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Contents

From the Editorial Board.....

Welcome to the 2016 January-June issue of FishTech Reporter. For the Indian fisheries sector this has been a period of significant developments and concerns. Release of the draft National Fisheries Policy and the Administrative approval of Government of India for implementation of the Central Sector Scheme -"Blue Revolution: Integrated Development and Management of Fisheries" are worth mentioning.

ICAR-Central Institute of Fisheries Technology has continued to grow and contribute to the fisheries sector during this period. This issue features 15 articles showcasing recent issues in the sector and ICAR-CIFT's technologies and process know how. Newly launched F.V. Sagar Harita is a solution to the absence of a standard combination green fishing vessel in the mechanized fishing sector of India. Articles on quality of boat building steel, combination gillnet and polypropylene (PP) sheet otter board features stories and innovations from the field.

A statistical quality index for shelf life prediction of *Pangasius hypothalmus*; and prevalence of multidrug resistant coagulase positive Staphylococci (MDR- CPS) in seafood address the quality issues. Two articles are on microencapsulation techniques for improving oxidative stability of fish oil. Quality and safety concerns of formaldehyde treated Indian mackerel as well as nutritional labelling of some commercially important fishes and shrimps from the retail markets of Kochi are of direct interest to the consumer. Jawala chutney powder and plastic mould for preparing shrimp analogue products are simple technologies for value addition. Production of bio-functional protein hydrolysate from different species of fish and fisheries waste, and salting and drying kinetics of brine salted and dry salted Ribbonfish (*Lepturacanthus savala*) are also covered in this issue. Energy use pattern of a seafood processing unit at Cochin, Kerala was studied to assess the energy footprint of fish processing plants. We are sure that the concerns and interests of fishers and consumers have been addressed in this issue.

F.V. Sagar Harita - An energy efficient combination fishing vessel from ICAR-CIFT

Baiju M.V. and Leela Edwin

ICAR-Central Institute of Fisheries Technology, Cochin

Modern fishing is one of the most energy intensive methods of food production. Motorized and mechanized fishing operations are dependent on fossil fuel which are non-renewable and limited. The First International Symposium on Fishing Vessel Energy Efficiency discussed important issues like energy auditing and development of green trawler (Rihan *et al.*, 2010: Thomas *et al.*, 2010). Annual fuel consumption by the mechanized and motorized fishing fleet of India has been estimated at 1220 million litres which formed about 1% of the total fuel consumption in India in 2000, releasing an estimated 3.17 m t of carbon dioxide into the atmosphere at an average rate of 1.13 t of carbon dioxide per ton of live weight of marine fish landed (Boopendranath, 2008). Various approaches to energy conservation in fish harvesting include vessel technology, fishing gear and methods and adoption of frontier technologies. Significant improvements in operational savings of fuel can be achieved by optimizing vessel and machinery design. Selection and deployment of energy efficient harvesting technologies appropriate for target resources is one of the main options available for fuel conservation. No standard design of combination fishing vessel incorporating fuel efficiency features, to reduce carbon footprint (green fishing vessel) is available for mechanized sector of India.

One of the main objectives of the project "Green Fishing Systems For Tropical Seas (GFSTS) funded by the ICAR-National Agricultural Science Fund was to construct a new generation energy efficient combination fishing vessel envisaged as a standard model for replication in the tropical waters. This combination fishing vessel (Fig. 1) was launched on the 18th April, 2016 by the Honorable Director General of ICAR, Dr. Trilochan Mohapatra at a function held at Cochin. The vessel was constructed at the Goa Shipyard Limited (GSL), Goa. The GSL partnered with ICAR-CIFT in the designing and model testing of the hull of this vessel. The database created on existing designs of fishing vessels was evaluated and the characteristic parameters and the operational inefficiencies against target performance values was evaluated. The benchmarking of the energy consumption parameters of the existing fishing vessels was also carried out. This database, first of its kind, added to the limited knowledge in this field.

Fig. 1. FV Sagar Harita

Novel Features of the Green Vessel

The hull form of the 19.75 m new generation energy efficient combination fishing vessel was developed based on the parent designs using the software Autoship and Maxsurf. The design was simulated to analyze and verify its behavioral characteristics such as resistance and sea keeping using Computational Fluid Dynamics (CFD) simulation software. After conducting model testing and stability analysis at Indian Institute of Technology (IIT), Madras as per the International Towing Tank Conference (ITTC) recommendations, the design was optimized. The novel features of the vessel are given in Table 1.

The hull is made of marine grade steel and the cabin and wheel house is made of FRP to

Table 1. Novel features of the 19.75 m FV Sagar Harita

Novel features	Advantages
Bulbous bow	Reduces resistance and improves fuel efficiency
Larger fuel tank (14000 L capacity)	For greater endurance at sea
RSW tank (4 -5 m^3)	Quick and better quality fish preservation
Solar panels (20 m^2)	Navigational lighting, wheel house, mess lighting, fan
Hydraulic long line winch	Reduces operation constrains and efforts by one third
Split trawl winch	To save deck space
Gillnet drum	Reduces the human efforts
Stainless roller at stern	For easy hauling of net
Net drum	For neat storage of gear
Freezer-cold store-RSW tank in a row	For easy handling and quality assurance of catch
Reduced wheel house height	For increased stability and carrying capacity with vessels of similar size also reduces the resistance
Efficient propulsion system	Increased thrust, maneuverability and energy efficiency during fishing operations
Bilge keel	To reduce rolling and improved sea keeping characteristics

reduce weight and to improve the carrying capacity and speed. The main engine power is 400 hp which is 20% lower than comparable size vessel. The fishing gear handling equipment such as split trawl winch, long line hauler, setter and gillnet hauler designed at CIFT with hydraulic power were installed onboard (Fig. 2). RSW tanks (0 °C to -1 °C) of 2 t capacity were also provided for good fish preservation practices. A 600 watt solar power panel is designed and installed for emergency lighting and navigational aids to promote the utilization of renewable energy resource in the sector. Acoustic trawl telemetry system with under water sensors is also installed onboard.

Fig. 2. Winches on deck of FV Sagar Harita

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Polypropylene sheet otter board: Innovation in the trawl sector of Veraval, Gujarat

Prajith K.K. and Ramachandra Khileri

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

The trawlnet designs and related accessories are undergoing random changes all over the world. Otter boards are not exceptional. Otter boards are sheer devices, which are used to keep the trawl mouth, bridles and warps horizontally open, during the tow. They keep the bottom trawl in contact with the seabed and help to maintain the fishing depths of mid-water trawl. Otter boards contribute about 25% of the total drag of the trawl system and are responsible for 16% of the total fuel consumption. Before the introduction of otter boards, the trawl net was kept open by means of a beam. But as the size of the boats and trawls increased it was not possible to use correspondingly longer beams as it created problems of handling onboard fishing vessels. There are several designs of otter boards used in our country. The major otter board types of India are rectangular flat otter boards, rectangular cambered otter boards, oval otter boards and rectangular V-shaped otter boards.

Rectangular flat otter boards of wood and steel construction are one of the earliest known designs and are still widely used for bottom trawling in India (Fig. 1). Rectangular cambered otter boards were introduced for bottom trawling in Gujarat waters. But these otter boards did not attain the expected popularity in spite of their better hydrodynamic properties, probably due to additional skills required to fabricate them. Oval otter boards with an oval profile are known to have improved performance on rough or hard bottoms. Rectangular V-shaped otter boards are simple in design and are constructed in mild steel. Main advantages are ability to tide over hard stony grounds, inherent stability and long service life compared to conventional flat rectangular boards.

Fig. 1. Dorsal and ventral view of traditional rectangular flat wooden otter boards of Veraval coast

Among these, rectangular flat otter board is widely used by Veraval trawl fishermen. Dimensions of typical wooden rectangular otter board are given in Table 1. The common timbers used for fabrication are imported Malaysian and Indonesian teak (₹ 1800/cubic feet), Valsadi (local name) (₹ 2200/cubic feet) and Burman wood (₹ 3000/cubic feet). Initially locally available babool wood (*Vachellia nilotica*) was used for the otter board construction. Babool wood is less durable and easily susceptible to bending and other damages.

Table 1. Details of rectangular flat wooden otter board used in Veraval coast

Sl. No.	Length (m)	Width (m)	Weight (kg)/Pair	Cost (₹)/Pair
1	1.30	0.68	80-100	15500-18500
2	1.45	0.76		
3	1.50	0.76		
4	1.60	0.83		
5	1.50	0.90		

In Veraval, the board is assembled by joining planks and fixing them together with long bolts or mild steel straps. A wide iron metallic shoe is used to prevent digging into the mud and is rounded off at the leading edge so that it can ride over obstructions. Sometimes a gap is left in between the planks which is said to prevent turbulence on the other side of the board. These boards are comparatively cheaper, easy to handle and easy to fabricate. However, these boards are hydro-dynamically not very efficient and also not suitable for rough grounds as they cannot slide over obstacles. Besides this, there are some operational and maintenance difficulties in the case of rectangular flat otter boards. Important problems are need for annual maintenance or replacement of wood and steel frame; increase in the weight on soaking in water; during off season, the wooden otter board get exposed to external climate which will lead to bending; and the iron frame of wooden otter board undergoes rusting.

Recently a progressive fisherman of Veraval, Gujarat Shri Prabhudas Bensala replaced the wooden otter board of his trawler with poly propylene (PP) (Fig. 2 and 3). Shri Bensala says "we need to replace and purchase the material for wooden otter board yearly due to many reasons. Once I noticed the radar of one of the boat of Maharashtra coast constructed with PP, later on I thought why we can not replace the wooden otter board with the same material".

Few months back Shri Bensala constructed 20 pairs of otter boards with PP and distributed among the fishermen of Veraval. From the trial of four months, he opined that the orientation and balancing of the PP otter board was good and the resistance was lesser compared to the traditional wooden otter boards. The construction coast of PP otter board is ₹ 25000-26000 whereas that of the wooden otter board is ₹ 15500-18500 only. But considering the durability and drag reduction, economically, the PP otter board design is likely to perform well in the long run. However, the efficiency and performance of the new otter board need to be studied for a long duration.

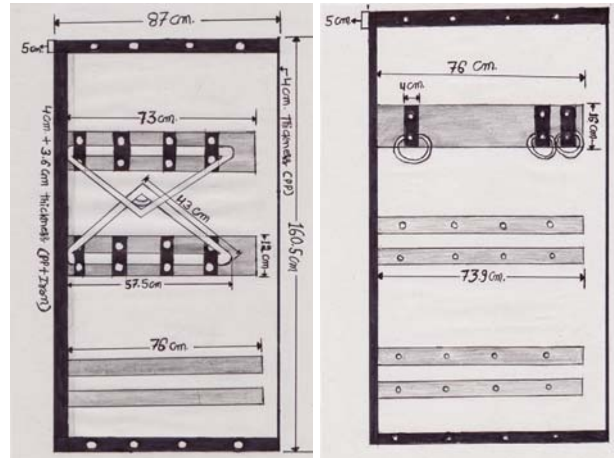

Fig. 2. Diagrammatic representation of dorsal and ventral view of rectangular flat PP otterboard

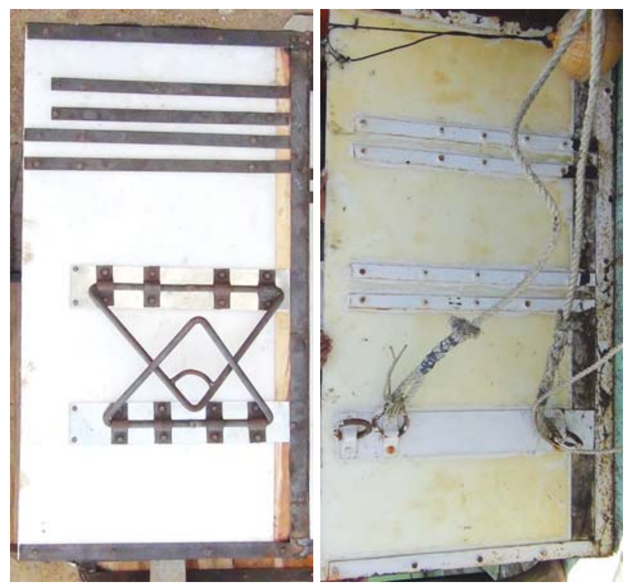

Fig. 3. Dorsal and ventral view of rectangular flat PP otter board of Veraval coast

Quality of boat building steel: Story from the field

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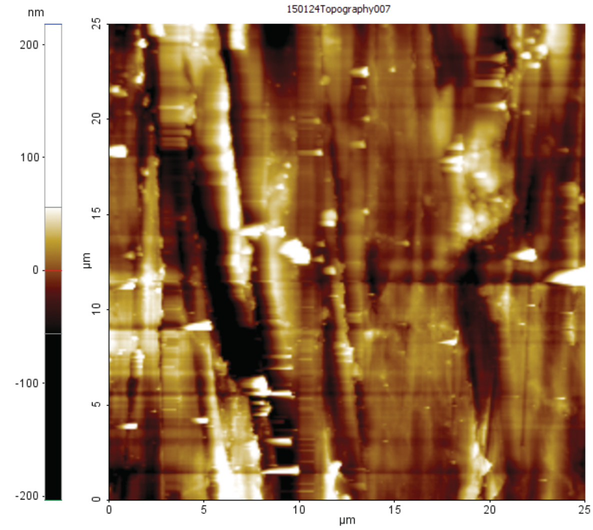
ICAR-Central Institute of Fisheries Technology, Cochin

Mechanization of fishing sector fuelled the construction of steel boats as it ensures ease of construction and operation. Globalization has enabled import of steels from countries like China and the sector is flooded with different grades of steels. The lack of an effective quality control system to evaluate the materials imported and very poor awareness among the users about the quality of the material used aggravate the situation. On the steel plates there is no marking of quality, manufacturer or other details which further denies the availability of quality material. Testing facility for quality assessment of the material is very meager in the Indian scenario. A group of fishermen from Kollam, Keala constructed fishing boats using steels procured from local markets and the same had undergone severe pitting corrosion within few weeks of service. The fishermen approached ICAR-CIFT to evaluate the steel used for boat construction. We tested the material to find out the reasons behind this atypical corrosion problem.

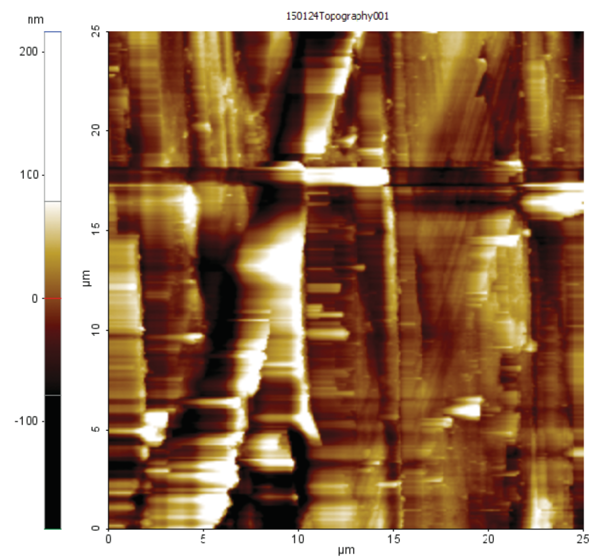
Two sets of samples of steel plates supplied by the fishing boat owners *viz.*, corroded plate cut from the hull of the vessel (marked as 'a') and unused part of the plate (marked as 'b') were used for quality evaluation. The sample plates were cut in to 5 × 3 cm sizes and were cleaned to remove paint and dirt through mechanical means as per ASTM standards. The surface of the plate was ground upto 600 grits. For AFM studies, it was ground upto 1500 grits. The panels were cleaned by sonicating in acetone and washed with Milli Q gradient water.

Surface morphology of the material

The panels were polished using sand papers upto1500 grits and the surface morphology was analyzed using Park Systems MX100 Atomic force microscope. The horizontal and vertical surfaces of the panels were analyzed. The micrographs exhibited thin cracks and surface roughness of about 19.93 nm and 29.44 nm, respectively for surface and vertical height in the 25 µm scanned region (Fig 1).



Horizontal section view



Vertical section view

Fig. 1. Atomic force micrographs of steel plates

Electrochemical Evaluation

Linear polarization measurements: The samples were cut to 10 × 115 cm sizes and polished upto 1000 grits after removing all dirts and paints from the panels. The panels were subjected to linear polarization studies using AUTOLAB PGSTAT 30 corrosion measurement system. The linear polarization studies were performed in 3.5% NaCl as electrolyte using Ag/AgCl (3M KCl) reference electrode, Platinum as counter electrode and sample as working electrode. The results are shown in Table 1 and Fig. 2. The results showed large variation in corrosion current density and polarization resistance within the sample itself. This indicates that the material is more prone to corrosion due to the varied currents showed by the specimen. A comparative evaluation with recommended boat building steel, IS 2062, is also given in Table 1. The results showed that the supplied material had lower polarization resistance and higher corrosion density. When the material is having higher Rp value, it indicates lower corrosion current density and higher corrosion resistance. In the present case, compared to the IS 2062, the material is less

Table 1. Linear polarization characteristics of steel samples supplied by the fishermen of Kollam in comparison to the recommended IS 2062 steel

Specimen	Linear polarization parameters	Steel sample supplied by Kollam boat owners	IS 2062 steel
Unused steel	Corrosion Current Density I_{corr} (A/cm^2)	1.54×10^{-05}	3.25×10^{-06}
	Polarization Resistance R_p (Ohm cm^2)	4480	10620
	Corrosion potential E_{corr} (V)	-0.488	-0.600 to 0.860
Corroded or used steel	Corrosion Current Density I_{corr} (A/cm^2)	8.22×10^{-06}	3.576×10^{-06}
	Polarization Resistance R_p (Ohm cm^2)	6390	9209
	Corrosion potential E_{corr} (V)	-0.567	-0.609 to -0.800

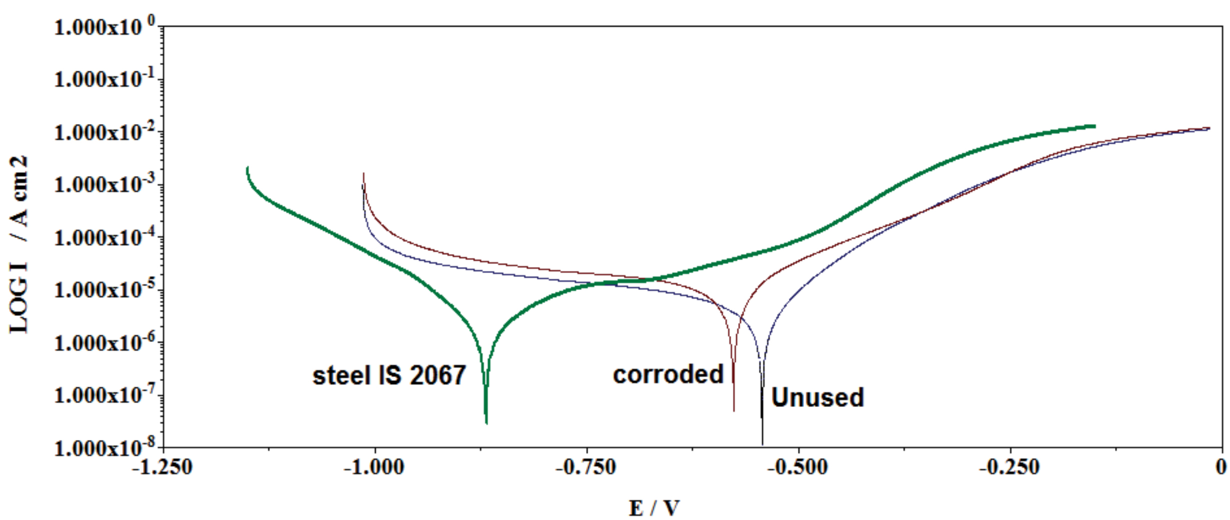


Fig 2. The Tafel plot of IS 2062 steel, unused and corroded steel supplied by the Kollam fishermen

resistant to corrosion and the higher standard deviation further highlights the instability of the material in seawater.

Electrochemical impedance spectroscopic (EIS) analysis: The impedance measurements were done by scanning 1MHz to 0.1Hz frequency with 5 decades at open circuit potential and the results are shown in Table 2 and Figure 3. The EIS data was fitted with simple Randle's Equivalent circuit models using FRA 2 software available with Autolab FRA2 module.

The polarization resistance (Rp1) at high frequency indicates the electrochemical impedance behavior of the outer-most layer of the steel and the Rp2 at low frequency region indicates the behavior of inner layer of the material. In the present case the Rp1 values were comparatively higher showing that the surface is resistant to corrosion mainly due to the influence of iron oxide present on the surface. The Rp2 of internal layer was 1104 Ohms cm^2 indicating the internal iron matrix and the value is comparable. EIS data of IS 2062 steel done at ICAR-CIFT on earlier occasions is given in Table 2. The results showed that Rp1 was very low and Rp2 was comparatively high. This indicates that the surface layer of Kollam steel is resistant to corrosion but

Table 2. EIS data of steel samples supplied by the fishermen of Kollam

Specimen	Electrochemical impedance parameters steel	Kollam Boat steel	IS 2062
Unused	Rp at high frequency domain Rp1 (Ohm cm^2)	115.53	23.09
	Rp at low frequency domain Rp2 (Ohm cm^2)	1104.67	1131
	Constant phase Element at High frequency domain C1 (μF)	148.67	10.96
	Constant phase Element at Low frequency domain C2 (mF)	0.32	0.48
Corroded	Rp at high frequency domain Rp1 (Ohm cm^2)	110.75	-
	Rp at low frequency domain Rp2 (Ohm cm^2)	726.00	-
	Constant phase Element at High frequency domain C1 (μF)	42.17	-
	Constant phase Element at Low frequency domain C2 (mF)	152.40	-

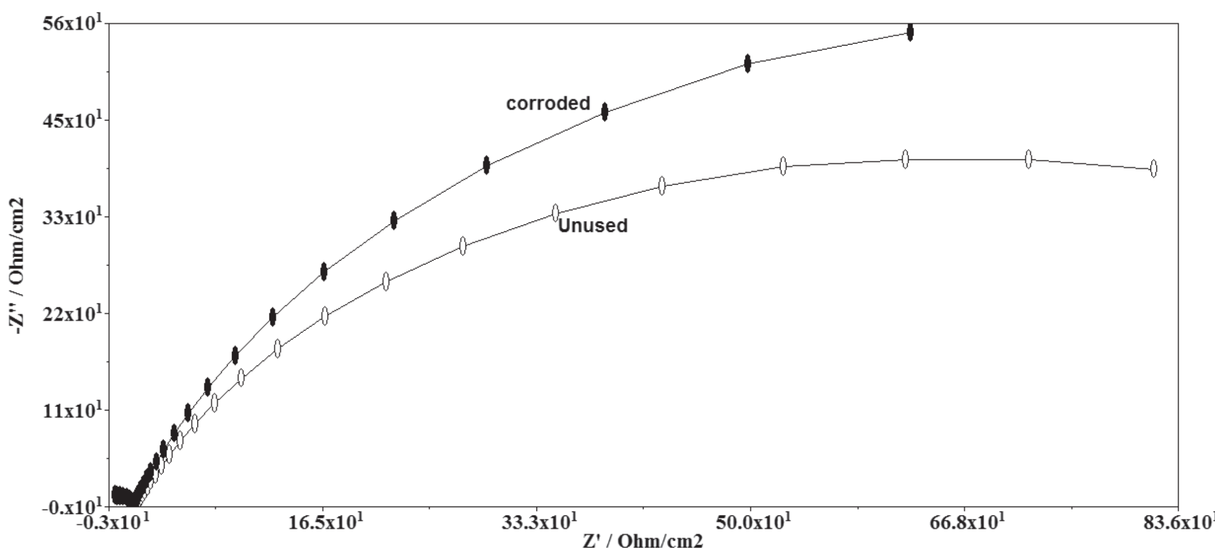


Fig. 3. Electrochemical impedance spectrograph of unused and corroded specimen of steel supplied by the fishermen of Kollam

easily ruptured under aggressive marine environments.

Chemical composition of steel

The steel samples were digested using conc. HCl and diluted to 100 ml. The samples were analyzed for metal composition using the Perkin Elmer Optima 2000DV Inductively coupled Plasma Optical emission Spectroscope and the results are shown in Table 3. The iron content was very low in the samples (about 80–82%). The elemental composition was compared with carbon steel specification from SAIL India brochure where the maximum Mn concentration was 1.5% (Table 4) while in the current samples it was only 1%. While digesting the sample, higher amount of undissolved particles and dirt were observed. Probably, the material had higher amount of iron oxides which was evident from the electrochemical impedance high frequency domain data.

Summary and conclusion

- The sample submitted by fishermen of Kollam was subjected to electrochemical, chemical and morphological studies. On AFM evaluation cracks were observed on the surface.
- The electrochemical evaluation showed that the steel had lower polarization resistance and higher current, indicating less resistance to corrosion in marine environments. Further evaluation with EIS also showed that the

Table 3. The chemical composition of carbon steel IS 2062

Grade	% Chemical Composition													Deoxidation
	C	Mn	Si	S	P	Al	Cr	Ni	Cu	Nb	V	Ti	N	
IS 1079 Gr O	0.15 max	0.6 max	-	0.055 max	0.055 max	-	-	-	-	-	-	-	-	Semi killed Killed
IS 1079 Gr D	0.12 max	0.5 max	-	0.04 max	0.04 max	-	-	-	-	-	-	-	-	Semi killed Killed
IS 1079 Gr DD	0.1 max	0.4 max	-	0.035 max	0.035 max	0.02 min	-	-	-	-	-	-	-	Al killed
IS 1079 Gr EDD	0.08 max	0.4 max	-	0.03 max	0.03 max	0.02 min	-	-	-	-	-	-	-	Al killed
IS 2062 E250 A	0.23 max	1.5 max	0.40 max	0.045 max	0.045 max	-	-	-	-	-	-	-	-	Semi killed Killed
IS 2062 E250 B	0.22 max	1.5 max	0.40 max	0.045 max	0.045 max	-	-	-	-	-	-	-	-	Killed
IS 2062 E250 C	0.2 max	1.5 max	0.40 max	0.04 max	0.04 max	-	-	-	-	-	-	-	-	Killed
IS 2062 E250 Cu C	0.22 max	1.6 max	0.45 max	0.04 max	0.04 max	-	-	-	0.2-0.35	-	-	-	-	Killed
IS 2062 E410	0.20 max	1.6 max	0.45 max	0.045 max	0.045 max	-	-	-	-	-	-	-	-	Killed
IS 2062 E450 D	0.22 max	1.6 max	0.45 max	0.045 max	0.045 max	-	-	-	-	-	-	-	-	Killed
IS 2062 E450 E	0.22 max	1.80 max	0.45 max	0.045 max	0.045 max	-	-	-	-	-	-	-	-	Killed

Source: http://www.sail.co.in/sites/default/files/plants/special-steel-plants/Salem_Userguide.pdf

Table 4. Chemical composition of steel supplied by fishermen of Kollam

Element	Unused (%)	Corroded (%)
Fe	80.09	82.48
Mn	1.092	0.996
Cr	0.011	0.012
Cu	0.007	0.005
Ni	0.006	0.005
Zn	0.014	0.007
Co	0.002	0.001

material was prone to corrosion in aggressive marine environments.

- The chemical composition of the material showed only about 80% of iron in the matrix.
- From our preliminary evaluation, the quality of the material was found inferior for use in aggressive environments. Finally, the steel used by the fishermen of Kollam for construction of boat is more prone to corrosion in the marine environments. Detailed evaluation is required from a metallurgical point of view to pinpoint the exact reasons for aggressive degradation and quality of the steel used.

Recommendations

- Detailed study on the quality of the steels used for boat construction needs to be carried out.
- There is an urgent need to make it mandatory to print the quality standards of the steel over the sheets.
- There is an immediate need to conduct awareness programmes for the boat owners regarding the standards of the steel and their properties.

First report on combination set gillnet from Puthuvype, Kerala

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Sharks and rays are mostly caught as bycatch in gillnets. However, gillnets targeting sharks (Akhilesh *et al.*, 2011) and rays (Sherief *et al.*, 2015) are operated in certain areas. Gillnet - trammel combination net has been earlier reported by Flewwelling *et al*. (2003). But for the first time, a shark/ray combination gillnet having two distinct portions/sections *viz.*, the upper panel targeted for sharks and the lower panel for rays is reported from Puthuvype, Kerala. Puthuvype is a small fishing village in Ernakulam district of Kerala. During a study of gillnet and trammel nets in February-March 2015, it was noted that fishermen from this area were using a combination net for catching shark as well as rays.

Design of a typical combination gillnet is depicted in Fig. 1. This net had two panels, upper and lower. Though both the panels were made of polyamide, the type of material, its thickness and mesh size varied between the panels. The upper and lower panels were joined by tying knots at

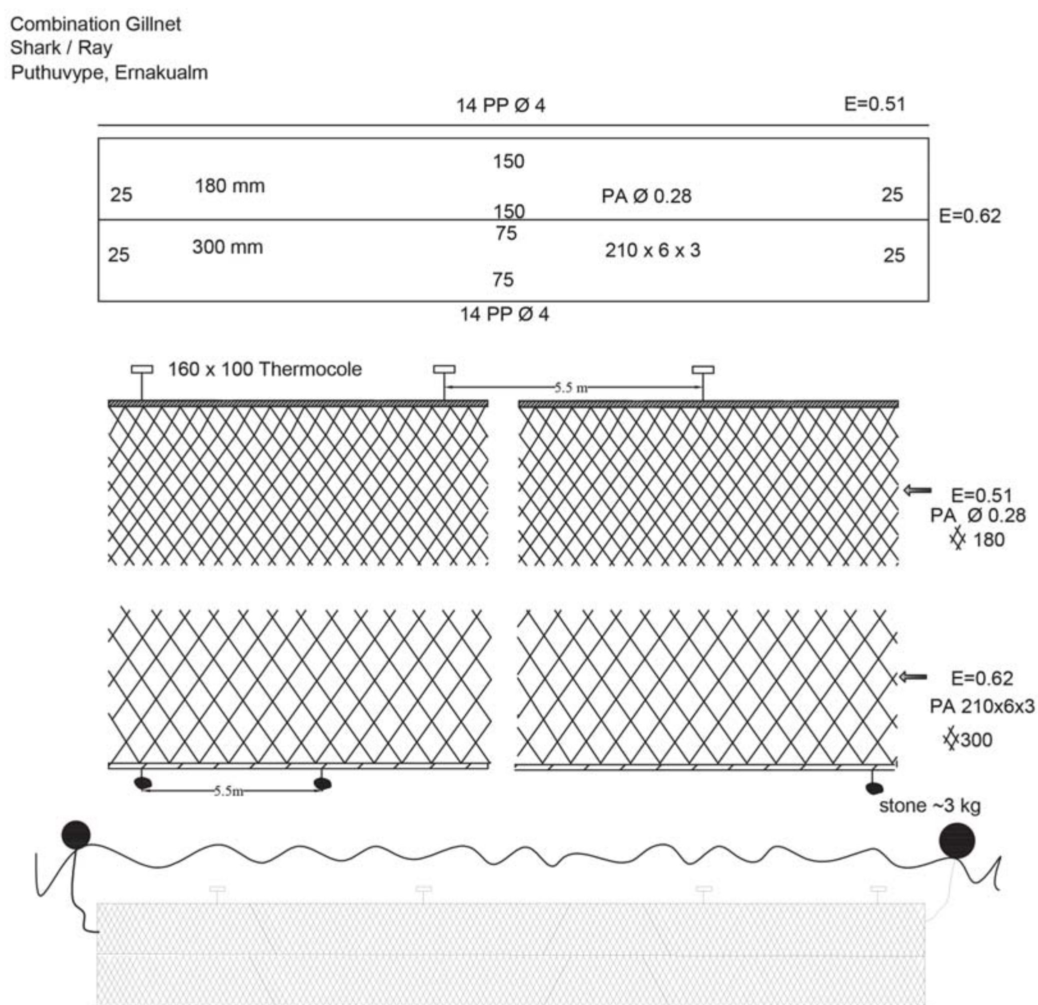

Fig. 1. Design of a typical combination gillnet

1.0 m interval throughout the length of the net. The gear had 27 m length and 9.7 m depth (25 mesh each in the upper and lower panel).

The main webbing of the upper panel was made up of polyamide monofilament of 0.28 mm diameter and 180 mm mesh size with a hanging coefficient of 0.51. The main webbing of the lower panel was made up of polyamide multifilament twine of 210 X 6 X 3 having mesh size of 300 mm with a hanging coefficient of 0.62. PP rope of 4 mm was used as head rope and foot rope in this gear. Thermocole of 160 x 100 mm approximately was used as floats at a distance of 5.5 m. Granite stone sinkers of approximately 3 kg weight were attached on foot rope at a distance of 5.5 m. There was no selvedge in top and bottom.

The net is operated as bottom set, during August - November months at a depth of 5 to 15 m depth from a craft of around 7.6 m to 9 m L_{OA} manned by two persons. This combination net is a resource specific gear targeted specifically for sharks and rays.

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Nutritional labelling of some commercially important fishes and shrimps from the retail markets of Cochin

Lekshmi R.G.K., Chatterjee N.S., Tejpal C.S., Asha K.K., Anandan R. and Suseela Mathew

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Fishery resources have been considered as an excellent source of dietary protein, minerals and vitamins. Fats and oils from fish is widely recognized as better dietary sources of long chain polyunsaturated fatty acids *viz.*, EPA and DHA which are not contained in the fats of terrestrial animals or in vegetable oils. Several reports confirmed that fish oil supplementation is beneficial for the healthy functioning of the heart, brain and nervous system. Many organizations like the health authorities in Canada (Scientific Review Committee, 1990) and the United Kingdom (The British Nutrition Foundation, 1992) have recommended higher proportion of n-3 fatty acid consumption as prophylactic and therapeutic aid for many cardiovascular ailments. Moreover, daily intakes of about 200–400 mg of long chain n-3 PUFA has been recommended in Europe and the US (de Deckere *et al.*, 1998; Simopoulos *et al.*, 2000). Apart from this, fish is considered as an affordable food source for about 400 million poor people in small island states (FAO, 2007).

Food composition data are needed to estimate the actual contribution of a particular food to the recommended dietary nutrient intakes of individuals or populations. Such data is also important for the development of food-based dietary guidelines and for labelling purposes. However, in many food composition tables, fish is included to a limited extent only. Considering this need, recently the FAO International Network of Food Data Systems (INFOODS) endeavored into developing a user databases for fish and shellfish (uFiSh). In the present study, nutritional labelling of some commercially important fishes and shell-fishes collected from retail markets of Cochin were carried out and the results are given in Table 1 and 2.

A total of four fishes collected during the months of October-November *viz*; Indian Mackerel (*Rastrelliger kanagurta*), Threadfin bream (*Nemipterus japonicus)*, Six-barred Reef Cod (*Epinephelus diacanthus*), Indian anchovy (*Stolephorus indicus)*, and two shrimps, Flower shrimp, *Penaeus semisulcatus* and Giant tiger prawn *(Penaeus monodon)* were biochemically analyzed in the present study. The protein content of these species varied from 18.22 to 23.46%. Among the samples analyzed, *Nemipterus japonicus* showed a higher protein content of about 23.46%, followed by *Rastrelliger kanagurta* (22.99%) and a comparatively lower protein content of about 18.02% was observed in Flower shrimp, *Penaeus semisulcatus*. Likewise, fat analysis showed that *Epinephelus diacanthus* was having higher fat content of about 4.03% followed by Indian mackerel (1.62%). Based on the RDI level given by National Institute of Nutrition (NIS), Hyderabad, the daily dietary percentage contribution towards protein and fat from these samples were calculated. It was observed that about 32–41% of the daily requirement of the protein can be met by the consumption of 100 g of these species, where higher protein contribution was recorded from threadfin bream (41.89%) followed by Indian mackerel (41.06%). Similarly, about 1.76–6.20% of the daily dietary requirement of fat can be obtained by the consumption of these species, with *E. diacanthus* contributing the higher proportion. Apart from this, combined caloric content of protein and fat was also estimated. About 88-127 calories per 100 g can be obtained from the consumption of these species with the highest caloric contribution from *E. diacanthus* followed by *R. kanagurta* and *N. japonicus*.

Table 1. Proximate composition of the species analyzed

Name of sample	Moisture (g/100 g)	Protein (g/100 g)	Fat (g/100 g)	Ash (g/ 100 g)	Total calories (Protein+ Fat)	Calories from fat (per 100 g)
Rastrelliger kanagurta	75.39	22.99	1.62	0.47	111	14.6
Nemipterus japonicus	75.51	23.46	1.03	3.16	108	9.3
Epinephelus diacanthus	72.45	21.60	4.03	1.92	127	36.3
Stolephorus indicus	71.86	22.16	1.15	4.83	103	10.3
Penaeus monodon	76.02	22.02	1.30	0.66	104	11.7
Penaeus semisulcatus	76.85	18.02	1.40	3.73	88	12.6

Table 2. Fatty acid, cholesterol and fat soluble vitamins content in the species analyzed

Name of sample	SFA	MUFA	PUFA	Cholest-erol	Vit.A	Vit.D	Vit.E	Vit.K
Rastrelliger kanagurta	253.47	100.17	462.17	78	16.13	17.13	241	7.57
Nemipterus japonicus	67.92	31.21	101.90	65.24	12.90	42.76	341	8.27
Epinephelus diacanthus	869.22	612.46	502.92	119.29	33.30	5.54	193	ND
Stolephorus indicus	217.90	64.90	513.28	104.97	24.37	23.87	508	ND
Penaeus monodon	101.06	70.30	201.12	155.19	31.71	20.28	871	12.73
Penaeus semisulcatus	73.03	46.29	85.29	153.58	41.94	77.86	1402	34.03

- Fatty acid and cholesterol content are expressed in mg/100g and vitamins in µg/100g of sample
- ND – Not Detectable

The important macro-elements like calcium, sodium and potassium content was also analyzed and it was found that calcium content was higher in all these species followed by potassium and sodium. The highest calcium content was found in *S. indicus* (754 mg/100 g) followed by *P. monodon* (633 mg/100 g) and *P. semisulcatus* (561 mg/100 g). The potassium level was higher in *S. indicus* (377 mg/100 g) followed by *R. kanagurta* (361 mg/100 g) and *N. japonicus* (347 mg/100 g). The lowest potassium content was noted in *P. monodon* (227 mg/100 g). The sodium content was found to be higher in *S. indicus* (323 mg/100 g) and lowest in *E. diacanthus* (37 mg/100 g). As per the RDI level given by National Institute of Nutrition (NIS), Hyderabad, it was found that about 2-13%, 5-9% and 54-75% of the daily dietary requirements of sodium, potassium and calcium, respectively can be obtained by the consumption of these fishes and shrimps. The fatty acid composition, fat soluble vitamins and cholesterol content in all these species were also analyzed and given in Table 2.

As expected, the polyunsaturated fatty acid content was more than monounsaturated and saturated fatty acid content in almost all samples except in *E. diacanthus* where a higher content of saturated fatty acids was observed. The highest monounsaturated fatty acid content was reported in *E. diacanthus* (612.46 mg/100 g) followed by *R. kanagurta* (100.17 mg/100 g) and the least was observed in *N. japonicus*. The polyunsaturated fatty acid content was found to be higher in *S. indicus* (513.28 mg/100 g) followed by *E. diacanthus* and *R. kanagurta*. As per the dietary recommendation given by NIS, Hyderabad, the daily dietary contribution towards fatty acids that can be obtained from the consumption of these species was calculated. It was found that 7.11-16.76% and 8.49-42.77% of the daily requirement of PUFAs can be met by the consumption of fishes and shrimps, respectively. The highest contribution of PUFA was from *S. indicus* (42.77%), followed by *E. diacanthus* (41.91%) and *R. kanagurta* (38.51%) and the least was from *P. semisulcatus* (7.11%). The highest cholesterol content was reported from shrimps in general than fishes (155.19 mg/100 g). About 51% of the daily requirement of cholesterol can be met by the consumption of shrimps. Likewise, the consumption of fishes can help in meeting 11.30- 39.76% of the daily cholesterol requirement. Among the fish samples analyzed, the highest cholesterol content was reported in *E. diacanthus* (119.29 mg/100 g).

Among the fat soluble vitamins, higher vitamin A content was reported in *P. semisulcatus* (41.94 µg/100 g) followed by *E. diacanthus* (33.30 µg/100 g) and *P. monodon* (31.71 µg/100 g) and the lowest content was reported in *N. japonicus* (12.90 µg/100 g). Vitamin D content was higher in *P. semisulcatus* (77.86 µg/100 g) and lowest in *E. diacanthus* (5.54 µg/100 g). Coming to the vitamin E content, the highest amount was reported from *P. semisulcatus* (1402 µg/100 g) followed by *P. monodon* (871 µg/100 g) and *S. indicus* (508 µg/100 g) and lowest content in *E. diacanthus* (36.93 µg/100 g). The vitamin K content was highest in *P. semisulcatus* (34.03 µg/100 g) followed by *P. monodon* (12.73µg/100 g). But in case of fishes like *S. indicus* and *E. diacanthus*, the vitamin K content was found to be below the detectable limits. In general, the vitamin analysis showed that *P. semisulcatus* was having higher amount of all the fat soluble vitamins than all the other samples analyzed. As per the RDI level given by NIS, Hyderabad, it was found that the consumption of these species can contribute as high as 4.66%, 519.06%, 9% and 28.36% of the daily requirements of vitamin A, D, E and K, respectively.

Conclusion

The nutritional composition of selected commercially important fishes and shrimps showed that the daily dietary requirement of 32–41% of protein, 1.76–6.20% of fat, 2-13% of sodium, 5-9% of potassium, 54-75% of calcium and 7.11-42.77% of PUFAs can be met by consuming 100 g of fish meat. Moreover, considerable amount of fat soluble vitamins and cholesterol can also be obtained from these species. Hence, these seafood sources can be considered as a better dietary source in terms of both nutrient availability and affordability.

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Effect of chitosan and oregano essential oil on the stability of microencapsulated fish oil

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Fish oil represents a functional food ingredient and an excellent source of omega-3 (n-3) polyunsaturated fatty acids (PUFA) like eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These long chain fatty acids play an important role in reducing the risk of cardiovascular diseases and promoting pre- and post-natal brain and visual developments in infants. Autoxidation of PUFA in fish oil leads to the development of oxidation products and limit the shelf-life of foods. Oxidation of omega-3 polyunsaturated fatty acids (PUFA) is prevented through the use of controlled storage conditions. (eg. packing in an inert atmosphere and chilling), addition of antioxidants, and by microencapsulation. Spray drying is commonly used in the food and pharmaceutical industries to transform liquid materials to dried powders and it has been widely applied to prepare omega-3 PUFA microcapsules. However, only limited numbers of wall materials are compatible with this technology. Hence, there is a need for new wall materials to be developed that can be used at high temperature and high evaporation conditions which prevail in the spray drying environment. Chitosan is a β (1,4) linked copolymer of D-glucosamine and N-acetyl-D-glucosamine and it has been studied in food applications including antimicrobials, edible films, emulsion stabilization, and texture modification. The present study was aimed to prepare fish oil microencapsulates by using chitosan, bovine gelatin and maltodextrin as wall material for encapsulation. Fish oil and wall material was used at the ratio of 1:2. In order to study the effect of natural antioxidants on the fish oil encapsulates, oregano (*Origanum vulgare* L) essential oil was added at 0.25% concentration and prepared encapsulates were coded as CHGME. Microencapsulates prepared without addition of oregano essential oil served as control (CHGM). Physical, chemical and oxidative stability of fish oil microencapsulates were analyzed. Microcapsules had a moisture content of 2.8-3.2%. Encapsulation efficiency of fish oil encapsulates ranged from 59.98-68.20%. Results showed that flow properties of fish oil encapsulates had less (23.08-24.58) Carr's value and passable flowability. Morphological characterization of fish oil encapsulates by scanning electron microscopy (SEM) revealed spherical shape of particles without any cracks (Fig. 1 and 2). Oxidative stability of fish oil encapsulates were monitored under

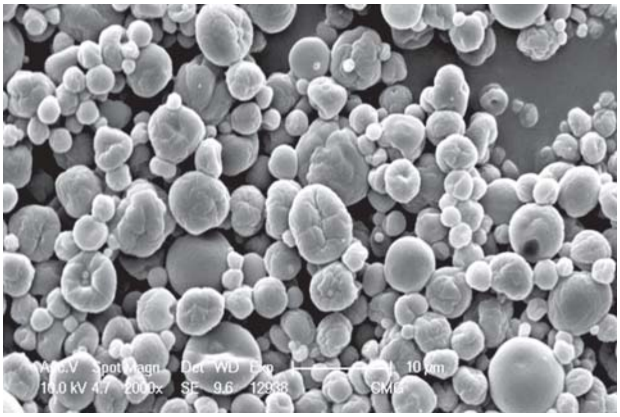

Fig.1. SEM image of microencapsulated fish oil prepared without oregano essential oil (CHGM)

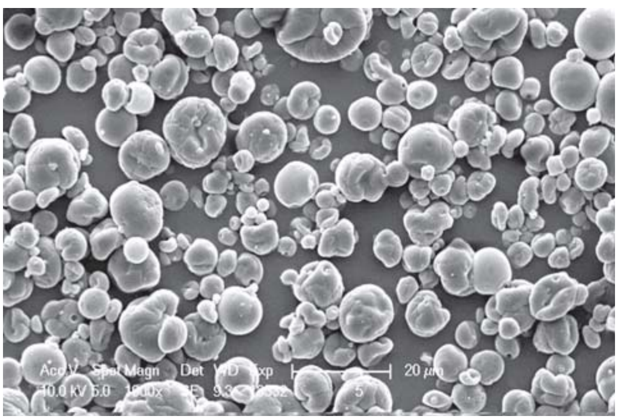

Fig.2. SEM image of microencapsulated fish oil prepared with oregano essential oil (CHGME)

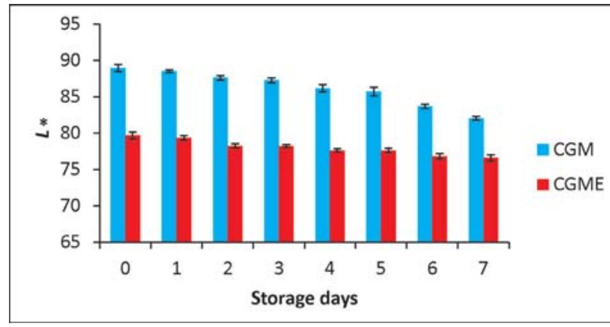

Fig.3. Changes in L* value of microencapsulated fish oil during storage

accelerated temperature of 50 °C for seven days at 24 hr interval and it was tested by thiobarbituric acid value. Tristimulus colour values of L*, a*and b* are used as indices of the colour changes in fish oil encapsulates during storage. A decreasing trend in L* (88.95 to 82.03 for CHGM sample; 79.65 to 76.6 for CHGME) was observed under accelerated storage (Fig. 3). Oxidative stability studies revealed that encapsulates prepared with oregano essential oil had lower TBA (0.78 mg malonal-dehyde/kg) value than control (8.2 mg malonal-dehyde/kg). Results from the study suggested that combined effect of chitosan and oregano essential oil could improve the oxidative stability of fish oil microencapsulates.

Oxidative stability of sardine oil microencapsulated by vanillic acid-grafted chitosan

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Importance of marine lipids in human health has been continuously increasing. Many pharmacological studies have shown the medicinal importance of n-3 fatty acids. The unsaturated moieties of omega-3 and omega-6 fatty acids are crucial for their health promoting functions. However, n-3 fatty acids are highly susceptible to oxidation. Oxidation reduces the quality of oil and produces off-flavour through the breakdown of lipid hydro-peroxides. Off flavour and colour degradation of fish oil are the limiting factors for its use in foods. Furthermore, the hydroperoxides generated during lipid oxidation also have been considered to be toxic. Prevention of oxidation of n-3 fatty acids is essential in allowing them to accomplish their original physiological functions. Hence, fish oil needs to be protected from factors that promote oxidation (oxygen, light, free radicals and pro-oxidants). Lipid oxidation of oils can be reduced by the addition of antioxidants or by microencapsulation. Microencapsulation is a very suitable method to facilitate the incorporation of omega-3 fatty acid into foods. Encapsulation by spray drying is a rapidly expanding technology in pharmaceutical and food industries, wherein a lipophilic active ingredient is loaded within a wall material to form microcapsules. Microencapsulation improves storage stability, ease of handling and controlled delivery of lipophilic active ingredient.

In the present study, microencapsulation of sardine oil by emulsification-spray drying technique was carried out for stabilizing the ω-3 fatty acids. Vanillic acid-grafted chitosan was used as a novel wall material. Further, the oxidative stability was assessed under accelerated oxidative atmosphere by conducting a rancimat test and peroxide value of the encapsulated powder was determined during storage at room temperature.

Stable emulsion of sardine oil and vanillic acid-grafted chitosan was prepared using 0.1% Tween 20 and 8mg of beta-carotene/g of oil. Microscopic structure of emulsion containing 0.1% Tween 20 (Fig. 1) did not show any coalescence. Lower cocentration of Tween 20 acted as a protective layer around the droplet in the emulsion and revealed good emulsion stability.

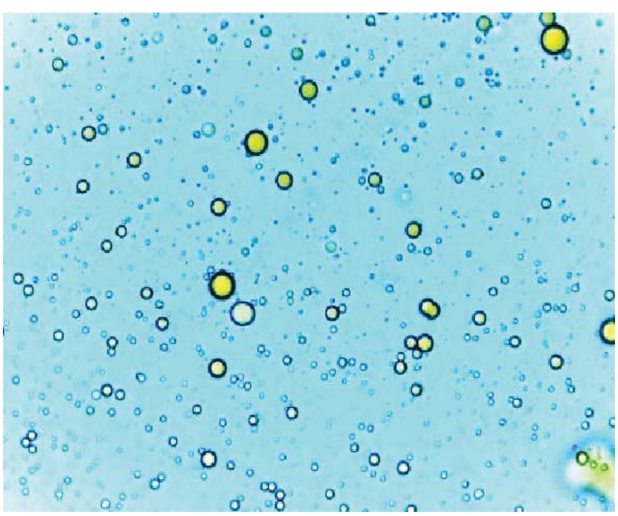

Fig. 1. Microscopic structure of emulsion containing 0.1% of Tween 20.

Moisture content of spray dried powder was found to be 2%. Moisture content along with temperature affects the shelf life of dried microcapsules. The maximum moisture specification for most dried powders in the food industry range between 3-4% (Kagami *et al.*, 2003).

Peroxide value of spray dried powder increased slowly during storage period (Fig. 2). The encapsulated oil was found to be less susceptible to lipid peroxidation compared to un-encapsulated one. Peroxide value of fish oil in free form increased throughout storage period. At the end of 4th week, the PV of the un-encapsulated oil reached 27.6 mmol/kg oil. Encapsulated fish oil exhibited slower rates of peroxide formation compared to un-encapsulated oil. The peroxide value of encapsulated fish oil on 4th week reached 5.5 mmol/kg oil only revealing that encapsulated fish oil is more stable than un-encapsulated fish oil.

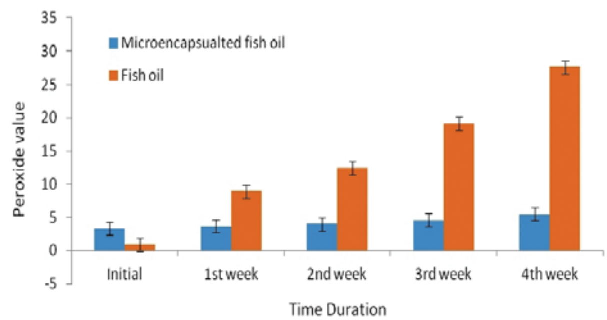

Fig. 2. Peroxide value of sardine oil and microencapsulated sardine oil powder

The accelerated rancimat test is an easy method (Velasco *et al.*, 2003) to determine the oxidative stability of oils. Encapsulated fish oil was heated under atmospheric pressure at 110 °C and bubbled with oxygen at constant flow, which can be considered as an accelerated oxidation test. Under these conditions, the lipids get oxidized to short chain volatile acids like formic acid and acetic acid which are collected in distilled water increasing its conductivity. The IP (Induction Point) value indicates the time required to produce a sudden increase of conductivity, which can be defined as an indirect measure of oil stability. Table 1 shows the Induction Point values of microencapsulated oil

Table. 1. IP values of microencapsulated oil compared to bulk sardine oil

Sample	IPR1 (At 110˚)	IP R2 (At 110˚)
5% fish oil	0.67 h±0.01	0.71 h±0.03
5% encapsulated fish oil	7.67 h±0.05	7.57 h±0.07

compared to bulk sardine oil. Bulk sardine oil presented an IP of 0.67 ± 0.01 h which is comparable to the value reported for fish oil (0.75 h), whereas microencapsulated oil showed IP value of 7.67 ± 0.05 h. IP values obtained for microcapsules clearly showed a protective effect of the vanillic acid-grafted matrix against sardine oil oxidation.

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Comparison of the properties of protein hydrolysates from white and red meat of tuna (*Euthynnus affinis*)

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The processing discards from the seafood industry account for nearly three-quarters of the total quantity of fish catch. These discards contain good quantity of valuable nutritional components and the potential utilization of these nutrients for various applications has been the focus of attention in the recent years. Several techniques have been developed to recover the essential nutrients and bioactive compounds from these protein rich fish processing wastes. Enzymatic proteolysis and solubilization of proteins from various sources has been studied extensively and described by several authors for the past few years. By adopting hydrolysis, these proteinaceous fish waste can be converted to hydrolysates with a range of potential applications.

Tuna and related species are very important economically and are rich sources of high quality protein. Converting these wastes to bioactive hydrolysate finds application in a broad spectrum of food ingredients. Protein hydrolysates are mixture of bioactive peptides obtained by the breakdown of proteins by hydrolysis either chemically or enzymatically. Protein-rich red meat from tuna has limited use compared to white meat and is usually processed into low market-value products and hence conversion of this red meat into protein hydrolysates may generate high value products. A comparative study of the properties of hydrolysates derived from tuna white meat and red meat were carried out. Protein hydrolysate was prepared using papain (enzyme: protein; 1:100) for 60 min. under optimal hydrolytic conditions and spray dried to obtain a fine powder of tuna white meat (TWPH) and tuna red meat protein hydrolysates (TRPH).

Determination of protein content of tuna waste and tuna protein hydrolysates (TPH) indicated an increase in protein from 26.34 ± 0.79% to 78.01 ± 1.37% for tuna white meat to its hydrolysate and 28.34 ± 1.63 to 75.17 ± 1.69% for tuna red meat to its hydrolysate, respectively. Solubilisation of protein during hydrolysis as well as removal of insoluble undigested non-protein substances after hydrolysis resulted in high protein content in hydrolysates. The protein recoveries from tuna red meat and white meat to their respective hydrolysates were 36.87% and 42.14%.

Colour of fish protein hydrolysate depends on the composition of the raw material, the hydrolysis condition and the drying method adopted. Analysis of colour using the colourimeter (Hunter Lab Colorimeter, Miniscan® XE Plus) gave an L*, a*, b* value (Table 1) revealed darker colour for TRPH than TWPH (Fig. 1).

Table 1. Colour of tuna red and white meat hydrolysates

	TRPH	TWPH
L* (Lightness)	83.14 ± 0.11	92.56 ± 0.10
a* (Redness/Greenness)	2.88 ± 0.10	-1.52 ± 0.14
b* (Yellowness/Blueness)	29.86 ± 0.24	15.34 ± 0.08

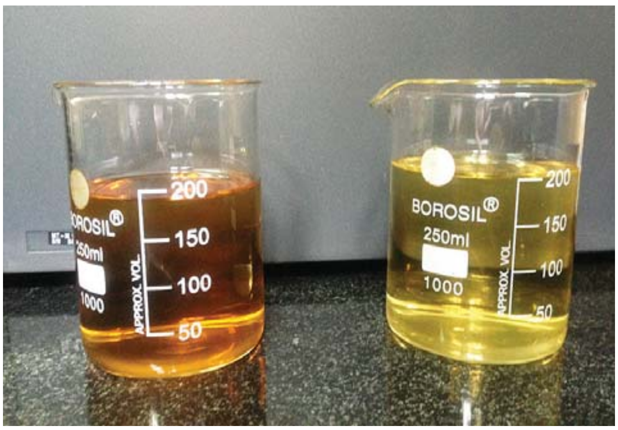

Fig. 1.Tuna red meat protein hydrolysate and tuna white meat protein hydrolysate

Evaluation of the protein hydrolysate functional properties *viz*. foaming properties and emulsifying properties revealed comparatively higher functionality for TWPH. Foaming capacity of TWPH and TRPH were 85 ± 5% and 75 ± 5%, respectively and foaming stability at 3 min. was observed to be 25 ± 5% and 23.33 ± 2.9%, respectively (Fig 2). Protein hydrolysates are good emulsifiers due to their improved amphiphilic nature that enable orientation at the oil-water interface for more effective adsorption. Emulsifying properties *viz*., emulsifying activity index and emulsion stability index were observed to be 5.94 ± 0.73 m^2/g and 24.51 ± 9.39 min., respectively for TWPH and 6.52 ±1.21 m^2/g and 16.57± 4.75 min., respectively for TRPH.

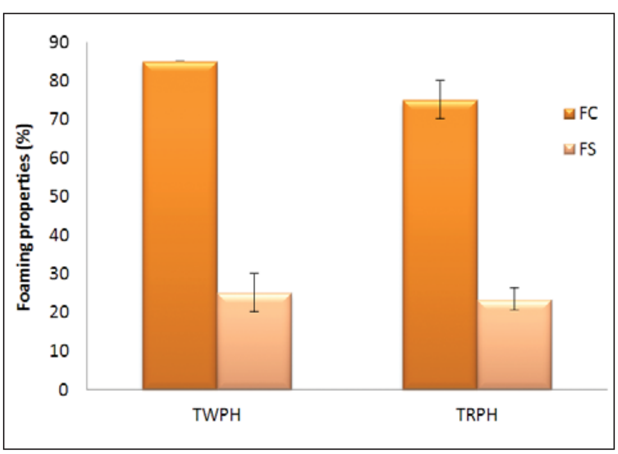

Fig. 2. Foaming capacity (FC) and foaming stability (FS) of tuna protein hydrolysates

Antioxidants are substances capable of delaying, retarding or preventing oxidation processes. Synthetic antioxidants have been used in order to prevent lipid peroxidation in food products, but in recent times more interest is generated towards finding antioxidants from natural resources that have little or no side effects. Protein hydrolysates (peptides) are potential antioxidants due to their chemical composition and physical properties. DPPH-free radical scavenging assay evaluates the free radical scavenging capacity of the sample. DPPH-free radical scavenging activity of 0.2% protein hydrolysate solutions was observed to be 81.5 ± 0.63% and 66.24 ± 2.42%, respectively for TRPH and TWPH. Reducing power is a measure of the iron-reducing capacity and samples with higher reducing power have better abilities to donate electrons and free radicals to form stable substances, thereby interrupting the free radical chain reactions. The reducing power of 1% protein solution was observed as 1.929 ±0.086 and 1.497± 0.086, respectively for TRPH and TWPH.

Effective utilization of fishery waste generated enormously from fish processing industry by recovering in the form of hydrolysates by enzyme application can satisfy numerous food and pharmaceutical applications. Comparison between the white and red meat protein hydrolysates from tuna meat revealed better functional properties for TWPH, whereas antioxidative activities were higher in TRPH compared to TWPH.

Salting and drying kinetics of brine salted and dry salted Ribbonfish (*Lepturacanthus savala*)

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Drying and salting are the oldest fish preservation techniques. Reduction of water activity (a_w) by salting and drying inhibits the growth of pathogenic and spoilage bacteria, yeasts and fungi, inactivate enzymes and decrease chemical reactions, and thus prolong the shelf life of fish. However, salting techniques, brine concentration and salting period have a direct effect on drying kinetics and characteristic of final products. Ribbonfish (*Lepturacanthus savala*) landed at Visakhapatnam harbour are traditionally salted, sundried and transported to different parts of India. A study was conducted to determine salting and drying kinetics of Ribbonfish during open sun drying.

Fresh Ribbonfish (138.79 ± 31.40 g average weight and overall length 52.50 ± 3.09 cm) were procured from Visakhapatnam fishing harbour and transported to the laboratory in ice. The fresh Ribbonfish had a moisture content of 75.6 ± 0.60%, protein 14.17%, ash 6.66 ± 0.22% and fat content of 3.5% (wet basis). Dry salting (1:4; one part salt to four parts fish) and wet salting of Ribbonfish was carried out in 21% brine solution at ambient temperature. After 24 h of salting, brine salted and dry salted Ribbonfish were sundried at average temperature of 35 °C and average RH of 60%. Samples were drawn at regular interval for analysis of salt and water content.

The rate of salt uptake was not constant for brine salted and dry salted fish (Fig. 1). During the first four hours of salting, for both salting methods, the rate of salt diffusion in the fish flesh was high, although much higher in brine salting. Salt content of fresh Ribbonfish was 0.72 ± 0.02%. After 24 h salting, the salt content increased to 11.17 ± 0.16% and 11.10 ± 0.01% for brining method and dry salting, respectively. However, Figure 2 shows that during the first salting hours (10 h approximately) water content decreased more rapidly in the case of dry salting.

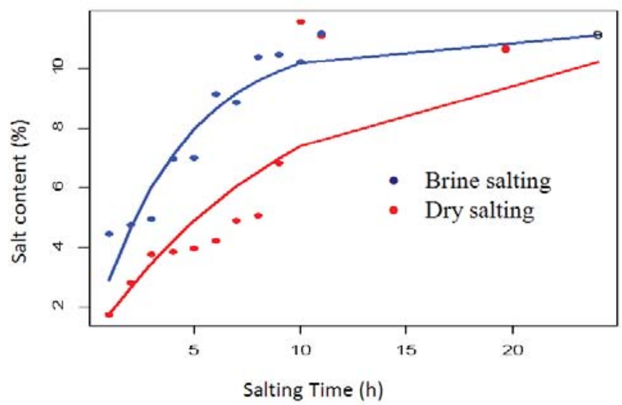

Fig. 1. Effect of salting method on salt diffusion

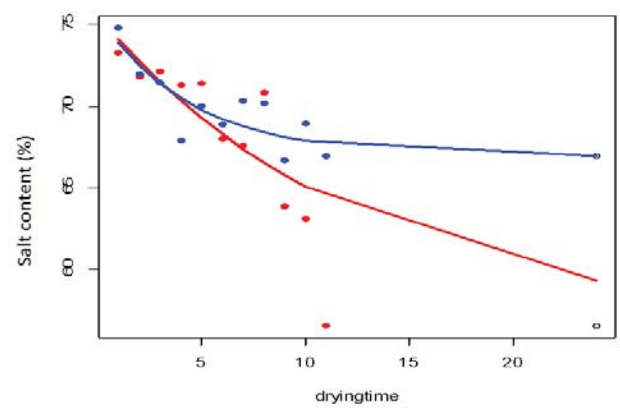

Fig. 2. Effect of salting methods on water content

In order to describe salt uptake, the following equations developed by Zuggaramundi and Lupin (1980) were used:

Salt uptake

$$X_s = X_s^0 exp\,(-k_s t) + X_s^1(1 - \exp(-k_s t)) \qquad (1)$$

Water exudation

$$X_w = X_w^0 \exp(-k_w t) + X_w^1(1 - \exp(-k_w t)) \qquad (2)$$

Table 1. Characteristic values for salting of Ribbonfish

Salting method	Salt diffusion				Water exudation			
	X_s	X_s^1	k_s (h^{-1})	R^2	X_w	X_w^1	k_w (h^{-1})	R^2
Brine salting 21% (w/w)	1.21	11.59	0.21	0.95	75.85	67.70	0.29	0.81
Dry salting (1:4)	0.60	13.80	0.07	0.82	75.26	44.23	0.04	0.90

Where,

X_s= salt content at salting time t, g/g NSSB

X_s^0= initial salt content, g/g NSSB

X_s^1= equilibrium salt content, g/g NSSB

X_w^0= initial water content, g/g NSSB

X_w^1= equilibrium water content for salting period, g/g NSSB

X_w = water content during drying, g/g NSSB

X_w^e= equilibrium water content for drying period, g/g NSSB

(NSSB - non salt solid basis)

k_s= specific rate of salt uptake, h^{-1}

k_w= specific exudation rate, h^{-1}

k_d= specific drying rate, h^{-1}

t= process time, h.

The results indicate that the salting specific constant (k_s) is greater for brine salting which agree with the fact that salt diffusion is higher in this case.

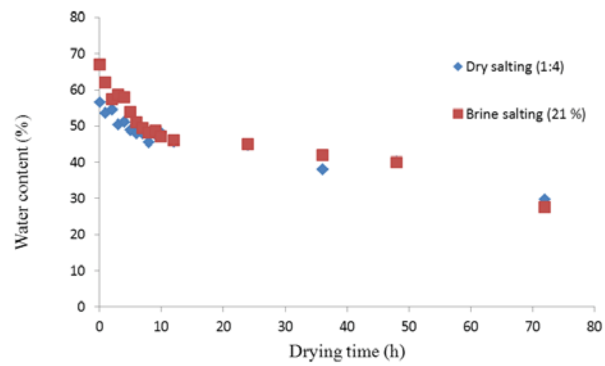

Fig. 3. Experimental drying kinetics of Ribbonfish

After 72 h of drying, moisture content decreased to 27.48 ± 0.46% for brining method, and of 29.65 ± 0.98% for dry salting (Fig. 3). The bacterial load of brine salted Ribbonfish (100 cfu/g) was relatively lower than dry salted Ribbonfish (200 cfu/g). However, the bacterial loads were far lower than that of commercial local sundried Ribbonfish (9800 cfu/g).

Jawala chutney powder: A byproduct from Jawala shrimp

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The over-exploitation of fishes in the ocean have been paid increasing attention for value addition of low valued fishes. Current scenario in fisheries all over the world is zero utilization of fishery waste. During 2014, the annual marine fish landing of Gujarat was 7.12 lakh tonnes and the non-penaeid shrimp contributed 67.50% in the Crustacean landing (CMFRI, 2015). *Acetes indicus* (Jawala shrimp) (Fig. 1), one of the major non-penaeid prawn abundant in Veraval, is caught in trawl net as bycatch and mainly used for fish meal production. Production of chutney powder from jawala shrimp is a better way to utilize this shrimp resource for the conversion of under-utilized bycatch into high value byproduct for human consumption.

Fig. 1. A: Fresh jawala shrimp; B: Jawala chutney powder

Jawala shrimps purchased from the local fish market were dried in the solar drier (CIFT Dryer-JSDE 5) until the moisture content reached 9%. Methodology for the preparation of ready to use jawala chutney powder (Fig 1B) was standardized. The shelf life of LDPE packed ready to eat jawala chutney powder stored at room temperature was assessed by total volatile base nitrogen (TVB-N) and total viable count (TVC) for six months at monthly interval.

The proximate composition of fresh jawala shrimp and jawala chutney powder were analyzed according to the AOAC method (2000). The protein content was very high in fish chutney powder (26.8%) than raw sample (8.0%). The higher protein content was due to the dried fish and the masala content present in the powder.The moisture content of fish chutney powder was 4.36% (Fig. 2).

TVC was assessed by the standard method of USFDA Bacteriological Analytical Manual (BAM) (2001). The chemical quality parameter, TVB-N, was analyzed by the method described by Conway and Byrne (1933). The pH value was determined

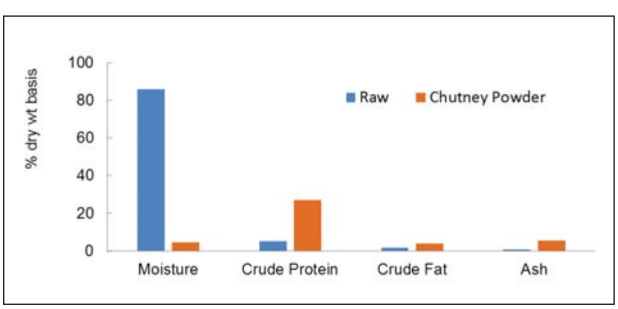

Fig. 2. Proximate composition of fresh Jawala sample and chutney powder

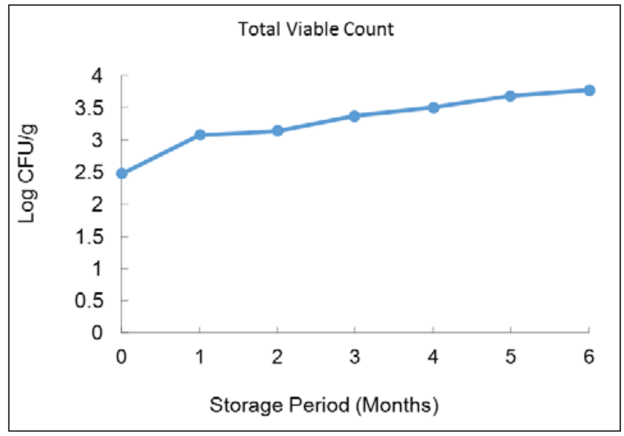

Fig.3. Total viable count of Jawala chutney powder

by dipping a pH electrode in the homogenate of samples in distilled water (1:1).

The initial TVB-N value was 3.8 mg/100g, which increased to18.1 mg/100g at the end of six months of storage period.The pH decreased from 7.1 to 5.4 during the six months of storage study. Changes in the total viable count (TVC) of jawala chutney powder are shown in Figure 3. The initial TVC of chutney powder was 2.5 log cfu/g, and this low initial TVC indicated the superior quality of raw material.TVC gradually increased and reached 3.78 log cfu/g at the end of the storage period. The storage study on both chemical and microbial quality of chutney powder revealed that the shelf life of the product was in acceptable condition even after six months.

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Plastic mould for preparing shrimp analogue products

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The gradual disappearance of conventionally processed fish products and their emergence in new forms and styles are expected to be the future trend in fish consumption. Seafood analogue products in ready-to-cook form have the potential for generating consumer appeal in the domestic market owing to their ability to be modified into a variety of shapes with desirable flavours. Shrimp analogue products are fish meat based products that mimic shrimps, both in appearance and flavour. They are prepared using surimi as the main ingredient. Surimi is stabilized myofibrillar protein obtained from mechanically deboned fish flesh that is washed with water and blended with cryoprotectants. However, to prepare shrimp analogue products, there is a need for a food grade plastic mould that can withstand steaming temperature and retain the surimi gel in place during cooking so as to enable the gel to transform in to shrimp shaped product. In this context, a food grade plastic mould that can be used for preparing shrimp analogue products was designed and fabricated.

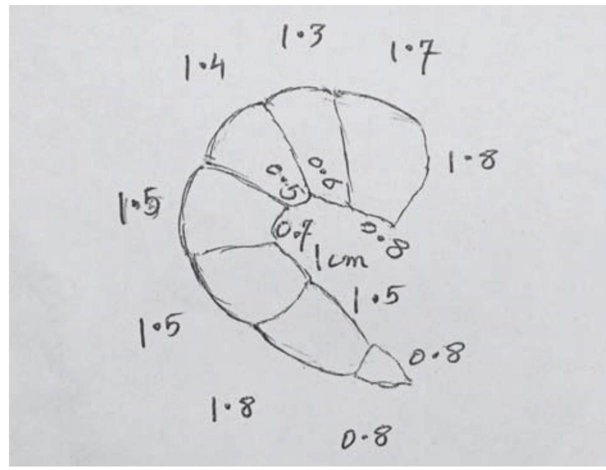

Fig. 1a. Outer dimensions of *L. vannamei* shrimp [Outer length (Convex) 9.7 cm, Inner length (Concave) 5.9 cm]

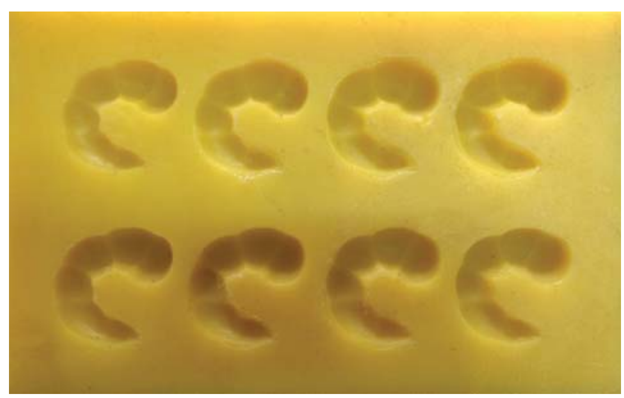

Fig. 1b. Plastic mould for shrimp analogues

Low density polyethylene (LDPE) block (30 x 18 x 5 cm) was used as base for engraving shrimp shapes. *Litopenaeus vannamei*, the commonly available farmed shrimp was used as the model shrimp. The dimensions of the *L. vannamei* shrimp (40 count) were measured (Fig. 1a) and was used as the prototype for engraving on the LDPE block. Computer numerical control (CNC) router, a computer controlled cutting machine was used to engrave the shrimp shapes (two rows of four shrimps) on the LDPE block (Fig. 1b).

The shrimp analogue mould is easy to clean as it has a non-absorbent and non-porous surface and can withstand steaming temperature. The mould finds use as template for making analogue shrimp products.

Development of principal component based quality index and shelf life prediction of *Pangasius hypophthalmus* stored in iced condition

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Preservation of fish is important in the context of providing quality product to the consumer. Chilling effectively delays bacterial growth and prolong the shelf life of fish. Various types of chilling systems have been used for seafood products including the conventional flake ice, refrigerated seawater, slurry ice and dry ice. Quality changes of ice stored *Pangasius hypophthalmus* were evaluated by assessing chemical, physical and sensory quality parameters. The primary objective was to develop a quality index in terms of all chemical, physical and sensory quality parameters using principal component analysis.

P. hypophthalmus, a commercially important freshwater fish was collected from a fish farm near Cherthala, Kerala. The average total length of the collected fish was 32-35 cm and average weight was 0.6-0.7 kg. Fish were kept in iced condition throughout the study and daily sampling was done for a period of 25 days. During storage study, chemical parameters *viz*:, TVB-N, TBA, PV, FFA and physical parameters *viz*: pH and water activity (WA) was also measured as per standard analytical procedures. Colour parameters of the samples *viz*: L*(lightness), a*(red/blue) and b*(yellow/green) were also measured. The freshness of whole fish was assessed by expert panel for different quality descriptors and the cumulative demerit score was recorded for every day for a period of 25 days.

The initial TVB-N value of fish sample was 2.8 mgL 100 g; which gradually showed an increasing trend during the period of storage and reached 23.8 mgL100 g sample on the 25th day of rejection. The initial PV value was 8.46 milli equivalents per kg and showed a decreasing value in most of the days and final PV value was 1.49 milliequivalents per kg on rejection day. TBA value showed an increasing trend initially up to 9th day of storage, followed by a static trend up to 22nd day of storage and again an increasing trend till the day of rejection of the product. The initial TBA value was 0.0078 mg malonaldehyde/kg and increased significantly to 0.28 mg malonaldehyde /kg on 25th day indicating the progress of lipid oxidation. FFA values showed a fluctuating trend initially up to 10th day of storage and thereafter increasing till rejection of the sample. The initial FFA content was 3.04 mg% oleic acid which reached 4.64 mg% oleic acid on the day of rejection.

The initial pH of ice stored fish was 6.78 which decreased to 6.43 on 7th day of sampling and gradually increased to 7.01 on rejection day. Initial water activity of ice stored fish was in the range of 0.98 to 0.998. This remained static throughout the study. The initial L* of the ice stored fish was 56.52 which showed an increasing trend throughout the storage period and reached 61.93 for ice stored fish. a* value showed a decreasing trend during the storage period from an initial value of 20.3 to 10.3. The initial b* value of ice stored fish was 34.10 and decreased to 23.88 on second day of sampling. On the day of rejection, b* value reached 27.33.

The organoleptic analysis was carried out by using demerit score sheet (Fig.1). The initial demerit score for ice stored fish was 1 which increased significantly to 23 on the day of rejection. This increase in demerit score is due to the characteristic changes in the appearance, texture of muscle, eyes, gills, belly etc.

Principal component analysis was performed for the chemical, physical and sensory quality parameters of ice stored fish for a period of 25 days. Variables *viz*. pH, water activity, TVB-N, TBA, PV, FFA, sensory score, L*, a* and b* were considered for the analysis. All the parameters

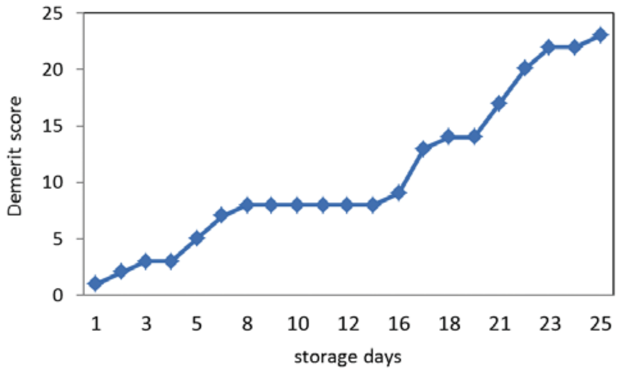

Fig.1. Organoleptic changes during ice storage

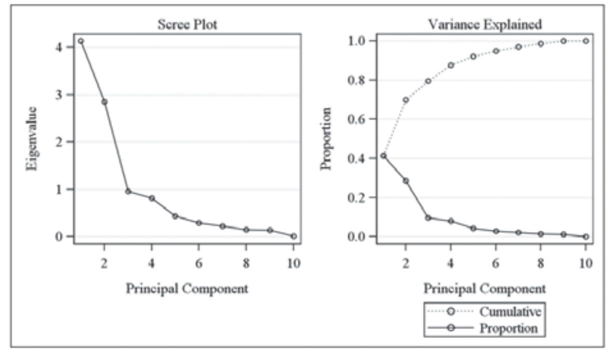

Fig.2. Variance explained by the principal components

except a* and b* produced a positive correlation with the storage days. All the correlation coefficients were significant at 5% level of significance except for PV, FFA and b*. First two principal components (PC1 and PC2) explained 70% of the total variability comprising PC1 and PC2 with 42 and 28% variability, respectively (Fig.2).

Table1. Principal component score of different quality variables

	Variables									
PC	pH	WA	TVBN	TBA	PV	FFA	SS	L*	a*	b*
PC1	0.340	0.375	0.422	0.372	0.078	0.223	0.454	0.193	-0.342	-0.097
PC2	-0.017	0.173	0.027	0.092	0.489	0.461	-0.024	-0.454	0.301	0.457

Principal component score of PC1 and PC2 for different quality parameters is given in Table.1. Storage day was considered as a function of these principal component score to predict the shelf life of ice stored Pangasius, i.e. / Shelf Life = f (PC1, PC2)+ e, where e is error term.

This type of combined index can be formulated in terms of changes in chemical, physical and sensory parameters and can be used to predict the shelf life of a fish species stored in chilled condition.

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Prevalence of multidrug resistant coagulase positive Staphylococci (MDR-CPS) in seafood

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Staphylococcus aureus is a common bacterium found on the skin and noses of up to 25% of healthy human being and animals. It is one of the most frequently occurring food-borne pathogen worldwide and causes food poisoning due to the presence of heat stable Staphylococcal enterotoxins (Anon, 2010). The number of outbreaks with Staphylococcal gastroenteritis is much higher than other microbial food-borne outbreaks (Jay, 2000). Several studies clearly suggested a possibility of potential public health hazard resulting from *S. aureus* contamination of seafood and are mainly due to unhygienic handling, processing and storage environment. In India, the rate of Staphylococcal infection is still higher because of the warm and humid climate (Bhatia and Zahoor, 2007). Coagulase production by *S. aureus* is considered to be an important criterion for the safety and quality of seafood (Anon, 2014). Even though the safety of food has dramatically improved, the progress is uneven and food-borne outbreaks from microbial contamination, chemicals and toxins are still common in many countries (Anon, 2007). The widespread use of antibiotics has provoked an exponential increase in the incidence of antibiotic resistance in recent years. Food contamination with antibiotic resistant bacteria can be a major threat to public health.

Seafood and its environmental samples such as Horse Mackerel, Indian Mackerel, Tuna, Ribbonfish, Seerfish, Croaker, Ghol, Dhoma, Sardine, Prawns, Shark, Rayfish, dried fishes, Cephalopods, surmi, salt, water, ice etc. were collected from in and around Veraval region, Gujarat. *S. aureus* was identified using BAM, USFDA, 2012 standard procedures and coagulase tube test were carried out with 0.5 ml of rabbit plasma containing EDTA with 2 drops of 18-24 hrs grown BHI broth culture (Fig.1). The beta-lactamase activity was done by iodometric tube method of Isenberg (2004). The antimicrobial

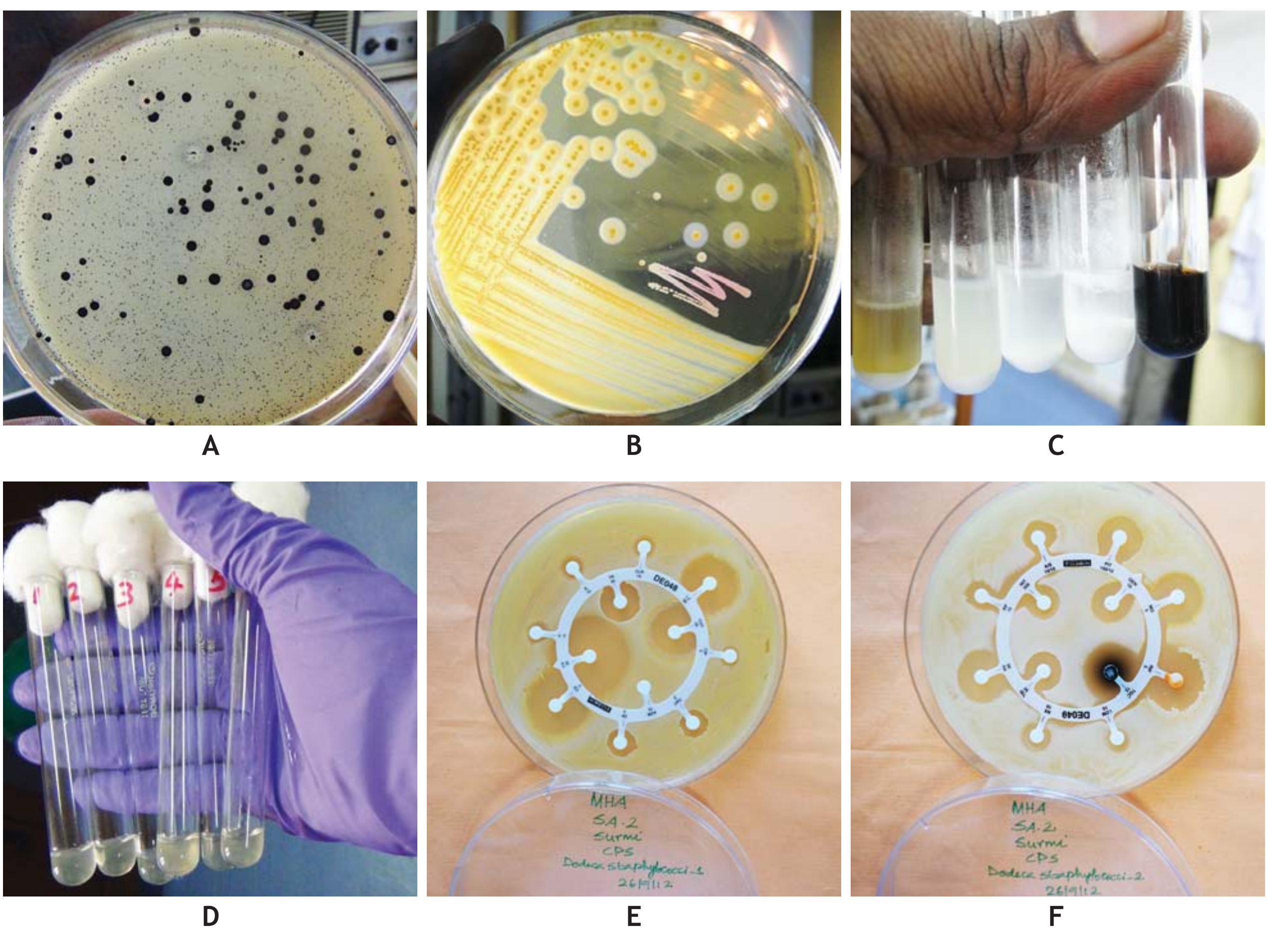

Fig. 1. Characterization of coagulase positive Staphylococci in seafood (A. Typical Staphylococci on Baird Parker Agar Plate; B. Coagulase positive Staphylococci on Mannitol Salt Agar; C. Beta-lactamase production on iodometric tube test; D. Coagulase test with Rabbit plasma; E. ABST to Dodecca Staphylococci-1 and F. ABST to Dodecca Staphylococci-2)

sensitivity test to 24 antibiotics (Dodeca Staphylococci-1 and 2, Hi Media, Mumbai) were carried out by disc diffusion method (Kirby-Bauers, 1966) on Mueller Hinton agar and resistance patterns specified by the CLSI, 2010.

A total of 235 isolates of Staphylococci were recovered from 408 seafood samples with incidence of 11.52% and the Staphylococcal count ranged between 2.0 x 10^1 and 7.8 x 10^2 cfu.g^{-1} of sample. Among the isolates, 12.77% were coagulase positive and 86.66% of coagulase positive Staphylococcal (CPS) isolates were positive for the beta-lactamase production. These CPS *S. aureus* isolates showed variable ranges of antibiotic resistance pattern to the different antimicrobials tested (Table1). All beta-lactamase CPS producing isolates demonstrated resistance to at least three groups of antibiotics i.e. multidrug resistant (MDR) Staphylococci. Higher incidence of beta-lactamase producing CPS *viz.*, 97.67% were resistant to azithromycin, ciprofloxacin and gatiflaxacin; 93.33% were resistant to lomefloxacin; 86.76% to erythromycin; 76.67% to nitrofurantoin clarithromycin, ofloxacin, moxiflaxacin and pristinnomycin; 83.33% to norfloxacin, 46.67% to ampicillin-sulbactum, 13.33% to teicoplanin and 6.67% to linezolid, co-trimoxazole, clindamycin and gentamicin. All the beta-lactamase producing CPS isolates were resistant to atleast one antibiotic and many were resistant to multiple antimicrobials (93.33%).

The present study revealed that seafood is

Table 1. Antimicrobial resistance patterns of coagulase positive beta lactamase producing Staphylococci from seafood

S.N.	Name of antibiotic discs	Number of resistant isolates	% of resistant Isolates
1	Penicillin (100U)	29	96.67
2	Azitrhomycin (15 µg)	29	96.67
3	Erythromycin (15 µg)	26	86.67
4	Clarithromycin (15µg)	26	86.67
5	Linezolid (30 µg)	2	6.67
6	Co-Trimoxazole (25 µg)	2	6.67
7	Vancomycin (30 µg)	0	0
8	Cefoxitin (30 µg)	0	0
9	Ciprofloxacin (5 µg)	29	96.67
10	Gatiflaxacin (5 µg)	29	96.67
11	Ofloxacin (5 µg)	26	86.67
12	Clindamycin (2 µg)	2	6.67
13	Tigecycline (15µg)	0	0
14	Moxifloxacin (5µg)	26	86.67
15	Gentamicin (10µg)	2	6.67
16	Rifampicin (5 µg)	0	0
17	Lomefloxacin (10µg)	28	93.33
18	Norfloxacin (10µg)	25	83.33
19	Novobiocin (30 µg)	0	0
20	Teicoplanin (15 µg),	4	13.33
21	Nitrofurantoin (300 µg)	23	76.67
22	Pristinnomycin (15 µg)	26	86.67
23	Ampicillin- Sulbactum (10/ 10 µg)	14	46.67
24	Piperacillin- Tazobactum (100/ 10 µg)	0	0

* ATCC 25923 was used as control strain for ABST

frequently contaminated with multidrug resistant beta-lactamase producing coagulase positive *S. aureus*, possibly due to poor hygienic profile of the handlers, processing and unhygienic environment of the fish source. Strict hygienic measures are required to reduce the Staphylococcal contamination, thereby to provide the wholesomeness of seafood. This study highlights the need for continuous surveillance of antibiotic susceptibility pattern of *S. aureus* with a view to prevent the sources of contamination.

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Quality and safety concerns of formaldehyde treated Indian mackerel

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Seafoods forms an important part of a healthy diet, but chemical contamination of seafood may lead to serious food-borne diseases. Marketing of formaldehyde contaminated fish in our country is posing a dangerous threat to fish consumers. Seafood vendors tend to use intentionally and carelessly formaldehyde to prevent fish from spoiling and to increase the storage time with reduced usage of ice. Food Safety and Standard Authority of India (FSSAI) have issued many newspaper reports on the marketing of formalin added fish coming from other states to markets of Kerala. Formaldehyde is a very reactive chemical which is being used as disinfectant and for preserving dead bodies. Apart from that, it is used widely in many industries like textile, paper, plastics and paint, etc. It is often added to food for pleasing the consumers, but this chemical poses serious threat to human health mainly due to its carcinogenic nature. Formaldehyde can also be developed during post-mortem in marine fish and crustaceans, from the enzymatic reduction of Trimethylamine-Oxide (TMAO) to equimolar amounts of formaldehyde and Dimethylamine (DMA). The commercially available form of formaldehyde is 30-50% aqueous solution. It is classified as a Group 1 carcinogen by the International Agency for Research on Cancer (IARC). Because of its adverse effects to human health it is prohibited under the Food Regulation Act-1985. According to the United States Environmental Protection Agency (USEPA), maximum daily reference dose (RfD) for formaldehyde is 0.2 mg/ kg body weight per day.

Since seafood is one of the most important food protein sources in India, intake of formaldehyde from contaminated fish is of great concern for human health. There is no information available on the formaldehyde residual level in formaldehyde treated fishes during ice storage and the associated biochemical, microbial and sensory changes. A detailed study was conducted at ICAR-CIFT to establish chemical safety of the formaldehyde contaminated or treated fish using the method of Castell and Smith (1973). The formaldehyde is formed naturally in the fish, the base level concentration was found to be 1.24 ± 0.02 mg/ kg in the untreated fish in minute quantities. The levels in control and treated samples were significantly different ($p<0.05$). The formaldehyde, which is taken into the fish gets washed out during the chilling process as indicated in Fig. 1.

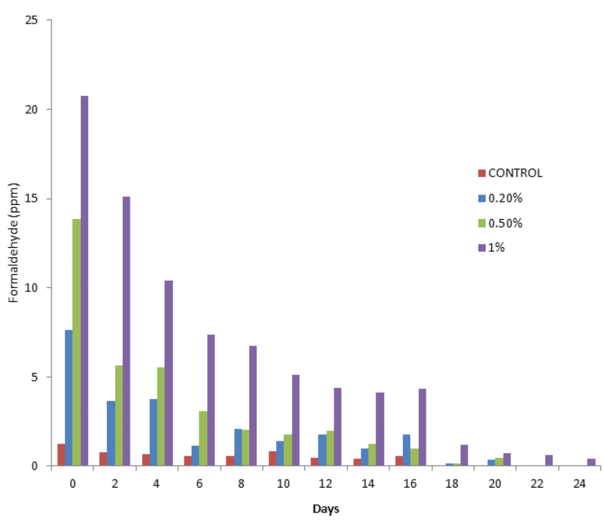

Fig. 1. Changes in residual level of formaldehyde in control and treated samples during ice storage

There was a statistically significant ($p<0.05$) decrease of formaldehyde content of treated samples during iced storage. A gradual increase of pH value was observed in both control and treated samples during iced storage. The pH of control sample on the 0th day was 6.49 ± 0 which increased to 6.76 ± 0.3. TVBN showed an initial increase just after treatment of the samples. The initial TVBN level of 13.2 ± 2.9 for the control sample increased by 16, 18 and 20 mg% with 0.2, 0.5 and 1% treated samples for unknown reasons. The final TVBN values of treated samples were much less than that of control on the day of rejection supporting the bactericidal action of formaldehyde. But the loss of formaldehyde could be facilitating the increasing of TVBN during the latter stages of storage. Initial aerobic plate count in untreated fresh mackerel was 4 log cfu/g, whereas the mackerel treated with 0.2%, 0.5% and 1% was 2.43 log cfu/g, 2.04 log cfu/g and 1.5 log cfu/g respectively indicating the bactericidal action of formaldehyde. The aerobic plate counts were the lowest in 1% formaldehyde treated samples, but aerobic counts of 0.2% and 0.5% treated samples were not showing much difference. Aerobic plate count of fish was typically 10^6 -10^8 at the point of sensory rejection. The shelf life of chilled fish increased gradually from 12 days to 20, 20 and 24 days, respectively for control, 0.2, 0.5 and 1% formaldehyde treated samples and this can mislead the fish consumers while purchasing and ultimately threaten the health of fish consumers.

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Energy use pattern of a seafood processing unit at Cochin, Kerala: An intra-plant comparison

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Energy management is crucial for the existence of seafood processing units and has gained much more significance in this climate change era, as it is highly linked to Green House Gas (GHG) emissions. Globally, demand for seafood products is increasing over the years through diversification at both products and destination level. However, energy costs of seafood processing units are escalating which ultimately affects the economic performance of the unit. Due to competitive and environmental reasons, it is essential to rework the energy consumption of each operation individually rather than as a whole unit. Hence, energy audit is considered as a prime criterion and being adopted by many processing units towards reducing energy levels in terms of units' of consumption and cost.

In general, electricity is the major energy source of seafood processing units. The level of energy consumption varied over time and between activities. A pilot study on intra-plant comparison of energy use pattern at a seafood processing unit in Cochin, Kerala showed that during 2014, the average annual energy consumption, energy cost and per unit energy cost were 42,137.33 kW, ₹ 7, 84,258.50 and ₹ 18.61, respectively. The energy consumption and costs incurred during the period 2009 to 2014 varied over the years, in accordance with raw material supply and product demand (Fig. 1 and 2).

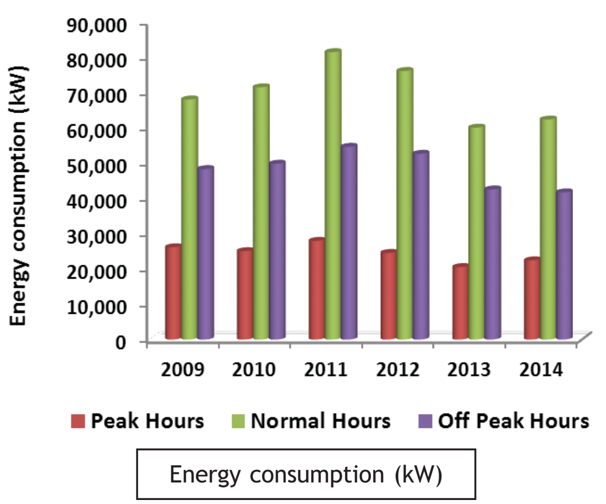

Fig 1. Energy consumption of seafood processing units (kW)

The comparison of energy consumption between the period 2009 and 2014 showed that even though the current energy consumption was decreased by 11.23%, there was an increase in energy cost by 15.30% from the level of 2009. The seafood processing unit produced 186.14 metric tonnes of products annually which comprised of 82% shrimps and 9% each of squid, cuttlefish and fish-based products. The average annual energy consumption of various products *viz.*, shrimp, fish and other cephalopods were 85815.45, 12259.35 and 24518.70 kW, respectively. Among the total energy consumption of the unit, the energy consumption was high for cold storage (16,854.93 kW; 40%) followed by production (12,641.20 kW; 30%), chilling (8,427.47 kW; 20%) and other activities (4213.73 kW; 10%).

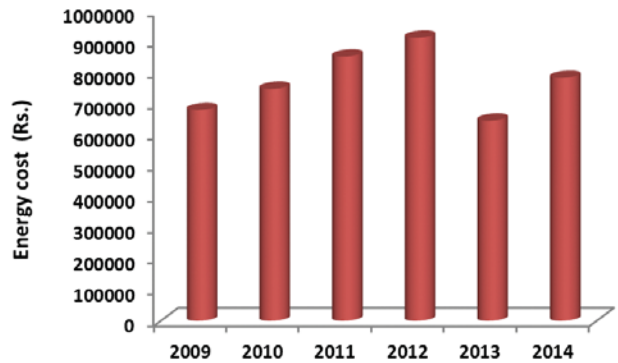

Fig 2. Energy costs of seafood processing units (₹)

The bivariate correlation between energy consumption and energy cost showed that the total energy consumption was significant and negatively correlated with the energy consumption at various periods *viz.*, peak, normal and off-peak hours, but it was significant and positively correlated in terms of energy costs. This revealed that the energy cost incurred is comparatively more influenced by the functioning of seafood processing units rather than units of consumption. The Pearson chi-square value also revealed that the energy use was significantly influenced by the performance of seafood processing units. As energy is considered as vital, training on energy management at the unit level is to be prioritized for effective energy utilization, optimization, and conservation.

11th

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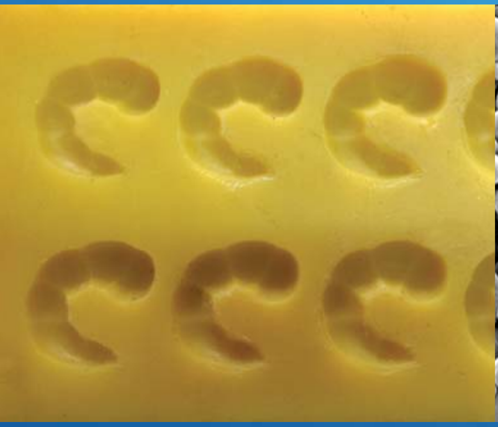

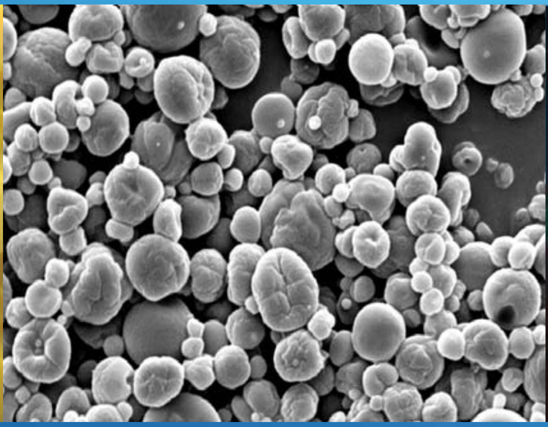

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