FISHTECH REPORTER

VOL.08 (2) JULY - DECEMBER 2022

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ICAR - CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY

विलिंगडन आइलैंड, मत्स्यपुरी पी.ओ., कोचिन - 682029, केरल, भारत

Willingdon Island, Matsyapuri P.O., Cochin - 682029, Kerala, India

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From the Editor's Desk

The fish supply chain starts from the oceans and ends up at the consumer and is a very important link in the supply of fish to the consumers. The chain is so important that it not only alleviates poverty but also uplifts the livelihood of many at the grassroots level. It is interesting to note that almost all the activities of the ICAR-Central Institute of Fisheries Technology are aligned well with the value chain and contribute to the strengthening of the value chain. The harvesting, the subsequent processing, and value addition addressing the nutritional significance and quality issues are addressed to the minutest level in the projects handled in the institute. The outputs are communicated through peer-reviewed journals and also through articles published in a popular style for the information of the nonscientific fraternity.

This edition of the FishTech Reports has 10 articles in different spheres. Starting from post-harvest, processing, value addition both from fish and fish waste, and quality issues are all addressed through different articles. On the harvest side, there are articles discussing the operation of dolnet and lift nets operated in different areas of the country. The remnants of fiberglass boats after condemnation and the issues associated with the disposal of the debris, both short-term and long term, are discussed to get an understanding of the man made hazard.

There are articles discussing good practices on the live fish transportation, quality dried fish products, fish as a source of protein to assuage malnutrition, and chitosan-hydroxyapatite based product for common application. These articles give a good insight in to the type of research going on in the institute in a simple way for the benefit of the large section of the readers but at the same time gives the information on the frontier areas of research and development.

I am sure the articles will give an understanding on the type of activities happen in the institute and further motivate the researchers to write informative articles for the benefit of the readers.

Editor

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CONTENTS

Use of double codends in dolnets in Mumbai region: a preliminary Report

Shravan K. Sharma[1]*, Remesan M. P.[2], Paras Nath Jha[2] and Asha K. K.[2]
[1]Mumbai Research Centre, ICAR-Central Institute of Fisheries Technology, Navi Mumbai - 400703
[2]ICAR- Central Institute of Fisheries Technology, Cochin - 682029
*Email: shravansharmacofsn@gmail.com

Dol netting is one of the major passive fishing methods used by traditional fishermen of Maharashtra and Gujarat. It is also a major gear operated by small-scale fishermen in countries such as India, Bangladesh, Malaysia, Indonesia, Thailand, and Myanmar. There are some regional variations in the design of the net and mode of operation. Bangladesh and India lead the way in the usage of this net in their coastal areas. Various studies have been conducted on the structure and operation of this net (Setna, 1931; Rammurthy and Muthu, 1969; Khan, 1986; Khan, 1987). Before mechanization, dolnets were operated at a maximum depth of 20-24 m, close to the shore. However, after mechanization, fishermen now set their nets at depths of 40 m. Dol nets can be operated to capture fish not only from the near bottom but also from mid-column to a few fathoms below the surface of the water. The first report on the operation of dol net was from Maharashtra, wherein details about fixing of dol net were described (Setna, 1949).

Dol net (set bag net) is a fixed, tapering bag net, resembling a trawl net, which is set in tidal streams by attaching it to anchors to hold it in place. The accomplishment of the operation relies on favourable conditions. The net tapers from the mouth to the cod end by gradually reducing the size and number of meshes. The nets were hand-braided and made mainly of nylon multi-filament for netting and other synthetic materials for framing lines. Dol net fishing targets species of fish that are not fast enough to swim against the current and stay in the same place with respect to the seabed (Akerman, 1986). After a few hours of shooting the net, it was hauled onboard and the catches were removed. Its simple design, construction, operation, and low investment have made this gear very popular among small-scale fishermen. Dol nets are operated by traditional, motorized, and mechanized boats, mainly in the states of Gujarat and Maharashtra. The difference in the method of operation between these two states lies in the way they anchor. Overfishing, inadequate management, and habitat degradation have resulted in the decline of fish stocks, posing a challenge to the sustainability of estuarine fisheries in tropical areas. The dominant species of demersal net catch along the northwest coast include Bombayduck, clupeids, elasmobranchs, catfishes, croakers, eels, ribbonfishes, threadfins, pomfrets, flatfishes, penaeid shrimps, non-penaeid shrimps, and lobsters (Sehara and Karbhari, 1987). The majority of small-scale fishers residing in and around Karanja and Vashi villages of Navi Mumbai rely heavily on dolnet fishing for their sustenance.

Catch composition from double cod end comprised of Harpodon nehereus (13.2 am), Coilia dussumieri, Acetes indicus (20 mm), Hisha Jiligera, Chirocenlrus dorab (54.2 cm), Thrissodes sp., Scoliodon spp., Carcharhinus spp., Arius spp., Tachysurus spp., Osteogerius spp., Otolithus spp, Johnius spp. and Protonibea diacanthus (32.5 cm). Bombay duck (28%) and Clupeids (20 %) contributed the maximum followed by Sciaenid (12%), Shrimps (12%) and Elasmobranchs (10%).

This report aimed to investigate the utility of double codends in dolnets of the Mumbai region. The main purpose of double codends (in a sequential form) in dolnets was to provide extra strength. The dolnet was affecting a separation of a codend into two distinct compartments - the inner one nested within the outer one - known as a double cod end. After consulting with the local fishermen, it was determined that the double codend was implemented to reinforce the dolnet and safeguard the inner codend of a smaller mesh size (10mm) from the large predatory fish in the ocean. From the study of design of dolnet, it was found that the dolnet was similar to other dolnet which length around 80 m and made up of different sections of varying mesh sizes.

In addition to its advantages, this codend style has several drawbacks. The inner mesh is larger than the outer one (15 mm vs 10 mm), resulting in a disproportionate juvenile catch in the outer layers. Additionally, larger fishes with higher girth sizes of 15mm or more are typically caught in codends with wider mesh sizes that open up more conveniently on the boat. Such fishes also tend to be of a better quality. Since the inner mesh size was 15 mm, fish that can pass through the 15 mm mesh size will be caught in the second cod end whose mesh size is 10 mm, and which has a provision to open the codend during onboarding. This kind of arrangement of sequential double codends ensures that the smaller size fishes or juveniles do not get crushed under the weight of the large fishes and helps in maintaining the quality of fish but the downside being significantly high juvenile catch.

Double codend with larger mesh outside was utilized primarily to protect the codend from dolphins and other large predators, a notion that was supported by the research conducted by Özbilgin and Tosunoğlu (2003). Tosunoglu et al. (2003) conducted a study which concluded that employing an additional mesh to the cod end mesh had no major influence on selectivity as the inner mesh was smaller than the outer codend mesh. This strategy of using double codends in parallel arrangements could enhance fuel efficiency and reduce discard mortality, as suggested by Broadhurst et al. (2009). Therefore, from a sustainable fisheries management point of view, fishers could try using equal-sized meshes in parallel cod ends to maintain the quality of fish caught and gain more profits, instead of using different mesh sizes of the cod ends.

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Fig. 1 *Picture showing two cod end one above another*

Fig. 2 *Two cod ends with different mesh sizes*

Khudajal: Used cloths turn to floating lift nets: Report from Maithon reservoir, Jharkhand

Sandhya K. M.*, Remesan M. P. and Prajith K. K.
ICAR-Central Institute of Fisheries Technology, Cochin
*Email: sandhyafrm@gmail.com

Small scale fisheries contribute 50% of the total fishery production of the world and majority of the production is utilised for human consumption (FAO, 2010). Nearly 60 million people are directly or indirectly involved in small scale fisheries and the sector provides 20% of the animal protein need of 3.2 billion people (FAO, 2018). More than half the world's fish catch is being produced by small-scale fisheries and 90–95 percentage of the catch is consumed locally (FAO, 2020). Globally, varieties of vessels and gear combinations are used for harvesting the locally available fisheries resources. Indigenous knowledge plays a pivotal role in small scale fisheries for making the operations effective and economical (Prajith et al., 2016).

In a recent field survey at Maithon reservoir of Jharkhand, Khudajal, an indigenous hand operated floating lift nets was noticed. Maithon reservoir (Lat: 23 0 7766′ N, Long: 86 0 8067′E) is impounded on river Barakar-the main tributary of river Damodar, having water spread 10,716 ha, mean depth: 9.1 m located in Dhanbad district, Jharkhand. It is the second largest reservoir after Panchet under Damodar Valley Corporation (DVC), impounded to serve the purposes of flood control, irrigation, water supply and hydro-electricity (Akansha et al., 2017). Besides this, fishing is one of the important activities prevailing in the reservoir and large number of fishermen are directly or indirectly involved in fisheries and allied activities. Gillnets are the major fishing gear used in Maithon reservoir followed by fyke nets, hook and line. Different types of locally constructed gears are also operated in the reservoir.

Khudajal is one of the commonly used indigenous hand operated floating lift net recorded from the reservoir. Lift nets are horizontal netting panels with square or cone shape which is stretched either by several rods, ropes or a frame with the opening facing upwards. Lift nets are mostly set at the bottom or middle of water column and different types of lift nets are operated in rivers, lakes, wetlands etc. Chinese lift nets operated along the back waters of Kerala, hand lift nets of north eastern states of India etc are some of the examples. Sometimes mechanical and boat assisted lift nets are also used which are operated from artisanal plank built boats. However floating type of lift nets are rarely seen.

Khudajal is made from old cotton cloth hung from two cross bar shaped bamboo strips which floats in the surface of the water. Corners of the square shaped cloth are tied to four edges of the crossly tied bamboo strips using twines. These twines are also made from narrow strips of old clothes. Square shaped cloth is having a length of 100-120cm and width of 80-90cm. Bamboo strips are of equal length having 45-55cm length and tied at the centre in a cross shape (Fig.2). The length of the attaching twine varies from 80-100cm depending on depth of operation.

Khudajal is mostly operated in the nearshore shallow regions of reservoir during summer months (March-May). The cloth part of khudajal with a bait placed in the centre is submerged into the water and touches to the bottom. A small stone is also placed at centre to keep the net in position. Bait is prepared out of wheat flour, fenugreek powder and cooked rice. Soaking time is usually 20-30 minutes. Fabrication and operation of khudajal is mainly done by considering the behaviour of the targeted species. Small prawns, which are slowly foraging and nibbling food are targeted. After the definite soaking time, the bamboo cross bars are lifted up by hand. While lifting, the cloth part turn into a miniature bag-shape which prevents the escapement of the catch. Ninety percentage of the catch consists of small prawns and remaining constituted by miscellaneous fishes such as *Chanda nama, Parambassis ranga, Puntius ticto, Lepidocephalichthys guntea.* Catch rates varies from 80-100g per day per net and about 10 numbers of khudajal are operated at a time by a single fishermen. Average catch per fishermen per day ranges from 800g-1kg and mostly used for household consumption.

Khudajal construction is very simple and requires less time and fetches very low cost only. Since it is made out of biodegradable materials like cotton cloth and bamboo strips, the gear does not cause any negative impact to the aquatic ecosystem. Further interventions can be made in khudajal to improve the catches.

Fig. 1 *Various stages of operation of Khudajal*

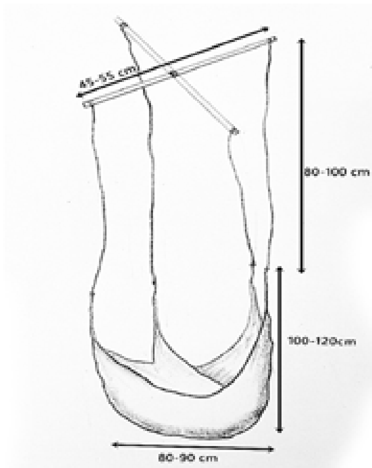

Fig. 2 *Diagrammatic representation of Khudajal*

Fig. 3 *Ingredients for the preparation of bait in Khudajal*

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Abandonment of fibreglass reinforced plastic (FRP) fishing boats along the Kerala coast

Manju Lekshmi N.*, Sreejith S. Kumar, Muhamed Ashraf P., Neeraj Kumar and Leela Edwin
ICAR-Central Institute of Fisheries Technology, Cochin – 682029
*Email: manjulekshmi.n@icar.gov.in

Introduction

Fibreglass reinforced plastic (FRP) is a thermosetting plastic in which resin bonds the glass fibres (woven roving & chopped glass mat) together to create thick layers with the aid of a catalyst and accelerator (Anmarkrud, 2009; Bajracharya et al., 2014). Polyester (bisphenolic and ortho - or isophthalic resins) make up roughly 75 percent of the FRP matrix (López et al., 2012), with isophthalic resins favoured for marine applications due to high strength and low permeability (du Plessis, 2010).

FRP was used in boat construction since 1940s due to the scarcity and high cost of locally available traditional materials like wood (Mohan Rajan, 1988). FRP is the preferred material for small fishing vessels because of its production capabilities, corrosion resistance, long shelf life, low operating costs, low water resistance, low maintenance, and good strength - to weight ratio (Baiju et al., 2013 & Baiju & Hridayanathan., 2002). FRP was first employed as a sheathing material for fishing vessels constructed with plywood and wood, and presently many of them are constructed exclusively with FRP. The sheathed boats have only a life of less than 10 years, while boats constructed primarily with FRP have a life of more than 30 years.

As the number of boats are increasing, disposal has become an issue for End-of-Life boats. Due to the lack of recyclability, there is no simple way to dispose of and existing options are quite expensive. It may seem tempting to get rid of the problem by dumping them in nature or in the marine environment (Eklund, 2013). Abandoned vessels are a sort of marine debris that is aground, broken apart, submerged, exhibits no signs of maintenance or usage, or is generally deteriorated (Smith, 2010). Abandoned boats are commonly observed on the foreshores, intertidal flats, and reefs, throughout the coastline (National Association of State Boating Law Administrators, 2009). There is currently no financially viable solution for recycling FRP materials used in the hull of boats (like melting, rolling, thermal forming, or molding into other usable physical forms) that are manufactured with thermoset resins (Somarajan et al., 2018). The International Convention for the Prevention of Pollution from Ships (MARPOL) forbids the discharge of plastic at sea, however, FRP hulls are excluded because MARPOL only applies to shipborne garbage. In 2016, the London convention and protocol discussed and identified abandoned FRP boats as an environmental threat and to be regulated (International Maritime Organization, 2019).

To identify the current status of FRP boat abandonment, a study was initiated by ICAR-CIFT in the selected fish landing centers of Kerala.

General observations of abandoned fishing boats along the Kerala coast

The majority of abandoned fishing boats are FRP sheathed over plywood / wood from the small-scale fishing sector (6 and 12 m in length). These boats are constantly exposed to outside forces such as bad weather and rough waters, which shortens their lifespan. The majority of boats are operated till the end of their service lives and are abandoned in the coastal areas and is a common problem in most of the fish landing centers of Kerala. Such boats threaten animals, destroy habitats, and contaminate the marine environment, in addition to posing navigational risks (Lord-Boring et al., 2004).

Types of disposals of abandoned FRP fishing boats along Kerala coast

The abandoned boats were observed throughout the stretch of the landing centers of Kerala.

Abandoned in the high tide line (damage with no attempt to fix)

End-of-life boats are frequently dumped in the landing centers and represented as being dysfunctional. These boats' hull damage indicates that they have been abandoned, as no attempt has been made to repair them. Based on the observations, it was found that these boats will eventually relocate to any open space in the aquatic environment.

Fig. 1 *Abandoned boats in the high tide line*

Abandoned in the disposal sites (evidence of attempts to conceal, vegetation growth, or damage on the deck)

Disposal sites are mostly away from where the majority of the fishing activity takes place. These locations have significant and obvious pollution with the weathered FRP debris due to the dumped/disposed of fishing boats. After being abandoned, boats are subjected to a harsh sea environment, which includes tidal and waves action, UV radiation, biofouling, and other factors that cause deterioration. The assessment revealed that there were broken FRP particles which will further leach into the aquatic systems with the possibility of entering the human food chain also. There are studies on the breakdown of microplastics in the marine environment but limited data on the weathering of FRP due to the disposal of fishing boats (Cooper & Corcoran, 2010).

Fig. 2 *Boats Abandoned in the disposal sites*

Abandoned in water (partially or completely sunk in water)

During cyclones or bad weather conditions, a lot of damage to the FRP fishing boats was reported from the Kerala fishing sector. Many of the damaged fishing boats were moored in water, became unrepairable, and were abandoned in the same conditions. Some of these boats are reported to be sunk in water.

Fig. 3 *Abandoned boat in water*

Burning of end-of-life boats FRP fishing boats

To save space for fishing activity, the fisher used to burn end-of-life boats in the marine environment. In most cases, it happens in the high tideline and the residue will wash out into the sea. Emissions from backyard burning of end-of-life FRP comprise a wider range of organic compounds. Burning these boat-building materials releases unintentional persistent organic pollutants (POPs), including dioxins and furans, into the atmosphere (Eklund, 2013). Cancer, allergies, hypersensitivity, central and peripheral nervous system damage, reproductive difficulties, and immune system disruption have all been related to POPs. (Zubair & Adrees, 2019).

Fig. 4 *Burnt remains of end-of-life boat*

Landfilling

The landfill is recognized as the major option for abandoned FRP boat disposal in spatially large nations and on some islands (Talouli, 2018). In addition to this, FRP is completely non-biodegradable, landfilling leads to merely accumulating the issue and postponing the solution (Ramesh et al., 2018). From the survey, it was identified that the FRP debris was used as landfill near the construction of the harbour. End-of-life FRP boats were crushed using an earth mover and land filled in some foreign countries.

Conclusion

FRP can be considered the most suitable material for fishing boat construction and is widely used for the same. The disposal of end-of-life FRP boats is a growing concern. In Kerala, most of the small-scale fishing boats are either constructed with FRP or sheathed with FRP. Life of FRP sheathed boats are comparitively less than FRP boats. There are no proper guidelines for the disposal/ recycling of end-of-life FRP boats. The practice of abandonment/disposal, identified from this study, is not eco-friendly and causes damage to the environment. Abandonment of the beach/disposal sites will reduce space, cause disturbance to fishing activities and also disturb the flora and fauna. FRP particles having a density more than seawater, which will sink easily to the sea bottom and enter the higher food chain through the filter feeders. Landfilling is one of the disposal methods which is not a permanent solution where the soil nearby is getting polluted by the FRP debris. Burning of FRP boats releases toxic persistent organic pollutants (POPs) into the atmosphere.

Further studies are to be initiated for the eco-friendly disposal or recycling of boat-building FRP material. ICAR-CIFT is conducting research primarily on impact of abandoned FRP fishing boats and its recycling options for resolving the related issues.

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Quality characteristics of spice extract coated dried Bombay duck

Jeyakumari A.[1]*, Narasimha Murthy L.[2] and Laly S. J.[1]
[1] ICAR- Central Institute of Fisheries Technology, Cochin – 682 029
[2] National Fisheries Development Board, Hyderabad – 500 052
*Email: jeya131@gmail.com

Bombay duck (*Harpodon nehereus*) is an abundant marine species in North West coast of India and major portion of landings are converted to dried product. The major problem associated with traditionally sun-dried Bombay duck are contamination by insect or pest, uneven drying. Hence, drying process under controlled temperature conditions has become most important in fish drying to achieve better quality of dried fish product. Although drying process reduce the moisture content and prevent the bacterial spoilage, addition of antioxidants or antimicrobial agents will enhance the shelf life of dried fish products. There is increase demand for antioxidant and antimicrobial agent from natural sources by the consumers due to harmful effect of synthetic antioxidants. Spice extracts and essential oils have been found to have an antioxidant and antimicrobial activity. The present work was aimed i) to prepare spice extract (water based) from clove (CLE) and cinnamon (CNE) ii) to prepare the spice extract coated dried Bombay duck iii) to study the quality changes of spice extract coated dried bombay duck under room temperature

Fresh Bombay duck were split opened, cleaned, dip treated (10min) with clove extract (20%), cinnamon extract (20%). The spice extracts were prepared by known quantity of spice powder were mixed in potable water and boiled for 5min (Extraction time was determined based on its antioxidant activity) and after cooling it was filtered and was used for dip treatment of Bombay duck. All the samples were dried at 60°C. Bombay duck dried without spice treatment was kept as control. Quality of spice extract coated dried Bombay duck were studied up to 4 months. Proximate composition was determined according to AOAC (2019); Total volatile base nitrogen content was determined by the method of Beaty and Gibbons (1937). Thiobarbituric acid (TBA) value was determined according to Tarladgis et al. (1960). Sensory evaluation was evaluated by the method followed by Tahra et al. (2018). Aerobic plate count was determined according to FAO (1992). Antioxidant activity of spice extracts were determined by DPPH assay according to Shimada et al. (1992)

Highest DPPH activity was found in clove extract (85.83%) followed by cinnamon extract (63.11%). Proximate composition of control and spice extract coated dried bombay duck is given in table 1. Biochemical analysis revealed that clove extract treated Bombay duck had a lower total volatile base nitrogen than cinnamon extract treated and control. Clove extract treated also reduced the oxidation in dried Bombay duck as indicated by lower TBA values (Table 2). Aerobic plate count (APC) showed an increasing trend during storage and reached the acceptable limit (5log cfu/g) for clove extract treated dried

Bombay duck on the 3rd month (4.9log cfu/g). In case of control (4.8log cfu/g), cinnamon extract treated (4.7log cfu/g) sample APC reached the acceptable limit during the 2nd month (Fig.1). Sensory analysis showed that overall acceptability score was higher for fish coated with spice extracts. Results indicated that clove extract treated Bombay duck had a shelf life up to three months. However, control and cinnamon extract treated sample had a shelf life up to two months. Results suggested that the combined effect of spice extract coating and drying could improve the quality of Bombay duck and enhance the shelf life of dried fish.

Table 1. *Proximate composition (DW basis) of spice extract coated dried Bombay duck*

Sample/ Parameter	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
Control	11.35 ± 0.15	69.94 ± 0.20	4.25 ± 0.02	14.15 ± 1.20
CLE	11.30 ± 0.18	71.40 ± 0.25	4.1± 0.01	13.05 ± 0.85
CNE	11.65 ± 0.20	69.50 ± 0.10	4.35± 0.15	14.04 ± 0.65

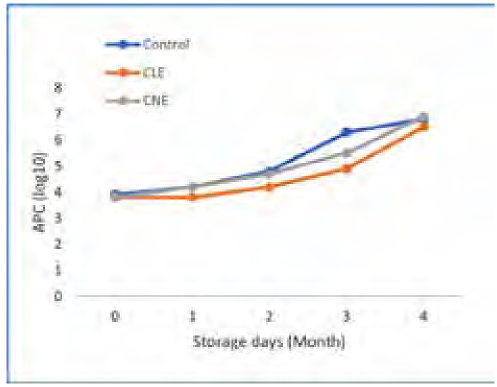
Results are mean ± SD (n= 3), Where, Control- Without spice treatment; CLE- 20% clove extract treated; CNE-20% cinnamon extract treated

Table 2. *Biochemical quality of spice extract coated dried Bombay duck*

Sample/ Storage period (Month)	0	1	2	3	4
TVB-N (mg/100g)					
Control	53.2 ±0.25	65.2±0.20	82.6±0.20	95.65±0.25	115.5±0.18
CLE	40.6±0.30	48.5±0.30	58.6±0.18	65.20±0.30	82.65±0.20
CNE	47.6±0.18	52.6±0.40	70.25±0.30	82.6±0.40	95.40±0.30
TBA (mg malonaldehyde/kg)					
Control	0.42±0.01	0.55±0.02	0.80± 0.15	0.95±0.05	1.20±0.10
CLE	0.18±0.02	0.25±0.01	0.45±0.12	0.65±0.02	0.80±0.05
CNE	0.25±0.01	0.32±0.05	0.52±0.02	0.78±0.15	0.85±0.15

Results are mean ± SD (n= 3), Where, Control- Without spice treatment ; CLE- 20% clove extract treated ; CNE-20% cinnamon extract treated

Fig. 1 *Changes in Aerobic plate count of dried Bombay duck during storage*



Bombay Duck

Dried Bombay Duck

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Live Fish Transportation: Effective Techniques and Good practices

Parvathy U.*, Binsi P. K., Sathish Kumar K., Murali S., Vishnu R. Nair and Jithin T. J.
ICAR-Central Institute of Fisheries Technology, Cochin-29
*Email: p.pillai2012@gmail.com

Globally, the demand for seafood has doubled in recent years necessitating an increase in fish production and an impulse for efficient and innovative marketing systems. Live fish, an indication of the best quality, guarantees freshness and hence has more consumer demand and price realization, unlike the other processed commodities. Among fish used directly for human consumption, live, fresh or chilled fish represents a major share of about 44%, as it is often the most preferred and most expensive form. Through the introduction of this live marketing technology, supply of prime quality seafood commodities can be ensured. Simultaneously it guarantees strengthening of the supply chain thus benefitting the grass root level community as well as end customers. South-east Asian Countries like Vietnam, Thailand and Indonesia have gone far ahead in the live fish trade, while India is yet to make a mark. The export of the country was about 7287 MT of live fish worth Rs. 324.26 crore during 2019-20, having an even higher scope for expansion (Jeyabal and Biju, 2021). Channelizing the harvested resources to the entire domestic stretch and international markets, is expected to make a significant increase in the GDP and foreign currency earning of the country.

In general, there are three basic transport systems for live fish trade viz. closed system, open system and the modified waterless system. The closed system (Fig. 1) is a sealed unit, poised with all the live transportation requirements whereas the open system (Fig. 2) comprises of water filled containers in which facilities for transportation are supplied externally (Omeji et al. 2017). The modified waterless system (Fig. 3) is operated without any water, by layering the species with pre-chilled materials such as sawdust, cotton etc. thereby maintaining cool and moist conditions (Parvathy et al. 2021).

Fig. 1 *Closed system for live fish transportation*

Fig. 2 *Open system for live fish transportation*

Fig. 3 *Waterless system for live fish transportation*

Currently, the practices followed for the live fish trade are rather primitive, including the use of bamboo or coconut coir-lined baskets to large plastic/aluminum containers for short-distance transportation to local markets. Insulated or non-insulated containers with ice or cooling gels to large trucks are employed for short-distance transportation while hauling trucks with more sophisticated facilities are used for long-distance transportation on a commercial scale. Though effective, these systems are quite expensive. The prevailing market price of the available international live fish container models are very high ranges between 2 to 10 lakhs; hence not economically feasible under the Indian scenario. In India, a customized design of live fish transportation system suitable to transport large varieties of species farmed in the country under economic mode is the pressing priority. ICAR-CIFT has done focused research in this line and developed a prototype for a viable live transportation system for effective marketing of commercially important aquaculture species.

Good harvest and post-harvest practices for live fish transportation

Live fish transportation relies on several internal as well as external factors which need to be considered critically for improving survival as well as the quality of fish during their transportation.

- Live fishes are commonly held and starved for a period of time, generally 24 to 48 hours prior to packing and transport, a procedure known as 'purging'. This procedure reduces water quality degradation during transportation on account of fecal matter excreted by the organisms.

- Harvesting during morning or night hours is recommended to avoid drastic temperature swings.
- Line fishing or traps are the best capture/ harvesting techniques that can be adopted as these are the least damaging techniques, thus less stressful to the species.
- Nets with knotless mesh are always recommended for harvesting live fish as they minimize the damage caused to skin and scales.
- On harvesting, air exposure should be kept to an absolute minimum.
- Minimize post-harvest handling to reduce stress and injuries. Stress results in an increased metabolic rate which will eventually increase oxygen demand and causes the release of metabolites such as carbon dioxide, ammonia accumulation etc.
- Acclimatization of fishes to the transportation environment and its conditions considering the temperature, aeration, and other water quality parameters should be effectively followed.
- Maintaining low temperatures, during transportation can help to reduce the metabolic rate of fish. Standardization in this regard is critical as it is species specific.
- Fishes should be maintained unfed during transport.
- Use of permissible water additives viz., anesthetics, anti-foaming agents, ammonia and carbon dioxide adsorbers etc. will aid in maintaining water quality and thus reduces the stress level of transported species.

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Development and inclusion of dried fish powder to alleviate malnutrition among fish consuming women and children of Odisha, India

Akshay P.[1], Gopika R.[1], Mohanty A. K.[2], Sajeev M. V.[1]*, Murali S.[1], Murugadas V.[4], Manoj P. Samuel[3], Ravishankar C. N.[4], George Ninan[1], Suseela Mathew[1]

[1] ICAR-Central Institute Fisheries Technology, Cochin

[2] ICAR-Agricultural Technology Application Research Institute, Umiam

[3] KSCSTE-Centre for Water Resources Development and Management, Kozhikkode

[4] ICAR-Central Institute of Fisheries Education, Mumbai

*Email: sajeev.mv@icar.gov.in

Introduction

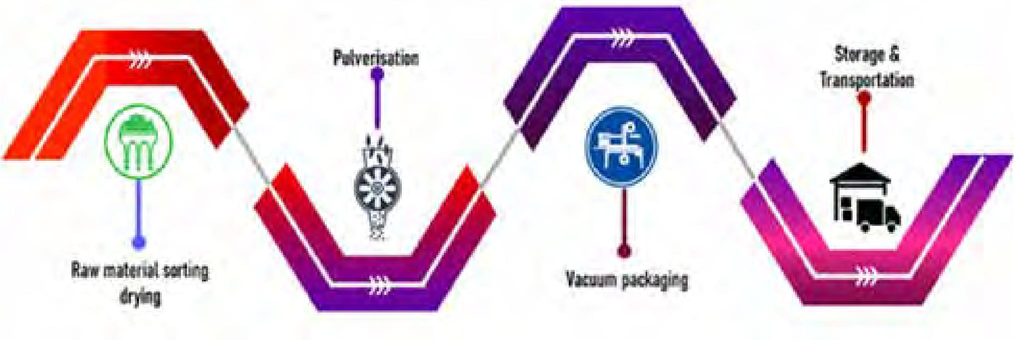
Fish is known for its high quality nutrients in right proportion, so is considered as a remedy to tackle the problem of malnutrition in developing countries. It contains good amount of quality protein with all essential amino acids. Marine fish has high levels of omega 3 fatty acids, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) which are playing major role in the development of eye and brain in children (Swanson et al., 2012). The effect of omega 3 fatty acids in neurological development in children is also well established.

Apart from the major nutrients, the presence of nutrients viz. iron, selenium, copper, iodine, magnesium, the important vitamins A, D, E and B12 in good amounts in fish makes it special as these nutrients are essential for the normal body functions (Bogard et al.,2015). All these nutrients are important during pregnancy and for the growth and development of infants. EPA is considered as a precursor for the production of prostaglandin 3 series which are less proinflammatory, making children healthier (Calder, 2013). EPA and DHA replace arachidonic acid in the phospholipid of membrane, making it less vaso constructive unlike eicosanoid 2 series (Calder, 2010). Hence a better balance of omega 3 to omega 6 fatty acids is absolutely essential in the diet of pregnant women and infants to maintain their health status.

In a vision to incorporate fish in the diet of pregnant and lactating women and children in a daily basis, as a collaborative program with WorldFish, Odisha Govt. and ICAR-CIFT, Cochin, a program was chalked out to supply dried fish and dry fish powder to children of rural districts of Odisha. The raw material was Anchovy, a small marine fish with good nutritional value. The production process was standardised at ICAR-CIFT, Cochin and transferred to entrepreneur through technology transfer process.

Processing of raw material and its nutritional profiling

The landing of anchovies in India is considerably high, the comparatively low price makes it a delicious item among the



coastal population (Immanuel et al., 2003). Anchovies are marine, small in size with a maximum length of 20cm (8 in). They belong to family Engraulidae, with a total of 17 genera and 144 species (Lavoué et al.,2014). They are fatty fish preferring warm water for their habitat.

The raw material used for the development of dried fish and fish powder is Anchovy fish (Stolephorous spp.). The procured raw material (Anchovy) for the purpose of product development was thoroughly cleaned to remove the extraneous materials present and was prepared for sorting and drying. The sorted and dried sample was then pulverised to obtain fine powder and vacuum packing was done for extended storage life. The products including dried and powdered anchovy was developed for supply to 50 Anganwadi Centres of Mayurbhanj District, Odisha. The detailed steps for the product development and final product are illustrated in below.

Proximate Analysis

Proximate composition of any food or feed gives an idea of the content of moisture, protein, lipid, ash and carbohydrate percentage of the contents (AOAC, 2015 & Ganogpichayagrai et al., 2020).

Table 2. *Proximate composition of Anchovy*

Proximate Composition	Wet Weight Basis	Dry Weight Basis
Moisture (%)	78.17	10
Protein (%)	18.32	75.52
Ash (%)	2.25	9.27
Fat (%)	3.50	14.43

Moisture

Water is essential to all living cells. The body fluids act as the medium of transport of nutrients, metabolites etc. In the absence of water, the system will not function. The proportion of water (moisture) in anchovy on wet weight is 78.17% (Table 2).

Protein

The second major constituent of fish meat, protein is generally present in the range 16-18%. Protein content of fish is considered low if it is less than 15%, high if between 15 and 20% and very high when above 20%. The protein composition of anchovy is 18.32% in wet weight basis and 75.52% in dry weight basis (Table 2) and it can be concluded that anchovy belongs to category of fishes with high protein content.

Fat

Fat is the third major constituent, quantity wise, in fish muscle. Seasonal variation is pronounced in fat content, compared to other constituents. Fish with fat content as low as 0.5% and as high as 18-20% are common. Fat is a stored form of energy and also part of the cell structure. During feeding season, the animals accumulate fat in certain tissues (liver, adipose etc.) which are called fat depots (Cohen & Spiegelman, 2016). This accumulated fat (depot fat) is mainly triglycerides. The phospholipids are essential components of all membranes (in combination with proteins) and play vital roles in the functioning of the cells. Unlike triglycerides, the level of phospholipids does not fluctuate very much, usually remaining in the range 0.5 to 0.8% of the tissue. Vitamins A, D, E, and sterols, hydrocarbons etc. are also found in fat. It is observed that anchovy have a fat content of 3.50% (wet weight) and 14.43% (dry weight).

Ash

Ash is the matter left out after complete combustion of the organism. The ash content gives a measure of the total mineral content in the tissue. Almost all the elements that occur in seawater are found to some extent in fish. These include sodium (Na), potassium (K), calcium (Ca) magnesium (Mg), manganese (Mn), zinc (Zn), copper (Cu) etc. The proportion of ash content in anchovy on wet weight and dry weight basis are 2.25% and 9.27% respectively (Table 2).

Microbiological analysis of product (Shelf-life studies for a period of 8 months)

Microbiological examination of vacuum-packed dry fish and fish powder was carried out as per USFDA BAM protocol every month for a period of 8 months (Feng et al., 2002). Total Plate count (TPC) was carried out in pour plate method in plate count agar, E.coli count in MPN method, Staphylococcus aureus count in BPA agar, presence of Salmonella V. cholerae and V. parahaemolyticus in TCBS agar, yeast and mould count in DRBC media. The observed TPC was <100 cfu/g and others such as Staphylococcus aureus, Salmonella, V. cholerae, V. parahaemolyticus, yeast and mould were not detected in the dried fish powder. The products were found to be safe for a period of 8 months.

Economic viability, technology transfer and product supply

The raw material was procured with a cost of Rs.100-150 per Kg which is cheaper than other fishes with pronounced nutritional qualities. And the final processed products have a market price of Rs. 50.40 /150 g (dried anchovy powder) and 133.00/480g (dry fish)

The products developed for the consumption purpose was distributed with the help of a private entrepreneur under the technical guidance of ZTMC-ABI and the technology for the dry fish powder was transferred to the same. The dried anchovy fish and dried anchovy powder were vacuum packed and was sent to the beneficiaries in Odisha in the months of March, April, May, June, July and August for the year 2021. A total of 4,950 packets of dried anchovy fish and 8,000 packets of dried anchovy fish powder were supplied to the beneficiaries in Odisha for a period of six months. The details regarding the supply of the products to the beneficiaries for each month are given in the table 2.

Table 2. *Product supplied to the beneficiaries in 2021*

	Month	Dried anchovy fish (Packets-150 g each)	Dried anchovy fish powder (Packets-480 g each)
	March	700	700
	April	700	2400
	May	900	1300
	June	900	1300
	July	950	1300
	August	800	1000
Total	Packets (Nos.)	4950	8000
	Weight (kg)	742.5	3840

The dry fish powder was added and cooked in the local curries and fed to tribal children by the WorldFish team. A third-party evaluation by MSSRF, Chennai found significant improvement in health of children after the continuous feeding with dry fish powder over a period of six months. Dry fish was supplied to tribal women, who also recorded significant health improvement during the intervention period.

Conclusion

Hygienically prepared dried fish powder added to local cuisine can be utilized to improve the health status of children among tribal populations. This can be given through anganawadis to be incorporated in the mid-day meals so as to tackle malnutrition. Though fish is highly nutritious, proper utilization is lacking in India. The intervention study in Odisha is an eye opener for researchers and policy makers involved in devising strategies for tackling the problem of malnutrition among tribal populations in similar settings.

Acknowledgement

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Chitosan and nano-hydroxyapatite for treatment of effluents in collagen peptide process line

Laly S. J.*, Jeyakumari A. and Binsi P. K.
ICAR-Central Institute of Fisheries Technology, Cochin
*Email: lalyjawahar@gmail.com

Seafood industry waste comprises both solid wastes like skin, viscera, bones, scales and liquid effluents. Accumulation of this waste in fish markets and seafood processing industry marks a considerable impact in the environment. The fish scales form approximately 2% of weight of fish and are rich sources of connective tissue protein and many minerals like calcium, magnesium, phosphorous, sodium, Sulphur etc. In the fish scale, there is a surface layer of hydroxyapatite and calcium carbonate and a deeper layer of collagen. Peptides prepared through hydrolysis of these collagen are of biologically active and have wider applications in food and pharmaceutical industry. Collagen prepared from the fish scales possess properties typical of type I collagen from fish skin (Jafari et al., 2020) which has many applications in cosmetic, pharmaceutical and food industries. Alkaline, acid or enzymatic treatments of the fish scales can be followed for collagen peptide preparation.

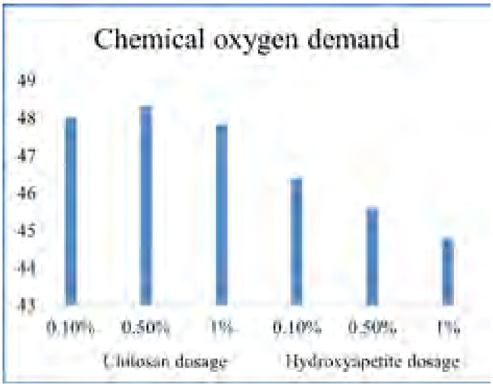
In the present study, effluent water generated during the preparation of collagen peptide from croaker fish scales was collected. The quality of the collected wash water from four washing processes and combined wash water was evaluated for parameters such as pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), total alkalinity and total acidity. Also, the effectiveness of coagulation flocculation treatment using chitosan and nano-hydroxyapatite to improve the appearance of wash water was carried out. The quality of the individual and combined wash waters (average) is given in Table 1. The soaking treatments of fish scales in alkaline and acid solutions resulted the changes in pH of wash water from the individual steps. As per pollution control board permissible value of COD is 250 mg/l, pH 5.5 - 9 and suspended solids 100 mg/l for industrial discharge of water (IS 2490). The final wash water effluent from collagen peptide preparation from the croaker fish scales is within the acceptable limit for environmental discharge.

The wash water mix was treated with chitosan and nanohydroxyapatite at dosages of 0.1, 0.5 and 1% for a period of 1 hour by using a magnetic stirrer and allowed the solution to settle for 2 hours. In case of coagulation flocculation treatment using chitosan, pH increased with increase of dosage while in case of treatment using nano-hydroxyapatite, pH decreased with increase of dosage. The chitosan and nanohydroxyapatite decreased the TDS with increase of dosage. While TSS increased slightly after treatment in both cases. Reduction in COD was more in the case of nano-hydroxyapatite treatment in comparison to chitosan treatment (Figure 1). The coagulation flocculation treatment using nano-hydroxyapatite was more efficient than chitosan in improving the quality of effluent water from collagen peptide preparation using fish scales.

Table 1. *Characterization of effluent water from collagen peptide preparation using croaker scales*

Parameter	Wash water 1	Wash water 2	Wash water 3	Wash water 4	Wash water mix
pH	6.88	9.32	5.69	5.25	7.02
Total Dissolved Solids (TDS) in mg/l	19.2	3.7	4.78	3.3	5.7
Chemical oxygen demand (COD) in mg/l	65.2	56	51.2	72	60.8
Total alkalinity in mg/l	24	465	-	-	-
Phenolphthalein acidity	-	-	462	690	-
TSS in mg/l					1.38

**Values in average*



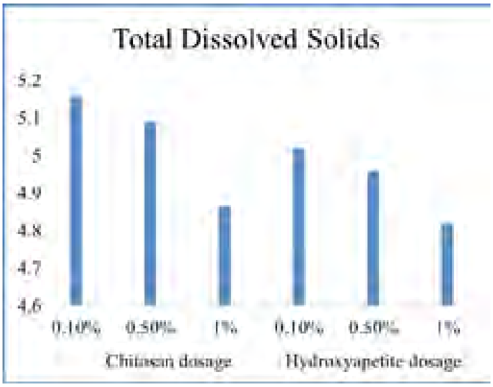


Fig. 1 *Changes in COD and TDS in effluent treatment using chitosan and nano-hydroxyapetite*

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Development of foliar spray from fish waste using a fermentation process

Devananda Uchoi*, Pankaj Kishore, Ranjit K. Nadella, Satyen Kumar Panda and Zynudheen A. A.
ICAR- Central Institute of Fisheries Technology, Cochin
*Email: uchoidev514@gmail.com

The application of organic fertilizers in agricultural crops has received much attention in recent years as excessive use of chemical fertilizers are found to cause detrimental effect on the environment and human health. Indiscriminate use of chemical fertilizers can contaminate the water table and underground water with toxic nitrogenous compounds like nitrate. Water with high nitrate concentration can immobilize hemoglobin in the blood of animals. Contamination of water and soil with heavy metals, particularly Arsenic (As), Lead (Pb), and Cadmium (Cd) is a serious health problem when chemical fertilizers are used continuously for a long period (Atafar et al., 2010). The consumption of food containing heavy metals can also lead to the development of terminal diseases such as chronic kidney disease and cancer (Sharma and Singhvi, 2017). Fish waste such as bones, skin, heads, viscera, and gills is generated in large quantities by fish processing units and retail outlets. Depending on the processing method of the fish, 30 to 70% of the gross weight goes as fish waste. Fish waste is found to be a rich source of micro and macronutrients with the potential for developing solid and liquid-based organic fertilizers (Ahuja et al., 2020). Fish waste provides the same nutrients as is available in fish and therefore allows the supply of essential nutrients to plants (Coppola et al., 2021). ICAR-CIFT has developed foliar spray from fish waste for agricultural applications using a fermentation process.

Fish waste was collected from retail outlets and brought to the laboratory in hygienic condition. The fish waste was made into a paste by a grinder, and a carbohydrate source (jaggery) and an anti-fungal agent (potassium sorbate) were added to the paste in pre-determined percentages. Three products were developed with different percentages of jaggery (10%, 15%, and 20% w/w) and potassium sorbate (1%, 3%, and 5% v/w) for 1 kg of paste. The paste was transferred into a steel container and distilled water was added in an equal ratio (1:1). The paste mixture was boiled at 90 °C for 15 min with proper stirring at 5 min intervals. After boiling, the liquid slurry was cooled to 30 °C and transferred into plastic containers.

Lactobacillus plantarum (ATCC 8014) was used as a starter culture for the fermentation of the liquid slurry. The overnight grown fresh bacterium culture with a cell density of 10^7 CFU ml^{-1} was inoculated into the container at 5% (v/v) of the liquid slurry and kept for fermentation at 30°C for 20 days. After fermentation, the liquid silage was filtered and the concentrate was collected and stored properly. The foliar spray was prepared from the liquid concentrate by 10-fold dilution with distilled water. Fish waste-based fertilizer nourishes the soil with organic matter and boosts soil health. Therefore, fertilizer made from fish waste may be an excellent alternative to chemical fertilizers. Additionally, the seafood industry, which has challenges with waste management, has an opportunity to turn waste into wealth.

Fig. 1 *(a) Fish waste, (b) Paste preparation, (c) Microbial silage, (d) Plastic containers used for fermentation and (e) foliar spray concentrate*

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Ulva lactuca: A promising source of antibacterial agents against *Pseudomonas aeruginosa*

Greeshma S. S.*, Rehana Raj and Asha K. K.
Mumbai Research Centre, ICAR Central Institute of Fisheries Technology, Navi Mumbai-400703
*Email: greeshma.ambadi@gmail.com

The global epidemic of resistance in bacteria against lifesaving antibiotics has prompted research to identify novel natural bioactive compounds with therapeutic potential (Lojewska et al., 2021). Seaweed, under the marine macroalgae category, offers a valuable source of bioactive compounds with nutritional and medicinal purposes (Ravikumar et al., 2022). *Ulva lactuca*, a green seaweed (Chlorophyta), is well known for its wide range of bioactive compounds with anticoagulant, immunomodulation, antihyperlipidemic, anticancer, antiviral and antioxidant properties (Kidgel et al., 2019). Information on the antibacterial potential of *Ulva lactuca* is still limited. Therefore, the present study aimed to prepare crude extract from green seaweed and to evaluate its antibacterial potency against Gram-negative and Gram-positive human and fish pathogenic bacteria in-vitro.

In this study, green seaweed extract (GSE) was prepared according to Jaulneau et al. (2010) by hot water extraction method followed by ethanol precipitation and dialysis with slight modifications. To evaluate the antibacterial activity of GSE, well diffusion assay was performed in Mueller Hinton (MH) agar (BD, USA) against various human and fish pathogens such as *Vibrio parahaemolyticus* (ATCC® 17802™), *Klebsiella pneumonia* (ATCC® 700603™), *Edwardsiella tarda* (ATCC® 15947™), *Pseudomonas aeruginosa* (ATCC® 10145™), *Aeromonas hydrophila* (ATCC® 35654™), *Salmonella Typhimurium* (ATCC® 23564™), *Escherichia coli* (ATCC® 10536™), *Proteus mirabilis* (ATCC® 12453™), *Proteus vulgaris* (ATCC® 33420™), *Vibrio mimicus* (MTCC® 11435™), *Vibrio cholerae* 0139 (MTCC® 3904™), *Enterococcus faecalis* (ATCC® 29212™), *Listeria monocytogens* (ATCC® 19115™) and *Staphylococcus aureus* (ATCC® 29213™). Young bacterial inoculums (1 ml) with OD adjusted to 0.5 McFarland standard were swabbed over MH agar with sterile cotton swab (HiMedia, India). 100 µl of GSE (300 mg/ml) was loaded in wells over the inoculated plate and incubated further at 37°C for 18-20 hours. The zone of clearance was measured with antibiotic scale and recorded.

In this study, GSE exhibited significant antibacterial activity against all pathogens tested while no inhibitory effect was observed on *K. pneumonia* and *S. aureus* (Table 1). Highest antibacterial activity of GSE was identified against *Pseudomonas aeruginosa* with a zone diameter of 28 ± 2 mm. Further, the antibacterial efficiency of green seaweed extract (300 mg/ml) was compared with various standard antibiotics which are widely used in treatment of *P. aeruginosa* infection in the health care system by disc diffusion assay (Table 2). Sterile disc coated with 50 µl of GSE along with known concentrations of antibiotics against Gram-negative pathogens were used in the study; while sterile disc coated with sterile distilled water was used as control. Young bacterial inoculums (1 ml) of *P. aeruginosa* with OD adjusted to 0.5 McFarland standard were swabbed over MH agar with sterile cotton swab (HiMedia, India). Discs were loaded over the inoculated plate and incubated further at 37°C for 18-20 hours followed by measurement of the clearance zone.

According to this study, the antibacterial effect of GSE against *P. aeruginosa* was found equivalent to commercial antibiotics used to treat *P. aeruginosa* infections in health care systems (Figure 1). Therefore, this study proves that the green seaweed *Ulva lactuca* with various bioactive compounds can be a promising source of antibacterial agents against *P. aeruginosa* and can be effective as a natural alternative preventive agent to control infections. However, phytochemical screening is to be carried out to identify the presence of secondary metabolites like alkaloid, steroid, phenolic and flavonoid groups which may be responsible for the antibacterial activity and further studies are required to understand their mode of bactericidal and bacteriostatic action.

Table 1. *The antibacterial activity of green seaweed extract (GSE) against human and fish pathogenic bacteria*

Sl. No	Bacterial culture	Zone of clearance (mm)*
1	*Vibrio parahaemolyticus* (ATCC® 17802™)	10 ± 0.89
2	*Klebsiella pneumonia* (ATCC® 700603™)	Nil
3	*Edwardsiella tarda* (ATCC® 15947™)	10 ± 0.52
4	Pseudomonas aeruginosa (ATCC® 10145™)	28 ± 0.52
5	*Aeromonas hydrophila* (ATCC® 35654™)	13 ± 1.03
6	*Salmonella typhimurium* (ATCC® 23564™)	10 ± 1.36
7	*Escherichia coli* (ATCC® 10536™)	11 ± 0.89
8	*Proteus mirabilis* (ATCC® 12453™)	11± 0.52
9	*Proteus vulgaris* (ATCC® 33420™)	12 ± 0.89
10	*Vibrio mimicus* (MTCC® 11435™)	11 ± 1.03
11	*Vibrio cholerae* 0139 (MTCC® 3904™)	10 ± 0.89
12	*Enterococcus faecalis* (ATCC® 29212™)	14 ± 0.52
13	*Listeria monocytogens* (ATCC® 19115™)	10 ± 0.52
14	*Staphylococcus aureus* (ATCC® 29213™)	Nil

*Mean value ± Standard deviation

Table 2. *Comparison of the antibacterial effect of antibiotics and green seaweed extract against P. aeruginosa*

I	**Antibiotics**			
Sl No	**Name**	**Code**	**Concentration (µg)**	**Zone of clearance (mm)**
1	Co-Trimoxazole	COT	25	18
2	Ampicillin	AMP	10	12
3	Chloramphenicol	C	30	18
4	Amoxiclav	AMC	30	Nil
5	Cefotaxime	CTX	30	24
6	Ceftriaxone	CTR	30	23
7	Cefoxitin	CX	30	15
8	Ceftazidime	CAZ	30	23
9	Cefpodoxime	CPD	10	28
10	Aztreonam	AT	30	26
11	Imipenem	IPM	10	26
12	Gentamycin	GEN	10	27
13	Azithromycin	AZM	15	21
14	Tetracycline	TE	30	15
15	Ciprofloxacin	CIP	5	37
16	Nitrofurantoin	NIT	300	21
II	**Green seaweed extract**			
1	*Ulva lactuca*	GSE	15 mg	28

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Seaweed biochar - production and applications

Rehana Raj[1*], Greeshma S. S.[1], Niladri Shekar Chatterjii[2], Asha K. K.[1]

[1] Mumbai Research Centre, ICAR Central Institute of Fisheries Technology, Navi Mumbai - 400703

[2] ICAR Central Institute of Fisheries Technology, Matsyapuri, Cochin, Kerala - 682029

[*]Email: rehanaraj9@gmail.com

Seaweeds which are normally grown for their applications in food and hydrocolloids also find use as feedstock for the production of biochar- "Carbon-flushed biotic charcoal" (Bird et al., 2011). They are known for their rigid carbon content permitting a slow carbon (C) release, which is significant especially as a source of carbon for soil amendments and also in amending degraded and low-fertility soils. This inherent property of seaweeds emphasizes their utilization as a source of bioenergy and in wastewater treatment (Woolf et al., 2010 & Han et al., 2018). Biochar is expounded as a carbon-enriched organic product derived as a by-product after the process of pyrolysis under high temperatures with limited oxygen supply. Biochar is a potential component for producing farm-based renewable energy in a green manner. The efficiency of biochar depends upon the raw material employed for carbonization, pyrolysis conditions, quantity of biochar applied etc.

Biochar produced from terrestrial woody plants with lignocellulosic feedstocks possesses greater C content (more than 70%) but with less nutritive benefits. On the other hand, seaweed biochar exhibits several specific characteristics for its employment in various fields (Bird et al., 2012; Woolf et al., 2010 & Han et al., 2018). The yield of biochar from seaweed is proportionately more when compared with biochar produced from terrestrial woody plant sources for lingo-cellulosic feedstocks with less C content. Seaweed biochar is known for its better exchangeable nutrient content and Cation Exchange Capacity (CEC). Retention of nutrients in agricultural soils will be effective with high CEC of seaweed biochar.

Seaweed biochar acts as an efficient bio-sorbent for metals from effluent wastewater. Certain toxic contaminants such as selenium (Se) have a better affinity towards modified seaweed biochar than any other passive bio-sorbents which can be employed in various water systems (Kidgell et al., 2014).

Sargassum wightii (brown seaweed) was utilized for the preparation of biochar in accordance with Sarfaraz et al. (2020) with minor modifications. The seaweed obtained from Manadapam coast of TamilNadu in dry form was weighed and subjected to charring. Charring was done at various temperature including 300, 350, 400, 450, 500, 550, 600°C for 1h in order to study the best yield and property of the biochar obtained. Yield of biochar varied from 40-48%. It was observed that the maximum yield was obtained at 400°C and the yield obtained was around 48%. The obtained biochar was then subjected to characterization. It was observed that pH varied from 8.5-11.5 among the different biochar obtained at various degrees of temperature.

Fig. 1 *Dried Seaweed*

Fig. 2 *Seaweed Biochar*

Temperature (°C)	Yield (%)	pH
300	43	9.3
350	46	8.5
400	48	9.5
450	45	10.5
500	43	11.3
550	41	11.5
600	40	10.6

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