluated for its quality attributes like colour, taste, appearance, flavour and overall acceptability; on a 9-point hedonic scale keeping 9 for excellent and 1 for very poor as per the method of Murray *et al*. (2001).

The desirable optimum combination of temperature and time for air frying was found to be 190 °C for 16 min. (Fig.1). The product was then further compared with deep fat fried fish fingers with already established optimum conditions (180 °C for 3 min. - Tokur *et al*., 2006, Zhang *et al*., 2012, Sebedio *et al*., 1993) and found that both products got similar acceptability as assessed by the sensory panellists.

The proximate composition analysis indicated significant difference in moisture and fat content of air fried and deep fat fried fish fingers. The higher moisture content (43.67%) in air fried fish fingers compared to deep fat frying (26.33%) may be due to longer frying time in air frying compared to deep fat frying. Lower moisture content in deep fat fried product in turn resulted in a higher fat

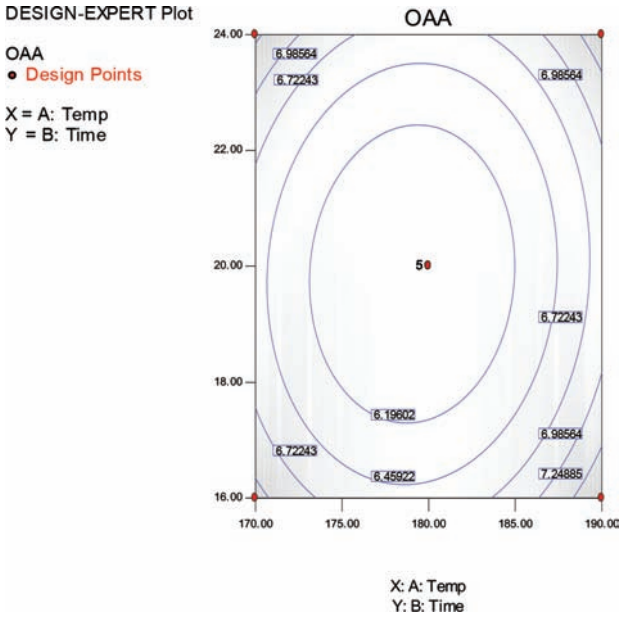

Fig 1. Contour plot of optimization of air frying for fish fingers

content (21.29%) than air fried ones (8.40%). The protein and ash content had shown no significant difference in frying methods irrespectively. (P<0.5)

Various reactions occurring during frying process like denaturation of protein, starch gelatinization, browning of batter and breading system etc. affects the crust formation and the colour of the fried product. The results obtained showed that air fried fish fingers have lighter colour than deep fat fried (Fig. 2). The redness values (a*) showed no significant difference while the yellowness (b*) was found to be higher for air fried product. The texture profile analysis of products showed that air fried products were having higher springiness and chewiness values which indicates the superior juiciness and mouth feel sensation of the product.

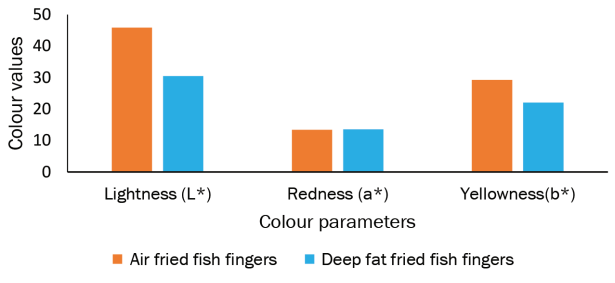

Fig 2. Colour parameters of air fried and deep fat fried fish fingers (*p<0.05*)

Deep fat fried fish fingers Air fried fish fingers

Major attraction of this technology is its economic viability. When compared with the huge volume of oil requirement in conventional deep fat frying, air frying requires only 3% oil. Hence it can be concluded that, air frying technology provides fast, effortless, safe frying with easy clean up and healthy food than other frying technologies.

Acknowledgements: This work was done at Defence Food Research laboratory (DFRL), Mysuru during the Professional Attachment Training of the first author. Thanks are due to Dr. M.C. Pandey, Scientist G, Department of Freeze Drying and Animal Products Technology, DFRL, Mysuru for his valuable suggestions during the research work.

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Air frying Vs oil frying of farmed tilapia (*Oreochromis mossambicus*) steaks

Mohan C.O., George Ninan, Zynudheen A.A. and Ravishankar C.N.

ICAR-Central Institute of Fisheries Technology, Cochin

Consumers are becoming more conscious about the healthy products which have resulted in the quest for newer processing methods. Although oil fried fish products are highly preferred by the consumers it affects the nutritional value considerably. Hence, air frying was evaluated as an alternative process for oil frying in this study. For this, two temperatures (180 and 200 °C) were considered for both air frying and oil frying. Frying duration of 3 and 6 min. were tested for oil fried tilapia at 200 and 180 °C, respectively. In air frying, time duration of 15 and 20 min. were tested at 200 °C, whereas 20 and 25 min. were used at 180 °C based on sensory appearance of the final product. The effect of different frying temperature and duration on the fatty acid profile, fat absorption, weight loss, shrinkage and instrumental colour was investigated. Weight loss was maximum in air fried steaks (50-61.88%) compared to oil fried samples (41.7-45.1%) (Fig. 1). Oil frying resulted in greatest shrinkage reaching a value of 39.90 and 33.68% for 180 and 200 °C, respectively. For air frying shrinkage ranged between 22.58-31.54%. Instrumental colour values of both oil fried and air fried samples were significantly different ($P<0.05$) from fresh samples. The results indicated that, air fried samples were lighter, less yellow compared to oil fried samples. Among the saturated fatty acids, the content of palmitic acid decreased significantly in the oil fried samples whereas linoleic acid increased compared to air fried samples (Fig 2). Loss of palmitic acid ranged between 61-66% for oil fried samples compared to 2.9-5.6% for air fried samples. Significant loss of Ω-3 fatty acids and increase in Ω-6 fatty acids were observed for oil fried samples compared to air fried samples (Fig 3). Level of linoleic acid increased to 5.2-5.6 times in oil fried samples compared to fresh tilapia. Whereas, in air fried samples the increase in linoleic acid was only 1.07 - 1.20 times. Loss of arachidonic acid was to the tune of 68-71% for oil fried tilapia steaks compared to an increase of 0.9-13.8% for air fried samples. Loss of EPA and DHA was only 1.5-10% and 0.4-

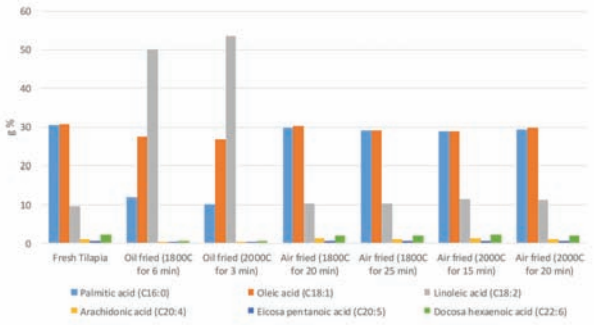

Fig 2. Fatty acid profile of oil and air fried tilapia steaks

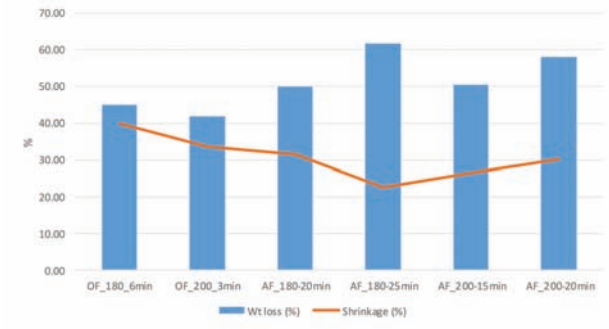

Fig 1. Weight loss and shrinkage of oil and air fried tilapia steaks

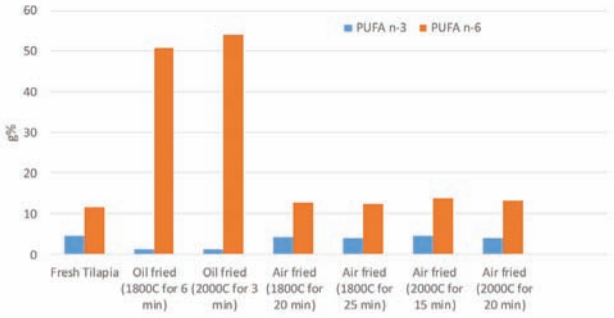

Fig 3. Changes in Ω-3 and Ω-6 fatty acids of oil and air fried tilapia steaks

8.4%, respectively in air fried samples compared to 43-54% and 71-74%, respectively for oil fried samples. PUFA/SFA ratio increased in oil fried samples whereas it did not differ in air fried samples. A better n3/n6 ratio was observed for air fried sample compared to oil fried sample. Air frying offers advantages that food products can be fried without using oil, preserving its natural colour, appearance and taste. Use of air frying helps in improving the health status of consumers and also improves the useful fatty acid profile of fish like tilapia.

Synthesis and characterization of seaweed extract based bioplastic reinforced with silver nano particles

Ashish Kumar Jha, Sivaraman G.K., [1]Asha K.K. and [1]Suseela Mathew

Veraval Research Centre of ICAR-Central Institute of Fisheries Technology, Veraval

[1] ICAR-Central Institute of Fisheries Technology, Cochin

Majority of the modern-day packaging materials are composed of fossil-based polymers which are hazardous for the environment. Biopolymers provides an excellent alternative to petroleum-derived polymers as they are environmental friendly, biodegradable, naturally available, renewable and comparatively cheaper. The importance of the biopolymer packaging material increases as they not only act as barriers to oxygen and carbon dioxide, but also provide a platform for incorporating a wide range of additives such as, antimicrobial agents, antifungal compounds, colourants and other desirable nutrients. In the recent past, biopolymers from different natural resources such as cellulose, starch, lignin, soy protein, whey protein, wheat gluten, etc. have been extensively tried for development of ecofriendly biodegradable packaging materials. Though biopolymer-based films can be prepared from proteins, carbohydrates and lipids, carbohydrate-based films are the most preferred ones, because of their colloidal properties and better film forming ability. This has created a new avenue for seaweed polysaccharides such as agar, carrageenan, alginates etc. Agar is a hydrophilic colloidal polysaccharide extracted from red algae (Rhodophyceae) and is composed of alternate repeating unit of D-galactose and 3, 6 anhydro-β-galactopyranose. Agar is known for its excellent gel forming ability, biocompatibility, thermo-plasticity and hence, it has been tested as an alternative source for the petroleum-based plastic packaging materials. Due to the biocompatibility and blending properties of agar, various materials such as cellulose, carrageenan, nano clay, banana powder, *Aloe vera* extract, metallic nano particles etc. have been blended with it to improve its mechanical and functional properties. The nano reinforcement of the bioplastic packaging films with antibacterial function is believed to be a promising intervention to maintain the food quality and extend the shelf life. In the present study, agar film reinforced with silver nano particles was prepared using a solution casting method and their properties were characterized. The FT-IR spectra (Fig. 1) reveals typical agaran peaks, the peak around 2925 cm^{-1} was associated with C-H stretching vibration. The peak near 1638 cm^{-1} corresponds to the stretching vibration of the conjugated peptide bond formation by amine and acetone groups. The bands at 1073 and 1045 cm^{-1} indicates C-O stretching group of 3, 6-anhydro-β-galactopyranose and the peak at 892 cm^{-1} was assigned to C-H stretching vibration of β-galactose. However, there were no changes in the position of peaks after the addition of AgNPs in the film matrix, which indicates that there was no chemical interactions formed between polymer matrix and AgNPs, though it could have made physical integration. Scanning electron microscopy (SEM) (Fig. 2) revealed the proper integration and uniform distribution of nano particles in film

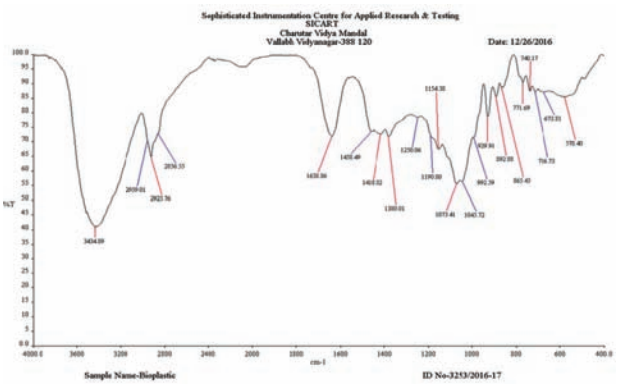

Fig. 1. FTIR analysis of film

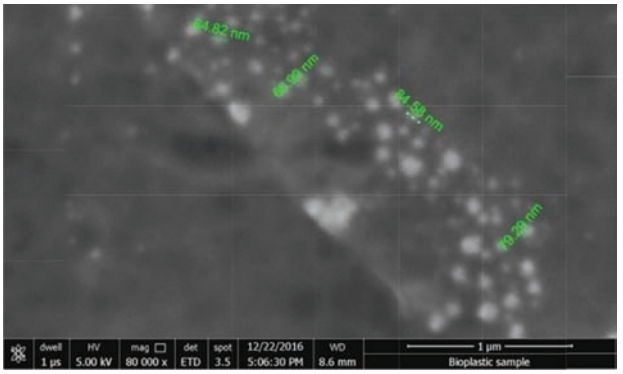

Fig. 2. Scanning electron microscopy showing the size of the nano particles

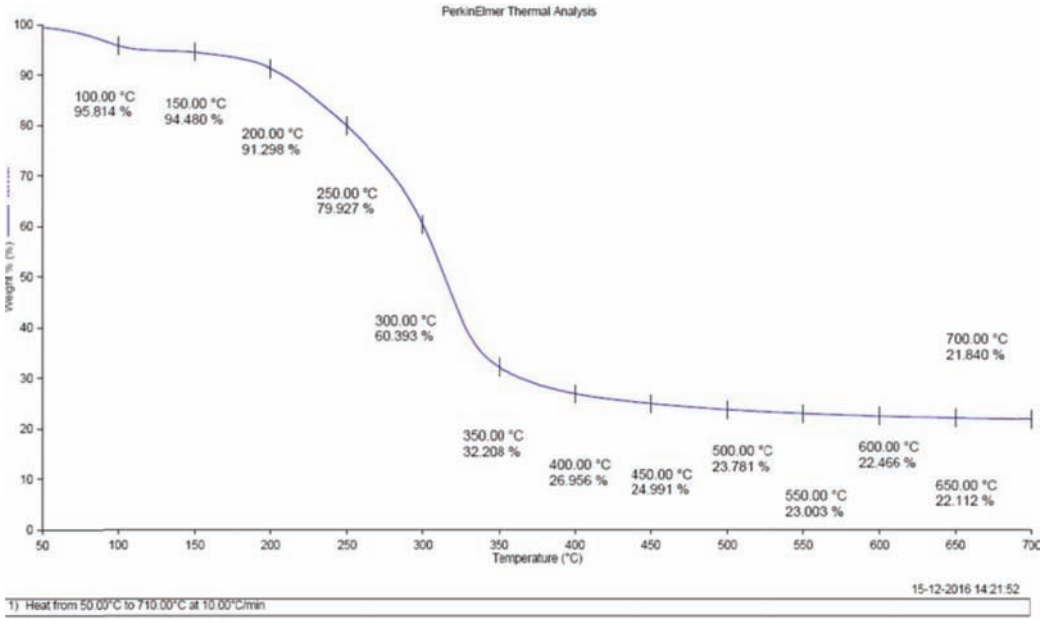

Fig. 3. TGA analysis showing thermal degradation pattern of film

matrices. It also confirmed the particle size of nano silver lied between 66 nm to 84 nm.The TGA thermograph (Fig. 3) showed two events of weight loss and the initial weight loss event was from 90°-100 °C where the film looses 4.2% of weight. The initial weight loss event was attributed to the evaporation of the moisture trapped in the polymer matrix. The second and major weight loss event was observed in the range of 200°-350 °C which is mainly due to the degradation of polymers and glycerol. The overall result of TGA analysis showed the stability of the biopolymer up to a reasonable temperature range. The nano particle incorporated agar film also exhibited a distinctive antimicrobial activity. The microbial analysis showed that the silver nano particle incorporated agar films has strong inhibition towards *Staphylococcus aureus* (ATCC 25923 and ATCC 43300) as well as emerging pathogen like MRSA (Fig. 4).

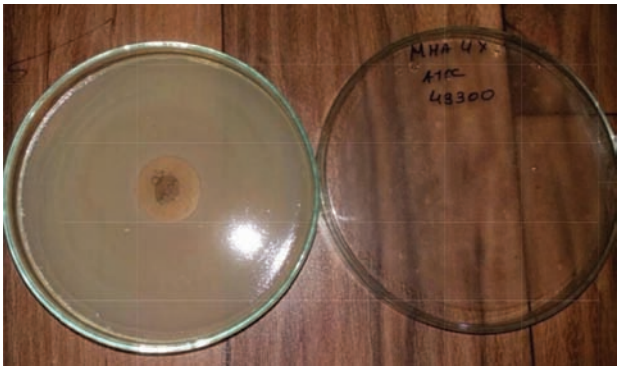

Fig. 4. Antimicrobial activity of film against *S. aureus*

Heavy metal content in fresh and frozen fishes available in super markets of Cochin

Laly S.J., Anupama T.K., Sankar T.V. and Ashok Kumar K.

ICAR-Central Institute of Fisheries Technology, Cochin

Heavy metal pollution of aquatic environment is a major concern since the advent of industrial revolution. The source of heavy metals includes direct atmospheric deposition, geologic weathering and discharges of agricultural, municipal or industrial waste. The incidents of heavy metal poisoning which resulted catastrophical effect on human beings across the world is still in history causing concern in the minds of people. Due to bio-magnification of heavy metals along the food chain, the unfavorable effects can increase. The indiscriminate discharge of heavy metals into the aquatic environment due to pollution is directly getting accumulated in the aquatic biota, particularly fish, which is preferred as a main protein source by a huge section of human population. The heavy metals in aquatic ecosystem can alter the growth, physiology, biochemistry and reproduction of the species and can also lead to the death of fish. These toxic elements can be detrimental to humans even at small concentration, if it is ingested over a long duration. As it is difficult to clear out toxic metals from our environment after its entry, it is highly essential to reduce the discharge of industrial wastes to the environment.

Fishes take in metals from the surroundings, directly or indirectly and accumulate in the body depending upon the intake, storage and elimination capacity. There are two categories of metals. The metals like aluminium (Al), cadmium (Cd), lead (Pb), mercury (Hg) and tin (Sn) which have no specific biological functions (Xenobiotics) and are non-essential metals and their toxicity increase with increase in concentration. While the content of essential metals like zinc (Zn), chromium (Cr), copper (Cu), nickel (Ni), cobalt (Co), molebdenum (Mo) and iron (Fe) at higher concentration can become toxic. The presence of toxic metals like mercury, cadmium and lead is included in all food safety regulations across the world countries. The metals like arsenic (As), chromium (Cr) and Nikel (Ni) were also considered in some regulations. In this context a study was carried out to ascertain the hazard level of these metals in the samples of fresh and frozen fishes available in super markets of Cochin. This assumes significance as the marketing channel through super markets is growing rapidly. A total of 45 samples of fishes sold in fresh and frozen condition from different super markets of Cochin were collected for the study. Fresh fish samples include *Lethrinus nebulosus, Nemipterus japonicus, Rastrelliger kanagurta, Lutjanus gibbus* and *Gerres filamentosus*. The frozen fish samples include Pangasius, Indian mackerel and Anchovy.

Table 1. Heavy metal content in fresh and frozen fishes collected from super markets

Heavy metals	No. of samples analyzed	Range (mg/Kg)	No. of samples present
As	45	Nd - 4.650	20
Cd	45	Nd - 0.235	28
Pb	45	Nd - 3.820	9
Cr	45	Nd - 0.493	17
Ni	45	Nd - 0.456	16
Sn	45	Nd - 0.943	16

The content of As, Cd, Pb, Cr, Ni and Sn in the meat of the samples were evaluated using ICP-OES (ICAD 6300 Duo view, Thermofisher, USA) (Table 1). Presence of As in fresh and frozen samples of super market was observed in 44.4% of samples with a maximum of 4.65 ppm which is well below the limit of 76 mg/kg (FSSR, 2011). Cd was detected in the 62.2% of the samples studied, with a maximum value of 0.235 mg/kg which is below the limit of 0.3 mg/kg for fishes (FSSR, 2011). While the Pb content crossed the limit of 0.3 mg/kg (FSSR, 2011) in 13% of fresh and frozen fish sample evaluated with a maximum of 3.82 (*Lutjanus gibbus*) and a minimum of 0.436 mg/kg (Frozen Pangasius). The lead content obtained in the current study is comparatively higher than the reports in fishes in and around markets of Cochin (Sivaperumal *et al*., 2007). Cr and Ni were present in 37.78% and 35.55% of the samples analyzed, respectively but were very much below the regulatory limits of 12 mg/kg for Cr and 70 mg/kg (USFDA, 1993).

The higher level of Pb (Fig. 1) in the fresh and frozen fishes collected from super markets is pointing towards the risk coming out of high industrial activity to our environment. Stringent regulations and actions are required to regulate the industrial discharges to water bodies.

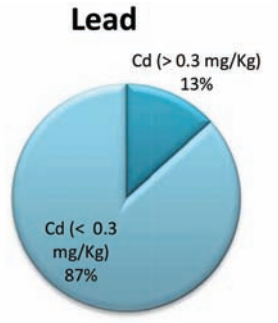

Fig. 1. Contaminaion level of lead in fresh and frozen fishes collected from super markets

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Growth kinetics and enterotoxin production of *Staphylococcus aureus* in fresh fish stored at 30°C

Anupama T.K., Panda S.K. and Ashok Kumar K.

ICAR-Central Institute of Fisheries Technology, Cochin

Staphylococcus aureus is an enterotoxin producing pathogenic bacterium occurring as commensal flora of humans on nasal cavity and skin surfaces (Alves *et.al.*, 2014). The lack of proper hygienic practices during handling and processing may result in the contamination of fish with *S. aureus*. The most common means of fish to be contaminated with *S. aureus* is through contaminated food contact surfaces or by contact with fish workers who are the carriers of this bacteria. This pathogen has a great importance to the food chain because of the ability of certain strains to produce heat-stable enterotoxins and other virulence factors responsible for Staphylococcal food poisoning (SFP), which is one of the most prevalent food-borne intoxication diseases. Staphylococcal enterotoxins (SE) are formed and secreted during late exponential or

post-exponential growth phase (Rosengren *et al.*, 2013). Many authors have reported the incidence of Staphylococcal enterotoxins in fish and fishery products (Chung *et al.*, 2010).

Usually, fresh fishes are displayed in retail or domestic markets at ambient temperatures without proper icing for several hours or kept for prolonged periods before the preparation in restaurants. During this course of time, fish proteins can breakdown into low molecular weight peptides and amino acids, which then support the growth of *S. aureus* (Simon and Sanjeev, 2007). As *S. aureus* is considered as a highly osmotolerant pathogen which can grow over a wide range of temperatures (10 to 45 °C), pH (4.5 to 9.3), and NaCl concentrations (up to 15%), complete elimination of this pathogen from food and contaminated surfaces is a difficult task. Even though normal cooking can kill this bacterium, the heat-resistant enterotoxins can persist and lead to SFP. The growth of enterotoxigenic *S. aureus* in fish and fishery products, causes a potential health hazard to consumers. Therefore, stringent good hygienic practices need to be followed to limit *S. aureus* growth and enterotoxin production.

In order to understand the growth kinetics and enterotoxin production potential of *S. aureus* in fish matrix, white sardine (*Escualosa thoracata*) was procured from the local market and analyzed for the absence of initial contamination with coagulase positive Staphylococci. Fish was weighed to 100±2g and packed separately in to sterile polythene pouches, spiked with six different concentrations (2, 3, 4, 5, 6 and 7 log cfu/g) of enterotoxigenic *S. aureus* strain AVS1 isolated from the salted, dried shark collected from the local market. The spiked fish samples were kept at fixed exposure temperature of 30 °C for 8 h. *S. aureus* count and enterotoxin production was analyzed by withdrawing each pouches at different time intervals (0, 2, 4, 6 and 8 h) by surface plating in Baird parker agar and using commercial test kit (3MTecra™, Staph Enterotoxin visual Immunoassay kit, Australia). Results showed that in 2-7 log *S. aureus* spiked samples (1 log interval), the count reached to 3, 5.09, 5.85, 7.09, 7.29 and 8 log cfu/g, respectively after 8th h of incubation at 30 °C (Fig.1). There was no enterotoxin detected in 2 and 3 log spiked samples after 8 h of incubation at 30 °C (Fig 2). Studies have showed that this bacterium must have a density of at least 5 log cfu/g or mL of food to produce sufficient quantities of enterotoxins to cause food poisoning. The enterotoxin was detected in samples spiked with 4, 5, 6 and 7 log cfu/g after 8, 6, 4 and 2 h, respectively when the *S. aureus* count reached to 5.85, 6.03, 6.44, 6.98 log cfu/g, respectively. Present study also envisaged that when the population of *S. aureus* reached >5.8 log cfu/g, the enterotoxin production was detected. The time required to produce enterotoxin decreased linearly with the increase in inoculum size (Fig.2).

The results of the present study showed that the exposure of fish to the inoculum level of 2 and 3 log cfu/g for 8 h at 30 °C does not appear to present the risk of causing *S. aureus* intoxication. This study also demonstrates that enterotoxin

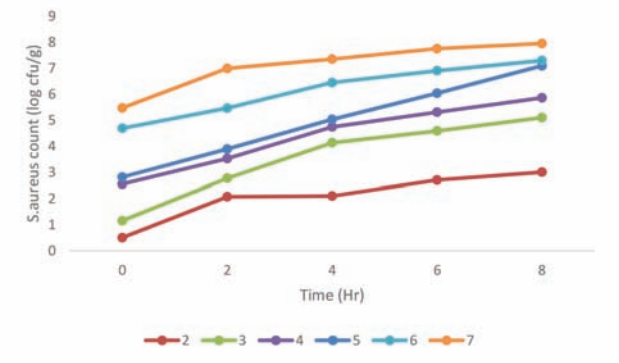

Fig. 1. Growth of *Staphylococcus aureus* (log cfu/g) in fresh fish at different inoculum level

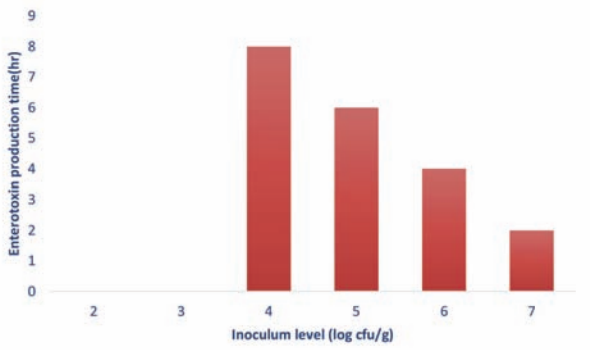

Fig. 2. Staphylococcal enterotoxin production in fresh fish at different inoculum levels

production in fresh fish is initiated when background load of *S. aureus* increased to 5.8 log cfu/g. Therefore, proper icing is necessary to prevent the growth of these organism and its enterotoxin production in the fish and also prevent prolonged exposure of fish to ambient temperature before undergoing processing.

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Antibiotic resistant profile of *Escherichia coli* isolated from the seafood samples of Veraval coast, Gujarat

Ahamed Basha K., [1]Sivaraman G.K. and Prasad M.M.

ICAR-Central Institute of Fisheries Technology, Cochin

[1]Veraval Research Centre of ICAR-Central Institute of Fisheries Technology, Veraval

India is bestowed with diversified aquatic resources with great potential of capture and culture fisheries. Seafood is an important source of nutrient-rich diet to humans in many industrialized countries. Aquaculture production is progressing and seafood trade is gaining more importance across the world. Indian seafood market is well established in the international seafood trade in terms of supplying quality fish and shellfish products. The present trend in the seafood trade lies with demand and supply of the processed aquatic products by importing countries. Till date, seafood trade barriers are of major concern to the industry and more attention should be given to overcome the barriers. Many consignments from India were withdrawn by importing countries over the years due to the presence of microbial hazards, banned antibiotics etc. The importance of the antibiotics as a growth promoter and bacterial suppressors are no way encourageable in aquaculture and seafood trade. Use and misuse of antibiotics contributed to the development of antibiotic resistance in bacteria and industrialized countries are combating hard to overcome this critical scenario. *Escherichia coli* is a known bacteria related to water contamination and unhygienic conditions during the handling process. Currently, six categories of diarrheagenic *E. coli* has been recognized: Enterotoxigenic *E. coli* (ETEC), Enteropathogenic *E. coli* (EPEC), Enteroinvasive *E. coli* (EIEC), Enterohemorrhagic *E. coli* (EHEC, Shiga toxin-producing *E. coli* or STEC), Enteroaggregative *E. coli* (EAEC or EAggEc), and diffusely adherent *E. coli* (DAEC) (Costa, 2013). In the present study, antibiotic resistance pattern in *E. coli* isolates from the seafood was carried out. A total of 31 *E. coli* were isolated from fish and shellfish of retail markets of Veraval coast, Gujarat, India as per the United States Food and Drug Administration Bacteriological Analytical Manual (Peter Feng *et al.*, 2011). All the 31 isolates were purified and characterized biochemically as rod shaped, catalase positive, oxidase negative, indole positive, methyl red positive, voges-

Proskauer negative, glucose fermenters, lactose fermenters and non-citrate utilizers. Antibiotic resistance in these 31 isolates were tested simultaneously using the standard agar disc diffusion method (CLSI, 2012) using Mueller-Hinton agar. All these isolates were grown overnight in Tryptic soya broth at 37 ºC and adjusted to 0.5 McFarland Standard. The multidisc (Icosa G-II-Minus, Himedia, India) used in the study contained the following antibiotics arranged equidistant to each other: Imipenem (IPM) - 10µg; Ciprofloxacin (CIP) - 5µg; Tobramycin (TOB) - 10µg; Moxifloxacin (MO) - 5µg; Ofloxacin (OF) - 5µg; Ceftazidime (CAZ) - 30µg; Levofloxacin (LE) - 5µg; Norfloxacin (NX) - 10µg; Co-Trimoxazole (COT) - 25µg; Colistin (CL) - 10µg; Nalidixic acid (NA) - 30µg; Augmentin (AMC) - 30µg; Cefoxitin (CX) - 30µg; Gatifloxacin (GAT) - 5µg; Gentamicin (GEN) - 10µg; Amikacin (AK) - 30µg; Aztreonam (AT) - 30µg; Ceftriaxone (CTR) - 30µg; Cefpodoxime (CPD) - 10µg and Nitrofurantoin (NIT) - 300µg. The plates were incubated at 37 °C for 18 h. The diameters of inhibition zones were measured in millimetre, and interpreted in accordance to CLSI recommendations. Among the 20 antibiotics tested against 31 isolates, 15 isolates showed resistance to Imipenem (IPM) with 48.38%, 12 isolates showed resistance to Nitrofurantoin (NIT) with 38.70% and 11 isolates showed resistance to Cefpodoxime (CPD) of 35.48% and eight isolates showed resistance to Nalidixic acid (NA) of 25.8%. None of the isolates showed resistance to Norofloxacin (NX), Levofloxacin (LE), Tobramycin (TOB), Amikacin (AK) and Cefoxitin (CX). The results are shown in (Fig. 1). Six out of 31 isolates have shown multi-drug resistance to more than three classes of antibiotics (16.1%). Multi-drug resistance in pathogenic bacteria is an universal problem across the globe and is prevailing in many fields of science. Therefore, strict awareness, measures and regulations are to be standardized for use in seafood production to combat this problem.

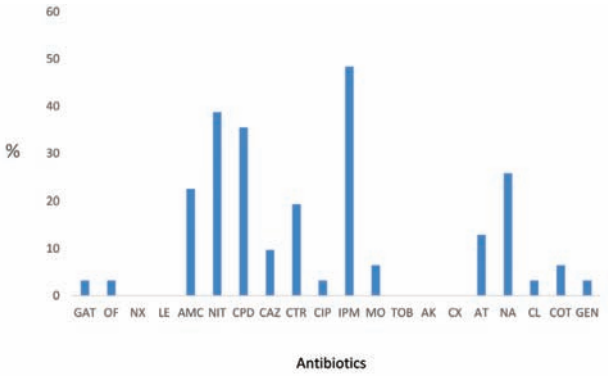

Fig. 1. Antibiotic resistance pattern of *E. coli* Isolates

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Isolation and antibiotic resistance pattern of Staphylococci from seafood of Veraval, Gujarat

Ranjit Kumar Nadella, Murugadas V., [1]Sivaraman G.K. and Prasad M.M.

ICAR-Central Institute of Fisheries Technology, Cochin

[1]Verval Research Centre of ICAR-Central Institute of Fisheries Technology, Veraval

Staphylococci are commonly associated with the skin of the food handlers which can act as a source of food contamination and is considered as a versatile human pathogen. In the recent years it has emerged as a major and most difficult pathogen to treat due to the resistance developed

against several antibiotics especially to Methicillin. They are also responsible for many of the community-acquired diseases and nosocomial infections in humans. They have been widely studied from livestock farms and food animals, meat and poultry products, milk and livestock workers, and fish handlers. The presence of antibiotic-resistant Staphylococci was well studied in cultured fish, fresh seafood, ready-to-eat and ready-to-cook fish products, seafood processing environments and ice. There are several factors responsible for the spread of these bacteria such as poor maintenance of hygiene and sanitation conditions by the fish handlers cross contamination during handling and storage. The antibiotic resistant pattern of *S. aureus* isolated from seafood was reported by Murugadas *et al.*, 2016.

This article reports the studies on screening of seafood samples for the presence of Staphylococcus from Veraval coast. A total of 17 *Staphylococcus* sp. were isolated from fish and shellfish products. The isolation was carried out as per the United States Food and Drug Administration, Bacteriological Analytical Manual (Bennett and Lancette, 2016). The biochemical characterization was carried out as per the standard procedures described in Bergey's Manual of Systemic Bacteriology (2005). All the 17 isolates were Gram positive cocci shape, catalase positive, oxidase negative and coagulase positive. The antibiotic resistance pattern was studied against 24 antibiotics belonging to more than nine major groups. The isolates which are resistant and sensitive to the tested antibiotics are given in Table 1. This indicates high percentage of resistance for Penicillin G (64.7%) followed by

Table 1. Percentage of resistant and sensitive *Staphylococcus* sp. isolated from seafood

Antibiotic and Concentration	Major group of antibiotic	Resistant		Sensitive		MDR (More than 3 classes)
		No. of isolates	%	No. of isolates	%	
1. Penicillin G (100U)	Penicillin	11	64.7	6	35.3	9 (52.9%)
2. Azitrhomycin (15 µg)	Macrolides	6	35.3	11	64.7	
3. Erythromycin (15 µg)	Macrolides	6	35.3	11	64.7	
4. Clarithromycin (15µg)	Macrolides	5	29.4	12	70.6	
5. Linezolid (30 µg)	Oxazolidinones	1	5.8	16	94.2	
6. Co-Trimoxazole (25 µg)	Sulphonamide	0	0	17	100	
7. Vancomycin (30 µg)	Glycopeptides	0	0	17	100	
8. Cefoxitin (30 µg)	Cephalosporin	2	11.7	15	88.3	
9. Ciprofloxacin (5 µg)	Quinolones	3	17.0	14	83.0	
10. Gatiflaxacin (5 µg)	Quinolones	3	17.0	14	83.0	
11. Ofloxacin (5 µg)	Quinolones	1	5.8	16	94.2	
12. Clindamycin (2 µg)	Lincosamides	4	23.5	13	76.6	
13. Tigecycline (15µg)	Tetracycline	0	0	17	100	
14. Moxifloxacin (5µg)	Macrolides	1	5.8	16	94.2	
15. Gentamicin (10µg)	Aminoglycosides	1	5.8	16	94.2	
16. Rifampicin (5 µg)	Ansamycins	0	0	17	100	
17. Lomefloxacin (10µg)	Quinolones	8	47.0	9	53.0	
18. Norfloxacin (10µg)	Quinolones	0	0	17	100	
19. Novobiocin (30 µg)	Aminocoumarin	0	0	17	100	
20. Teicoplanin (15 µg),	Glycopeptides	0	0	17	100	
21. Nitrofurantoin (300 µg)	Nitrofurans	1	5.8	16	94.2	
22. Pristinnomycin (15 µg)	Streptogramin	7	41.0	10	59.0	
23. Ampicillin-Sulbactum (10/10 µg)	Penicillin	3	17.0	14	83.0	
24. Piperacillin- Tazobactum (100/ 10 µg)	Penicillin	10	58.8	7	42.2	

Piperacillin/Tazobactam (58.8%). No resistance was observed for Co-Trimoxazole, Vancomycin, Tigecycline, Rifampicin, Norfloxacin, Novobiocin and Teicoplanin. The percentage of antibiotic resistance of the *Staphylococcus* sp. isolated from seafood is shown in Fig. 1.

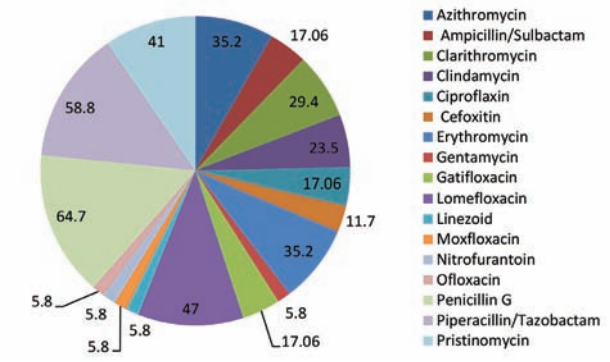

Fig.1 Percentage of antibiotic resistance of *Staphylococcus* sp. isolated from seafood of Veraval

The antibiotic resistant profiles were carried out using disc diffusion method (CLSI, 2014) on Mueller-Hinton agar. The overnight grown cultures (Tryptic Soy broth, BD Difco, India) was centrifuged (Heraeus Kendro: Biofuge Stratus, UK) at 2,500 xg for 30 min. at 4 °C and the pellet was dissolved in normal saline. The optical density was adjusted to 0.5 McFarland standard and spread onto the agar plates. Further, the antibiotics (Staphylococci I and Staphylococci II disc, Himedia, India) were placed on to the plate and were incubated at 37 °C for 16-20 h. The antibiotics used and their concentrations are provided in Table 1. The diameter of the inhibition zones were measured in millimetre and interpreted in accordance with CLSI guidelines. The resistance profile of the 17 isolates against the tested antibiotics is given in Table 2. Out of 17 isolates, nine exhibited multi-drug resistance (MDR) to the tested. The MDR rate is 52.9%. Among nine multi-drug resistant isolates, two were resistant to Cefoxitin which are multi-drug resistant Methicillin resistant *Staphylococcus aureus* (MRSA). The high prevalence of multi-drug resistant *Staphylococcus* sp. in the fishery products

Table 2. Antibiotic resistance profiles of *Staphylococcus* sp. isolated from seafood

Sl No	Culture	Resistance pattern	Class of antibiotic
1	S1	LOM	Q
2	S2	P LOM LZ	P Q O
3	S3	P PIT RP AZM E CLR	PP S MMM
4	S4*	P PIT RP AZM E CLR CD A/S CX	PP S MMM L P C
5	S5	Sensitive to all classes	
6	S6	LOM CIP GAT	QQQ
7	S7	P PIT RP AZM CLR GEN NIT	PP S MM A N
8	S8	LOM CD GAT	Q L Q
9	S9*	P PIT RP E CD A/S CX	PP S M L P C
10	S10	P PIT LOM CIP	PP Q Q
11	S11	PIT LOM CIP GAT	P QQQ
12	S12	P PIT RP AZM E CLR	PP S MMM
13	S13	MO	Q
14	S14	P PIT RP AZM A/S	PP S M P
15	S15	P PIT RP AZM E CLR	PP S MMM
16	S16	P PIT LOM CD OF	PP Q L Q
17	S17	P LOM	P Q

(S-*Staphylococcus* sp. LOM - Lomefloxacin; P - Penicillin G; LZ - Linezolid; PIT – Piperacillin - Tazobactum; RP - Pristionomycin; AZM - Azitrhomycin; E - Erythromycin; CLR -Clarithromycin; CD - Clindamycin; A/S – Ampicillin - Sulbactum; CX - Cefoxitin; CIP -Ciprofloxacin; GAT - Gatiflaxacin; GEN - Gentamicin; NIT - Nitrofurantoin; MO -Moxifloxacin; OF - Ofloxacin; Q - Quinolones; P - Penicillins; O - Oxazolidinones; S -sulphonamide; M - Macrolides; L - Lincosamides; C - Cephalosporins; A - Aminoglycosides; N – Nitrofurans *Presumptive MRSA isolates)

is of high concern in terms of consumer health. Therefore, awareness is to be created among the food handlers about the cleanliness and the measures to be taken to reduce the prevalence of this hazardous bacterial pathogen.

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Evaluation of dry rehydratable film (3M™ Petrifilm™) method for microbial enumeration in fish samples

Femeena Hassan and Nija K.V.

ICAR-Central Institute of Fisheries Technology, Cochin

Petrifilms eliminate the time for media preparation and sterilization.The 3M™ Petrifilm™ is an all-in-one plating system. Rather than a petridish, 3M™ Petrifilm™ makes use of a thin plastic film as carrier of the culture medium. 3M™ Petrifilm™ comprises a cold-water-soluble gelling agent, nutrients and indicators for activity and enumeration (Jasson *et al.*, 2010). Day by day developing food testing sector provides alternatives to existing standard methods. Before adopting novel techniques it is important to evaluate the effectiveness of the method. In this backdrop, a study was carried out to evaluate the applicability of the petrifilm method for enumeration of aerobic microorganisms, Enterobacteriaceae, *S.aureus*, *E. coli* and Coliforms by comparing the results of petrifilm method with that of standard enumerating techniques. Evaluation of dry rehydratable film (3M™ Petrifilm™) method for microbial enumeration in seafood samples is depicted in Fig.1.

Seven seafood samples were analyzed for microbial parameters like Aerobic Plate Count, Enterobacteriaceae, *Escherichia coli*, Total Coliforms and *Staphylococcus aureus*. Analysis were performed using petrifilms and standard conventional agar plates in triplicate (n=3).The fish *Elagatis bipinnulata, Caranx* spp., *Scomberomorus commerson* and *Lethrinus lentjan* were collected from Cochin Fisheries Harbour. *Fenneropenaeus indicus* (headless), *Thunnus albacores* (loin) and *Octopus vulgaris* (Baby octopus) were obtained from a processing plant in Cochin.

Petrifilms were developed in the early 1980s for enumerating aerobic bacteria in food samples. Petrifilm™ Aerobic count plates have an indicator dye and built in grid allows for fast and accurate identification of colonies, within 48 hours over a growth area of approximately 20 cm^2. The comparison of mesophilic count of fish samples with Petrifilm method against the pour plate method showed a significant correlation ($r=0.991$, $p < 0.05$). The reduction of the dye in the upper film of the plates gives red colour to aerobic bacterial colonies. Linton *et al*. (1997) reported that in conventional media certain mesophilic

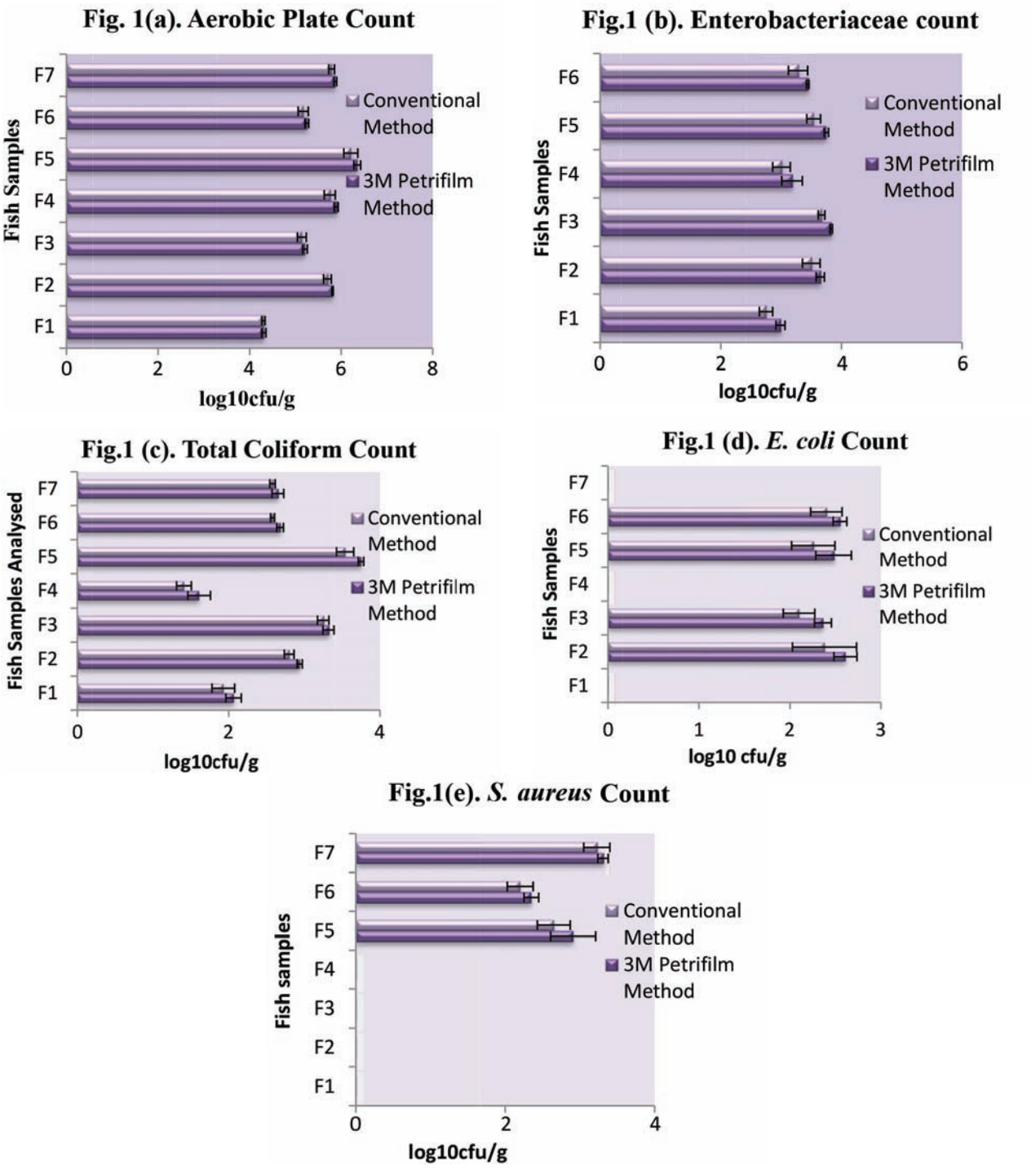

Fig. 1. Evaluation of dry rehydratable film (3M™ Petrifilm™) method for microbial enumeration in fish samples

F1 - *Elagatis bipinnulata*, F2 – *Caranx* spp., F3 – *Scomberomorus commersonii*, F4 – *Lethrinus lentjan*, F5 – *Fenneropenaeus indicus* (headless), F6 - *Thunnus albacores* (loin), F7 - *Octopus vulgaris* (Baby octopus)

bacteria may be better recovered due to an optimal water activity and oxidation/reduction potential. In the present study, these differences did not affect the microbial counts. The mean log values of Aerobic Plate Count given by two methods are shown in Fig.1(a). The lack of

significant differences between means ($P< 0.05$) and the high correlation coefficient showed that Petrifilm is a suitable and convenient alternative to the standard traditional method for the enumeration of mesophilic flora in fish samples.

Enterobacteriaceae is a diverse family consisting of Gram-negative, oxidase negative bacilli. They produce acid from glucose; are facultative anaerobes; reduce nitrate to nitrite; and may be motile or non-motile (Kornacki and Johnson, 2001). Enterobacteriaceae were found to be a part of spoilage microflora in fish samples. Members of Enterobacteriaceae are commonly used as indicator microorganisms for assessing food safety and hygiene, since they are found in the gastrointestinal tract of humans and animals (Forsythe, 2002) and can cause diseases and even economic losses (Trabulsi, 2005). Traditional methods use violet red bile agar with glucose for enumerating Enterobacteriaceae. The 3M™ Petrifilm™ Enterobacteriaceae count plate enumerates Coliforms plus potential pathogens and give a picture about the contamination of food samples in as quick as 22 hours. The product consists of a medium optimized for the growth of Enterobacteriaceae, yet inhibitory to the growth of Gram-positive bacteria. The 3M™ Petrifilm™ Enterobacteriaceae Count Plates are an effective method to assess environments such as post-process food contact surfaces, and help us to quickly determine potential sources of contamination. This plate enumerates all Coliforms as well as potential pathogens such as *Salmonella, Shigella* and *Yersinia*. In this study, the correlation coefficient between the Petrifilm method and traditional VRBG plates for Enterobacteriaceae enumeration was 0.985.The counts given by both methods were not significantly different ($p < 0.05$).Therefore, the Petrifilm EB count plate method can be adopted for the enumeration of Enterobacteriaceae in fish samples.

The 3M™ petrifilm™ *E. coli*/Coliform count plate provides a confirmed result in 24 to 48 hours. Omitting the confirmation steps increase productivity and reduce overall lab costs. Fast, accurate, results will be obtained in 24 hours. In 3M™ petrifilm™ confirmed Coliform colonies are red and blue with associated gas bubbles and *E. coli* are blue colonies with associated gas bubbles. The mean $\log_{10}$ transformed values of *E. coli* exhibited by *Caranx* spp., *Thunnus albacares*, *Scomberomorus commersonii* and *Fenneropenaeus indicus* on Petrifilms were 2.61 $\log_{10}$ cfug^{-1}, 2.55 $\log_{10}$ cfug^{-1}, 2.36 $\log_{10}$ cfug^{-1} and 2.48 $\log_{10}$ cfug^{-}1, whereas traditional petriplates exhibited a count of 2.38 $\log_{10}$ cfug^{-1}, 2.4 $\log_{10}$ cfug^{-1}, 2.1 $\log_{10}$ cfug^{-1} and 2.25 $\log_{10}$ $cfug_1$, respectively. There was no significant statistical difference ($p < 0.05$) between the mean $\log_{10}$ counts from the Petrifilm plate procedure and those with the conventional T_7 agar plates and VRBA plates. The corresponding correlation coefficients of *E. coli* and total Coliforms were 0.88 and 0.995.

The 3M™ petrifilm™ Staph Express count plate provides confirmed *Staphylococcus aureus* results in as quick as 22 hours. Distinctive red-violet colonies make interpretation very easy. Of the seven fish samples analyzed only three fish samples exhibited positive results for *S. aureus*. *T. albacares*, *F. indicus* and *O. vulgaris* gave mean $\log_{10}$ value of 2.35 $\log_{10}$ cfug^{-1}, 2.91 $\log_{10}$ cfug^{-1} and 3.31 $\log_{10}$ cfug^{-1} on Petrifilms whereas *S. aureus* count on Baird parker petriplates were 2.2 $\log_{10}$ cfug^{-1}, 2.65 $\log_{10}$ cfug^{-1}, and 3.2 $\log_{10}$ cfugm^{-1}, respectively. The correlation coefficient between traditional method and Petrifilm method for *S. aureus* enumeration was 0.928. No significant variation ($p < 0.05$) was noted between BP agar plates and 3M™ petrifilm™ Staph Express count plates.

The colony counts of *E. coli*, Coliforms, Enterobacteriaceae, aerobic microorganisms and *S. aureus* obtained by Petrifilm method are well correlated with the counts obtained by conventional standard plate techniques. The $\log_{10}$ counts of the Petrifilm plate procedure were slightly higher than those of the traditional methods. Traditional methods have great possibility of errors during media preparation, sterilization etc. which in turn reflects in the test result. Compared to traditional methods, chances of contamination is less with petrifilms. Petrifilms are compact and space savers in incubators. Therefore, the Petrifilm technique can effectively be applied for routine microbiological analysis of

food samples as a convenient alternative to conventional method for enumeration of aerobic microorganisms, Enterobacteriaceae, Total Coliforms, *E. coli* and *S. aureus*.

In the field of food protection, early screening of food products is an important measure to prevent epidemics relating to food-borne pathogens. Novel techniques should be adopted to reduce the work load and laboratory expenses. Petrifilms are a good alternative as it can enhance accuracy of test results and address the overall concerns facing the laboratory today: job satisfaction, decreased length of stay and safety. Financial savings can also be realized as a result of labor reduction.

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Multi-drug resistant *Salmonella* in seafood

Greeshma S.S., [1] Navami Krishna, Toms C. Joseph, Murugadas V. and Prasad M.M.

ICAR-Central Institute of Fisheries Technology, Cochin

[1]St. Thomas College, Palai, Kottayam

Salmonella is a gram negative bacteria which belongs to the family Enterobacteriaceae and is one of the most important food-borne pathogens globally. Non typhoidal *Salmonella* (NTS) refers to a range of *Salmonella* serotypes other than typhi and paratyphi. They mainly cause diseases ranging from mild gastroenteritis to life threatening illness and is of great public health concern world-wide. Due to indiscriminative use of antibiotics in animal and human disease treatment, there is an increasing incidence of antibiotic resistance in non-typhoidal *Salmonella* and it is quite alarming too. Along with this, disposal of untreated organic wastes also adds significantly to the development and wide spreading of Multi-drug resistant (MDR) *Salmonella* strains recently. There are only limited studies in India regarding the prevalence of multi-drug resistance in seafood *Salmonella*.

In this context, the present study was conducted to estimate the antibiotic sensitivity pattern of *Salmonella* isolates collected from seafood. *Salmonella* isolates (n=157) from seafood of Cochin local markets were tested for antibiotic susceptibility using Kirby-Bauer disc diffusion method as per CLSI standards. The test was performed on Mueller-Hinton agar (Difco, USA) using *Escherichia coli* (ATCC 25922) as a reference organism for quality control. The isolates were tested for the 20 antibiotics using ICOSA G-II minus disc (Himedia, India). These antibiotics belongs to different classes *viz.*, quinolones, aminoglycosides, carbapenems, cephalosporins,

sulfonamides, polypeptides, nitrofuran and combinations.

The antibiotic susceptibility pattern indicated that 15.92% of the *Salmonella* isolates were multi-drug resistant (Fig. 1 and 2). Fortysix, 45, 26, 8, and 6% of the isolates showed resistance towards imipenem, nitrofurantoin, cefpodoxime, ceftriaxone and augmentin, respectively. A total of 1.27% of the isolates showed resistance towards ceftazidime, aztreonam, nalidixic acid and moxifloxacin, while only 0.63% of the isolates showed resistance towards colistin, gatifloxacin, ofloxacin and norfloxacin. One hundred percentage of the isolates studied were susceptible towards amikacin, ciprofloxacin, co-trimoxazole, gentamycin, tobramycin, levofloxacin and cefoxitin. Among the multi-drug resistant isolates 87.5% showed resistance towards three antibiotics *viz.*, imipenem (Carbapenem class), nitrofurantoin (Nitrofuran class) and cefpodoxime (3rd generation Cephalosporin class). A total of 4.25% of the MDR isolates showed resistance to more than five classes of antibiotics studied.

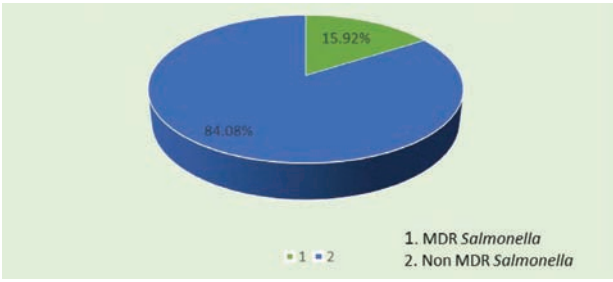

Fig. 1. Prevalence of multi-drug resistant *Salmonella* in seafood

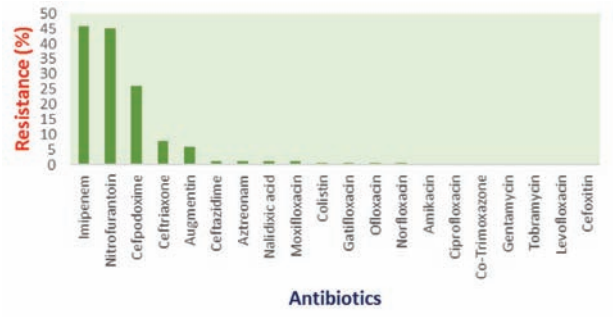

Fig. 2. Resistance pattern of *Salmonella* isolates

The results of this study revealed higher incidence of multi-drug resistance in *Salmonella* towards the frequently used classes of antibiotics in human medicine. In this study, maximum resistance (46%) was shown for imipenem (Carbapenem class) which is generally considered as the last choice of medicine for infections caused by gram negative bacilli. Hence, judicious use of antibiotics in human and veterinary medicine is mandatory and inevitable to avoid MDR *Salmonella*.

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Antibiotic resistance to third generation cephalosporins of *Escherichia coli* isolated from seafood

Sivaraman G.K., Deesha Vanik, [1] Visnuvinaygam S., [2]Ahamed Basha K. and [2]Prasad M.M.

Veraval Research Centre of ICAR-Central Institute of Fisheries Technology, Veraval
[1] Mumbai Research Centre of ICAR- Central Institute of Fisheries Technology, Mumbai
[2] ICAR-Central Institute of Fisheries Technology, Cochin

Occurrence of pathogenic *Escherichia coli* in seafood is directly related to faecal contamination and through infected handlers during pre and post harvest stages. Frequent use of large number of antibiotics in human therapies, farm animals and aquaculture led to increase the incidence of antimicrobial resistant bacterial strains (Sapkota *et al.*, 2008 and Cheong *et al.*, 2014). Third

generation cephalosporins are broad-spectrum drugs with high intrinsic activity against gram negative bacteria. A widespread and indiscriminate use of antibiotics coupled with the transmissibility of resistance could lead to the emergence of antibiotic resistant *E. coli* (Kang *et al.*, 2005). Several studies demonstrated the prevalence of resistance in Enterobacteriaceae in food products such as meat, chicken, raw milk, fish and environment. Increasing resistance to these newer antimicrobial drugs is a cause of concern because it could be a proxy for the emergence and spread of Enterobacteriaceae strains producing Extended-Spectrum Beta-Lactamase (ESBL) and posing an emerging threat to public health. Recently, several studies have shown infiltration of resistance genes into food chain *via*. direct contact with humans and animals (Egea *et al.*, 2012). Under these circumstances, a preliminary study was carried out to monitor the prevalence of third generation cephalosporin resistant *E. coli* in seafood.

A total of 238 seafood samples were collected from fish market and fish processing industries of Veraval region, Gujarat during 2012 to 2016 and were screened. *E. coli* isolates were identified as per Surendran *et al.* (2013). Four numbers of 3rd generation cephalosporins (HiMedia, Mumbai) were tested by the disk diffusion method on Mueller-Hinton agar with 0.1mL of *E. coli* equivalent to 0.5 McFarland standards in accordance with CLSI guidelines (CLSI, 2014) of antimicrobial concentration: Ceftazidime (CAZ) 30 µg, Ceftizoxime (CZX) 30 µg, Cefotaxime (CTX) 30 µg and Ceftriaxone (CTR) 30 µg and incubated for 18-24 hrs at 37 °C. The results were interpreted employing standard methods (CLSI, 2014) wherein the radial zone of inhibition of growth were expressed as 'sensitive or 'resistant'.

The preliminary epidemiological study was carried out to assess the *in vitro* antimicrobial resistance to four commercially available third generation cephalosporin antibiotics *viz.*, CAZ, CZX, CTX and CTR in *E. coli* isolates from seafood. *E. coli* counts ranged from 2×10^1 to 2×10^2 cfu.g^{-1} which clearly indicates the possibility of faecal or sewage source as contaminant. Twenty eight samples were found positive with incidence rate of 11.76%. Antimicrobial resistance pattern of *E. coli* strains to third generation cephalosporins are given in Table 1 and 2. Overall higher rate of resistance to third generation cephalosporins ranged from 7.14% to 17.86% with 2 to 5 number of isolates from these seafood samples. The higher rates of resistance to third generation cephalosporins was 14.29%, 10.71% and 10.71% with CAZ, CTX and CTR and the least was found with ceftizoxime (7.14%), respectively. The intermediate resistance was found to CAZ and CZX with 3.57% and CTX and CTR with 7.14%, respectively among these *E. coli* strains. Whereas, two *E. coli* isolates consistently showed resistance patterns with either two or three or with all the third generation antimicrobial combinations and were isolated from Ribbonfish samples. The overall result of the present study shows that the presence of third generation cephalosporin resistant *E. coli* strains in Gujarat is currently not very high. However, if not checked in right time it may shoot up and cause a very serious public health problem among the seafood consumers. The constant use of third generation cephalosporins in the treatment of infections in developing countries like India, is probably the reason for these

Table 1. Percentage of antibiotic resistance of *E. coli* strains to third generation cephalosporins

Name of the antibiotics	No. of resistant strains	% of resistant strains	No. of inter-mediate strains	% of inter-mediate strains	No. of susceptible strains	% of susceptible strains
Ceftazidime (CAZ)	4	14.29	1	3.57	23	82.14
Ceftizoxime (CZX)	2	7.14	1	3.57	25	89.29
Cefotaxime (CTX)	3	10.71	2	7.14	23	82.14
Ceftriaxone (CTR)	3	10.71	2	7.14	23	82.14

Table 2. Antimicrobial resistance patterns of *E. coli* isolates to third generation cephalosporins

Resistant type	No. of resistant strains
CAZ	4
CZX	2
CTX	3
CTR	3
CPM	5
CAZ - CTR	3
CAZ- CTX	3
CAZ- CZX	2
CTR- CTX	3
CTR- CZX	2
CTX- CZX	2
CAZ - CTR- CTX	3
CAZ- CTX- CZX	2
CTR- CTX-CZX	2
CAZ - CTR- CTX- CZX	2
CAZ - CTR- CTX- CZX- CPM	2

incidence and the spread of highly resistant *E. coli* strains. It is further suggested that the strict hygienic practices such Hazard Analysis Critical Control Point (HACCP), Good Hygienic Practices (GHP) and Good Manufacturing Practices (GMP) are to be followed during the entire chain of seafood processing in order to produce wholesome seafood.

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Fishermen preferences towards gear-based fish conservation technologies in Sindhudurg district, Maharashtra

Arathy Ashok and Madhu V.R.

ICAR-Central Institute of Fisheries Technology, Cochin

Sindhudurg district, located at the southern tip of Maharashtra is endowed with a coastline of 121 kilometers. There are 526 mechanized vessels in the district, engaged in fishing operations (ICAR-CMFRI, 2010) and total trawlers operating are 317. In order to reduce the negative impact of trawling

and to achieve sustainable fish production, different conservation policies had been enforced by Maharashtra government such as seasonal trawl ban, ban on night trawling etc. Recently ICAR-CIFT has made different technology interventions for conserving fishery resources in Sindhudurg district under a GOI-UNDP-GEF Project. The present study tried to explore preferences of fishers towards different gear based fisheries conservation technologies in Sindhudurg district.

The study was undertaken in three major fishing centres in Sindhudurg district *viz*; Devgad, Malvan and Vengurla. Twenty fishermen and three net makers from these fishing centres were interviewed using structured interview schedule covering socio-economic status of the respondents, technology use details and awareness and adoption level related to different technologies.

Details of usage of technologies by fishers

Wooden trawlers of varying lengths (28-55 feet L_{OA}) were being used by the fishermen in Sindhudurg district for trawling operations. Recently construction of Fibre Reinforced Plastic (FRP) vessels for trawling operations are also being taking place especially in Devgad which has an FRP boat building yard also (Fig. 1). The engine power (HP) of mechanized trawlers ranged between 87-99 HP. Two types of trawl nets are being used for fishing *viz*; shrimp trawl and fish trawl (locally known as *Chaalu* and *Disco jaals*, respectively) with codend mesh size ranging between 20-30 mm. Shrimp trawl is mainly operated during November to May and fish trawl during August to October. Duration of fishing trips varied from single day up to five days and fishing is carried out in the depth of around 50-60 m. Otter boards made of wood are exclusively used as sheer devices (Fig. 2).

Fig. 1. FRP boat building yard at Devgad

Fig. 2. Wooden otter boards used in Vengurla

Awareness and adoption of gear-based conservation technologies

As a part of the GOI-UNDP-GEF project, several gear-based conservation technologies developed by ICAR-CIFT were demonstrated to the trawl fishermen of Sindhudurg district. Demonstrated technologies included CIFT-Semi Pelagic Trawl System (CIFT-SPTS), CIFT-Juvenile Excluder cum Shrimp Sorting Device (CIFT-JESSD), CIFT-Turtle Excluder Device (CIFT-TED) and use of square mesh codend in trawls. The level of awareness and adoption of these technologies are indicated in Fig. 3.

High level of awareness was observed in case of use of square mesh codend in trawls (100.00

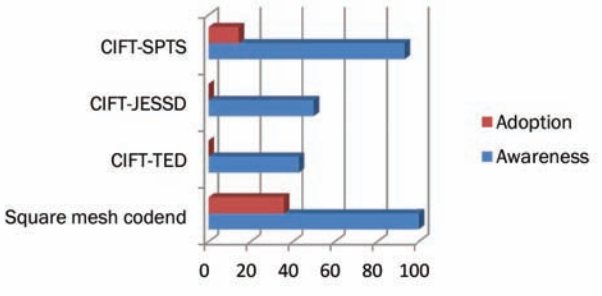

Fig. 3. Awareness and adoption of gear-based fish conservation technologies in Sindhudurg

per cent) and CIFT-SPTS (92.86%). In addition to having high awareness level, majority of the respondents had undergone field trial using the square mesh codend. Complete adoption of the technology was observed in case of 37.50% of the respondents. Adoption of CIFT-SPTS was mainly observed in Vengurla Taluka of Sindhudurg district. Since turtles are not a major problem in the region, the fishermen were not using CIFT-TED. Also, adoption was not found in the case of CIFT-JESSD.

Fishermen's perception about advantages and disadvantages of square mesh codend technology were further explored to understand the reason for adoption/non-adoption of the technology. The results are indicated in Figure 4.

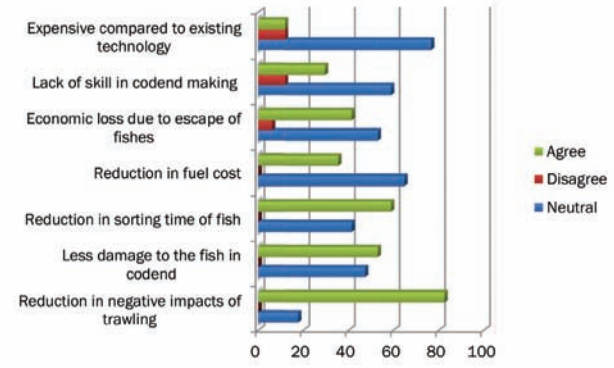

Fig. 4. Perceived advantages and disadvantages of use of square mesh codend

Fifty nine per cent of the fishermen agreed that there was reduction in sorting time by using square mesh codend in trawls and they were satisfied with the availability of cleaner catch in codend through efficient filtering of debris from the codend. Due to less drag of the net, 35.29% of the fishermen felt that there is a reduction in fuel cost. Majority of the fishermen (82.35%) agreed that this technology will help to reduce the negative impacts of trawling. One of the disadvantages perceived by fishermen in using the square mesh codend is the escape of small sized fishes, which finally constitute the bycatch, which also give them a revenue.

Adaptation of the technology in local context

A major problem faced by Sindhudurg fishermen during fish trawling was the attack by ribbonfish and subsequent damage to the fishing net. In order to reduce the damage to the codend and to avoid escapement of fishes, fishermen generally use a cover codend. At the initial stages, the fishermen were using square mesh codend with 1.25 mm diameter and later, taking into account the damage by the ribbonfish, the fishermen in consultation with ICAR-CIFT, started designing their own codends with 2.5 mm diameter twines which was found to have multiple benefits *viz*; less damage to net due to ribbonfish attack and cleaner catch in the codend.

Major constraints for adoption of technology

Even though there is gradual trickling down of square mesh codend technology to fishermen, they expressed few constraints in adopting the technology. They are:

- Lack of uniform policy across different states (Problem of inter-territorial conflicts)
- Use of high power Chinese engines in fishing vessels of neighboring state
- Lack of proper monitoring mechanism for law enforcement

According to Rogers Innovation Decision Process (Rogers, 2003), adoption decision of any technology undergo five stages *viz*; knowledge, persuasion, decision, implementation and confirmation. In case of technologies intended for natural resource conservation, as the benefits are indirect and time consuming, implementation of proper supporting policies are essential. In case of square mesh codend technology intervention in Sindhudurg district, GOI-UNDP-GEF project has initiated steps to supply square mesh codends to all 317 trawlers operating in the region, which will be a major boost for adoption of this technology. In addition, proper institutional mechanism by the government can help to ensure the continued adoption of the technology by all trawl fishermen.

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Study on drying of fishes using CIFT dryers

Fasludeen N.S., Manoj P. Samuel, Murali S. and George Ninan

ICAR-Central Institute of Fisheries Technology, Cochin

Drying preserves fish from decay by removal of moisture from fish, thereby arresting the growth of bacteria, action of enzymes and chemical oxidation of the fat. Open yard drying of fish was an age old practice, known for higher microbial load, lower product quality and longer drying time. In addition, traditional method of fish drying may add up impurities like dust, sand, insects and bird waste in the dried product, thereby lowering market price (Yusuf and Agarwal, 1989). Use of solar dryer helps not only to reduce losses and maintain the quality of the product but also helps in conserving the conventional energy sources (Sablani *et al.*, 2003). ICAR-CIFT have developed different types of solar dryers for hygienic and effective drying of fish and fishery products.

Atmospheric parameters like temperature, relative humidity and solar radiation were recorded at one hour interval. Relative humidity varied from 69.4 to 85.4%, solar radiation varied from 125 to 1257 w/m^2 and ambient temperature varied from 29.6 to 34.4°C during drying operation. Solar - electrical hybrid dryer was used for drying of Mackerel' and 'Nandan' fish. The dryer showed excellent heat sealing property by attaining 65 °C within 8 minutes under no load conditions. The initial moisture contents of Mackerel and Nandan fish were 80% and 77%, respectively. For both types of fishes, maximum amount of water was removed during first two hours of drying *i.e.* till 40-50% moisture content (Fig 1). Thereafter, the drying rate was reduced and the similar trend was continued till 8 hrs of drying for Nandan fish and 12 hrs of drying for Mackerel fish. Final moisture content attained in dried Mackerel and Nandan fish were 14.5% and 14% respectively. Time taken for drying of Mackerel was 15 hours and Nandan was 10 hours. The result of sensory analysis of dried fish was observed to be within the acceptable limit. The observed water activity for dried Mackerel and Nandan fish was 0.78 and 0.76, respectively which indicates quality dried product. Similar results were also reported by Sapkale *et al.* (2003) for solar dried Mackerel fishes.

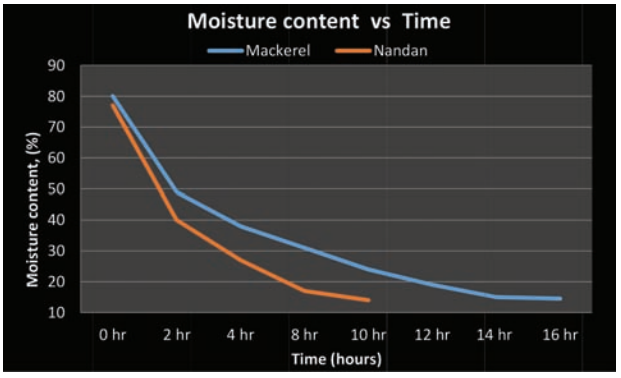

Fig. 1. Drying curve for Mackerel and Nandan fish

Drying of sole fish in solar cabinet dryer with electrical back up was carried out. The initial moisture content of salted fish was observed to be lower than fresh fish. Till first 6 hrs of drying, moisture content of fish decreased linearly with time. However after 6 hrs, the drying rate came down and the moisture removal from material was almost observed to be zero, implying materials equilibrium with the drying conditions (Fig 2). Totally it has consumed 8 hours to reach 18-20% moisture content with the water activity value of 0.70 for salted fish and 0.74 for fresh fish. The results revealed that salted fish consumed more time than fresh to attain almost similar final moisture contents. Joshi *et al.* (2014) noticed same trend for drying of fishes in improved solar

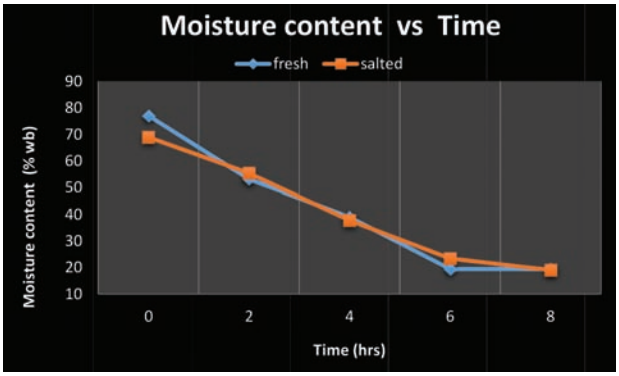

Fig. 2. Drying curve for fresh and salted sole fish

dryers.

The drying experiment of electrical dryer was conducted at 60°C temperature with average drying chamber temperature of 55°C. The moisture removal behavior of fresh and salted fish was slightly varied with drying time (Fig. 3). Fresh fish took 8 hrs to attain safe final moisture content, whereas salted fish took 10 hrs to achieve the same. The major advantage of electrical dryer is the controlled drying conditions, thereby uniform drying resulting in high quality dried product.

Solar tunnel dryer was also used for drying sole fishes. During drying, temperature inside the drying chamber varied from 29°C to 65°C due to variations of atmospheric conditions. In addition no backup or supplemental heating was installed in the drying chamber. The average fish temperature while drying was 45°C with chamber RH of 75%. The average solar radiation intensity during the drying days was 350 W/m^2 which consumed three days to attain safe storage moisture content (<20 % M.C.). Bhor *et al.* (2010) observed similar results for dhoma fish drying under tunnel dryer. It was observed that due to bad atmospheric weather conditions fish quality was poor. The fungal growth was observed on dried sample due to longer drying time. It is concluded that solar energy based dryers developed by ICAR-CIFT are efficient in drying the fishes to safest moisture content within the lowest possible drying time.

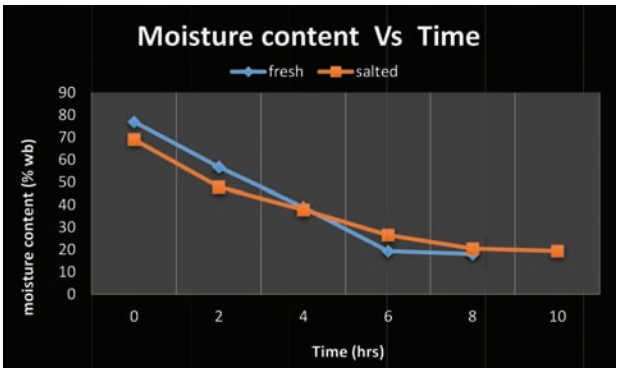

Fig. 3. Drying curve for fresh and salted sole fish dried in electric dryer

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New addition to Indigenous fish processing interventions - CIFT descaling machine

Zynudheen A.A., George Ninan, Manoj P. Samuel, Gokulan C.R. and Ravishankar C.N.

ICAR-Central Institute of Fisheries Technology, Cochin

Fisheries in India has emerged as an important economic sector with varied resources and potentials. Apart from engaging about 14 million people in different activities, the sector plays a significant role in meeting the nutritional security of the country. Despite the bountiful fishery resources, the demands of the consumers are seldom met in terms of availability of fish. A major factor contributing to this scenario is the post harvest losses, which in fisheries is around 18%. To alleviate these losses, improvement to post harvest operations *viz*. pre-processing and processing techniques, packaging and cold chain systems is required.

Of the various problems faced by fish processing sector, removal of scales from fishes is a major one. Generally scales of fishes are removed manually by knives, which is laborious and time consuming. Hence, an attempt was initiated by ICAR-Central Institute of Fisheries Technology, Cochin, to design and develop machines for descaling of fishes. These descaling machines are accepted among industrial as well as domestic sector as a boon against the existing tedious method of removing scales. Moreover, mechanical descaling minimizes the physical damages to the cleaned fish and are sensorily more appealing. Also, the scales can be accumulated and collected for the development of high value end products.

CIFT descaling machine is designed in three different variants, *viz*. the high end model with variable drum speed, table top model with fixed drum speed and a basic hand operated variant. All these models are capable of removing scales from small and medium sized fishes ranging from marine to freshwater species like sardine, anchovy, pink perch, rohu, tilapia, etc. Separate provisions are given for washing and collecting the removed scales. The machine takes only 3-5 minutes to clean 6 kg fish depending on the size. The scale removal efficiency is 95-100% depending upon species. De-skinning of squid was also attempted and it was observed that up to 90% removal efficiency is obtained. Since there is some entangling of tentacles of squid species, the machine can be used for de-skinning of squid tubes more effectively.

Apart from removing the scales of fishes, the process improves the appearance of the dark skinned fishes like tilapia, pearl spot etc.

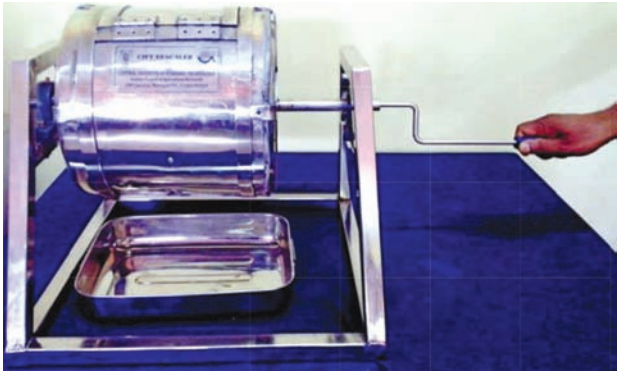
Squids for de-skinning

Squids in de-scaling machine

Agricultural products like Chinese potato and ginger which are difficult for de-skinning can also be successfully cleaned in this machine. This machine is used for standardizing the descaling conditions like rpm and time required for various species and conditions so that low cost machine specific for each species could be developed. The hand operated model is designed specifically for reducing the production and operating costs involved and also to make the technology reachable in areas suffering lacunae in supply of electricity. A handle is fitted at the side to rotate the drum manually. This machine is specially suited for road-side fish vendors and hotels.

The use of descaling machines serves not only the purpose of cleaning the fish but also keeps the process and surroundings clean without spilling of scales. They mainly aims at reducing human drudgery involved in removing the scales from fishes. Also, scales that amount upto 3-7% of the fish weight are good source of collagen and hydroxyapatite which is used in medicinal and nutraceutical fields. Six units of low cost machines have been transferred to entrepreneurs and found to have excellent performance in terms of scale removal and easy maintenance. The machines are under patenting of ICAR-CIFT.

Fish de-scaling machine with fixed drum speed



Hand operated fish de-scaling machine

Fish de-scaling machine with variable drum speed

Fish before and after de-scaling